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ABSTRACT

This report on continuing education in science and engineering was prepared in response to the National Science Foundation (NSF) Authorization Act of 1977. It contains: (1) recommendations for implementation in 1978; (2) an analysis of information on the employment and availability of scientific, engineering, and technical manpower; and (3) an assessment of the extent to which a federally-supported continuing education program could alleviate unemployment and under-employment among scientists and engineers. The report is organized in two parts. Part A contains a definition of continuing education in science and engineering and a discussion of the need for it. Part A also gives a description of the basic NSF plan for continuing education. Part B describes the interim report leading to the plan, the commissioning of papers, and the August, 1977 meeting at which the papers were presented. Appended to the report are the six papers prepared by experts to be presented to the NSF committee on continuing education in science and engineering. (BB)

Continuing Education in Science and Engineering

December 1977

Prepared for:
National Science Foundation
Directorate for Science Education
Office of Program Integration

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PREFACE

The explanatory statement of the House-Senate Conference Committee related to the National Science Foundation Authorization Act of 1977 required a report on continuing education in science and engineering including:

- a. recommendations for implementations in FY. 1978;
- b. analysis of information on the employment and availability of scientific. engineering, and technical manpower;
- c. an assessment of the extent to which a federally-supported continuing education program could alleviate unemployment and underemployment among scientists and engineers and lead to the greater application of their skills to the solution of problems the nation is facing in areas of civilian science and technology.

The initial response to this requirement was the *Interim Report: Continuing Education in Science and Engineering* which was prepared by the Directorate for Science Education of NSF and submitted to the Congress on February 28, 1977. This report is included here as Appendix G.

Following submission of the *Interim Report*, discussions involving Congressional and NSF staff members in March 1977 outlined additional steps to be taken to obtain more information and extend and refine the program plan in the Interim Report. This report discusses what has been done since the submission of the *Interim Report* and records the conclusions reached.

This report was prepared by staff members of the Office of Program Integration and the Division of Science Education Development and Research of the Science Education Directorate. It is based on a review of the literature, input received from other NSF staff members, six papers commissioned by NSF, and input received from two public meetings. Part A provides a synthesized overview of the Science Education Directorate's perspective on continuing education in science and engineering and includes a proposed program plan. Part B describes the process that led to this report. The Appendices contain resource and reference material including the six commissioned papers.

The National Science Foundation is grateful for the contributions of all the individuals who are identified in various places in this report. The National Science Foundation is, however, solely responsible for any errors, findings and interpretations except as noted in the commissioned papers.

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CHRONOLOGY

1. September, 1976. House-Senate Conference Report on NSF Authorizing Legislation for 1977 requiring a report on "Continuing Education in Science and Engineering."
2. December 13, 1976. Meeting of experts at NSF offices (see Appendix G).
3. February 28, 1977. "Interim Report: Continuing Education in Science and Engineering" submitted to the Congress (Appendix G).
4. April 1, 1977. Meeting at NSF to identify topics and authors of commissioned papers, and possible participants in the August meeting (see Part B, 1 and 2).
5. May, 1977. Six papers requested by NSF.
6. July, 1977. Six papers received by NSF and distributed to meeting participants (Appendices A through F).
7. August 5–6, 1977. Meeting at NSF (see Part B. 3.).

Continuing Education in Science and Engineering

EXECUTIVE SUMMARY

The Interim Report (Appendix G) provides an "analysis of information on the employment and availability of scientific, engineering, and technical manpower." The most striking thing to emerge from this analysis is the dramatic and well-publicized problem of oversupply of Ph.D.'s. Recent projections made by the National Science Foundation indicate that between 375,000 and 400,000 science and engineering doctorates would be available to the U.S economy in 1985, compared to about 295,000 available positions in college and university teaching and nonacademic R&D employment that have traditionally made direct use of advanced education and research skills provided by doctoral education. Lack of academic openings will have at least two results: It will be difficult for new Ph.D. holders to start academic careers and the average age of academic faculties will increase.

However, over the past decade unemployment rates for scientists and engineers have been significantly less than the rates for the total labor force. In particular, the national figure for Ph.D. unemployment across all fields is now only 1.2 percent and most analysts believe that few Ph.D.'s are likely to be unemployed in the future. This means that in 1985 about 90,000 science and engineering doctorate holders are expected to be engaged in nonacademic and non-R&D employment. There are indications that "credentialling"—increasing educational prerequisites for jobs—is occurring at all levels. Whether the jobs themselves are changing in nature and content to be commensurate with the prerequisite training (enrichment) or whether underutilization of skills is the case is difficult to assess.

There are two polar points of view regarding this situation. One point of view holds that the basic problem is so fundamental and complex that the best policy of the Federal Government is to let the forces of the market prevail. A contrasting point of view asserts that since the tight academic job market may be discouraging or diverting an entire generation of talented youth from scholarly pursuit the Federal Government must intervene to forestall negative consequences for the future intellectual condition of the nation. In any case, continuing education does not appear to be effective in dealing with underemployment or the effects on academia of the "freeze-out" of young talent. Strategies for opening up faculty positions for young people deserve investigation.

Continuing education is relevant to maintaining the vitality and productivity of employed scientists and engineers. It takes many forms ranging from informal activities in the work place to formal courses in universities. However, continuing education alone does not solve the problem of maintaining professional vitality on the individual and system level. Continuing education is only one element in a complex of factors. In particular, the relevance and potential efficacy of continuing education is influenced by organizational factors such as job design, supervision, colleague interaction, and reward systems.

Continuing education is a widespread practice. There is a propensity for individual scientists and engineers to maintain or upgrade their technical competence, and employers appear to invest significantly in continuing education. A recent survey showed that over 35 percent of a national sample of scientists and engineers received nonformal training in each of the years 1972 through 1975. These nonformal training activities were principally "on-the-job training" or "courses at employer's training facility." The prevalence of this type of training must be taken into consideration in formulating any future continuing education programs directed to scientists and engineers. Because of the great variation in the nature and scope of continuing education, the investment in it is hard to measure, but one estimate is that business and industry spend $17 billion annually on continuing education of all types.

Our analysis shows that while continuing education is a substantial enterprise in terms of the investment and participation of individual scientists and engineers and their employers, it is a highly fractionated, uncoordinated set of operations in which industry, academia, the professional societies, and independent entrepreneurs pursue their own individual paths in response to what they perceive to be their own individual needs. A portion of the NSF program plan for FY-1978 is intended to be a step toward providing a framework in which coordination of the various elements of continuing education in science and engineering can be fostered.

PART A: Background and Plan

1. DEFINITION OF CONTINUING EDUCATION IN SCIENCE AND ENGINEERING

Education and training are important to professionals in staying up to date in their present and future careers. This is reflected in considerable investment by individuals and organizations in "continuing education" (CE). It is difficult to provide a single, precise definition of "continuing education." In this section we attempt to describe the term using criteria and characteristics.

It is important to distinguish between technical education and business/management education. For our purposes, the former deals with the substantive content of science and engineering. It is this content that is the focus of CE as the term is used in this report.

CE is usually distinguished from initial education. It is education that occurs or is taken after beginning full-time employment as a professional scientist or engineer. It is also becoming increasingly common to distinguish CE from advanced education. The latter refers to, say, what a scientist or engineer (employed or not) with a baccalaureate degree might do to obtain an advanced degree. Advanced education is usually aimed at raising an individual's formal capabilities and perhaps prepare for increased responsibilities. CE, on the other hand, is usually addressed to such purposes as updating and diversification for maintaining competency of a professional on his or her present job or develop competency in a new field but not necessarily on a higher level. Katz (see Appendix E) lists 18 objectives which CE might address.

Attempting to define CE in terms of learning also presents difficulties. This is so because a great deal of learning occurs naturally on the job. As Katz puts it: "Most scientists, engineers, and technicians learn anywhere between zero to 100% or more of what they need to know to keep doing what they are doing by doing it." For our purposes CE refers to an activity that supplements and further stimulates learning on the job.

Learning can also occur informally. An example is an adult watching the Nova program on television. Although the show certainly has a structure and the director may be using that structure to develop a set of learning goals, the viewer is not aware of any goals. He or she is left simply to view the show in an unstructured way, randomly assimilating whatever information seems interesting to him or her. Game playing by children may also produce learning, but the child is usually interested in playing the game and whatever learning takes place is unintentional and non-goal directed. With these considerations in mind, we consider CE as structured, goal oriented, and intentional and perceived as such by both teacher and student.

A final consideration we introduce in defining CE is duration. To include as CE a 15-minute briefing or a single two-hour seminar we regard as expanding the definition too far to be useful. On the other hand, short courses and intensive workshops lasting a day or two may provide a significant increment of training. Accordingly, we believe that CE would include an educational program of duration adequate to convey a significant increment of training.

In summary, continuing education in science and engineering (or CE) is understood to be described as any course or educational program:

- the substantive content of which deals with scientific and engineering knowledge;
- taken by or intended for professional scientists and engineers after initial employment as such;
- that addresses such purposes as updating and diversification rather than advanced education;
- that is structured, goal oriented, and intentional;
- that has duration adequate for a significant increment of training.

While this definition of CE is somewhat narrower than the popularly-held concept, it does encompass many forms and practices. CE can be formal course work taken at a university or at the employer's training facilities. It can be of the on-the-job type, correspondence courses, or independent study, and includes what faculty members usually do on sabbatical leaves.

2. THE NEED FOR CONTINUING EDUCATION

The need for continued education stems in part from the nature of science itself. Science is dynamic and cumulative. The growth of scientific knowledge and information is continually opening new lines of investigation, sometimes adjacent to existing lines and sometimes farther removed. Individual scientists and engineers must have the ability and the opportunity to master new lines of investigation if they are to maintain their individual productivity and contribute to the vitality and productivity of the scientific enterprise. The problem of keeping up to date with the growth of knowledge has become complicated by the fact that the rate of knowledge growth is accelerating.

At the system level, maintenance of vitality in knowledge production is greatly assisted by the inflow of young, newly trained talent. During most of the decade of the 1960's both supply and utilization of science and engineering talent were growing sharply Toward the end of the 1960's we began to see signs of oversupply Data on oversupply of scientists and engineers are discussed in Appendix G It is clear that academic careers for new Ph D holders will be difficult to obtain and that the inflow of newly trained talent into academe has slowed considerably.

By contrast, shifts and adjustments can be made more easily in industry than in academe Detailed studies of personnel dynamics in industry and the problem of vitality on the system level are not available, but the problem is believed to be influenced mainly by general economic conditions When the economy is vigorous and profits are up, there is increased hiring and increases in other activity in industry aimed at improving vitality of scientific and engineering personnel Conversely, when the economy is sluggish or in recession the capacity of industry to address vitality is reduced It is not known whether there is a slowdown in the inflow of new talent into industry similar to that in academe and what the consequence might be for the vitality of the scientific and engineering enterprise at the system level. However, some observers believe that because the economy has not been notably vigorous for the last five years or so, there has been an erosion in the flow of newly trained talent into industry.

The ability of professionals to maintain effective performance appears to be related to aging as well as to knowledge growth The *Interim Report* (Appendix G) cited findings that individual performance among technically trained personnel peaks at an early age and declines steadily thereafter While the general phenomenon is not new (and of course does not affect everyone), the age at which this is happening is falling Data were also cited indicating that the average age of the stock of human resources in science and engineering is increasing. This appears to be a potentially acute phenomenon in academe and may be so (although perhaps less acute) in industry

A significant new insight relative to the maintenance of professional vitality concerns the importance of the work environment This was mentioned in the *Interim Report* and emerges as a theme implicitly or explicitly in all six of the commissioned papers (Appendices A through F). Important elements of the work environment include job design, supervision, colleague interaction, and reward systems A job that is challenging stimulates vitality and encourages learning that occurs naturally by doing the job Conversely, dull jobs can have the opposite effect. Leadership provided by managers is one of the most important influences on the behavior of professionals and therefore has a significant impact on individual performance and productivity Opportunities for peers to interact also promote learning with the opposite effect occurring from isolation Similarly reward systems in organizations can either encourage or discourage learning and the maintenance of professional vitality The effects of the work environment are discussed extensively in the Dubin paper (Appendix C)

In addition to the foregoing conditions which influence the vitality and productivity of both academic and non-academic scientists and engineers, there are special conditions in colleges and universities which create interest in faculty development In addition to the slowdown in mobility, Bergquist (Appendix A) mentions three. First, students are becoming increasingly heterogeneous. They now come from lower socioeconomic classes, from an older age group, and from different racial and ethnic backgrounds. Faculty must respond to this heterogeneity with a more diverse and flexible set of instructional goals and strategies. Second, colleges and universities can no longer operate in isolation An increased sense of accountability leads to keener evaluation of performance. If faculty are to be evaluated then they must also be given an opportunity to improve performance in areas of deficiency Third, as traditional enrollments drop off, colleges and universities are seeking to attract new audiences. This usually requires changes in programs and educational structures which in turn creates a need for faculty members to accommodate these changes.

Up to this point, we have argued that the need for continuing education stems from knowledge growth and is complicated by demographic (e.g., aging), supply-demand, and personnel mobility factors. We have also pointed out that the relevance and potential efficacy of continuing education is addressed to the problem of maintaining professional vitality on the individual and system level, but is only one element in a complex of factors. The six commissioned papers shed some light on some of the other elements involved and their relation to continuing education. In the remainder of this section we consider some more specific problems associated with continuing education as such.

Several of the papers implicitly and explicitly argue that the content of continuing education programs must vary with the specific purpose being served. Assisting scientists and engineers in keeping current, providing them with new skills needed in their present job, assisting them in making a significant career shift, or addressing what appear to be special problems for engineers at mid-career each requires a different approach. Katz (Appendix E) specifically addresses the problem of differing audiences while Biedenbach (Appendix B) discusses the potential and limitations of various delivery modes. These elements—content, audiences, and delivery mode—are key aspects of any planning framework for continuing education.

However, a special issue arising from the inquiry conducted over the last several months has to do with relations between academe and industry. It is believed that the spectacular growth in the decade of the 1960's of the utilization of scientists and engineers within academe and the concomitant growth in supply of academics skewed the initial training provided these professionals. That is, the initial training is oriented more toward future academic work than it is toward work in industry or other non-academic settings Moreover, non-academic scientists and engineers (who comprise about half of all scientists and engineers) make up a significant audience for the continuing education offered by colleges and universities Again. the academic orientation of the faculty teaching in continuing education programs offered by colleges and universities may be insufficiently sensitive to the needs of industrially employed scientists and engineers.

In industry. few companies are large enough to maintain their own in-house facilities and resources for continuing education. Facilities and resources of colleges and universities can potentially be brought to bear on the problems of such companies Hazzard's paper (Appendix D) discusses the problem of the academic-industrial interface and this emerges as an issue deserving special attention.

In summary, the maintenance of the "quality" of the stock of human resources in science and engineering is the basic problem to which continuing education is relevant This problem arises from knowledge growth and is intensified by organizational. demographic, and supply-demand factors Planning for continuing education should keep in mind the aforementioned factors in addressing issues involving content, audiences, and delivery modes The academic-industrial interface emerges as a key issue in considering continuing education Finally, it is worth noting that the Kaufman paper (Appendix F) highlights how little is known about the utility and effectiveness of continuing education

3. REASONS FOR HEIGHTENED INTEREST IN CONTINUING EDUCATION

One of the key recommendations emerging from the August 5–6. 1977 meeting was based on the proposal of Lindon Saline of the General Electric Company for establishing a Commission on Continuing Education in Science and Engineering (Appendix I) Saline cited several indications why establishment of such a Commission is timely and these provide some of the reasons offered here. along with others as to why there is heightened interest in continuing education in science and engineering today.

Societal values and priorities are moving slowly but surely toward realization of lifelong learning One piece of evidence for this is the general growth of adult education (the percentage of the population participating in adult education activities has almost doubled since 1957) These values and priorities are reflected in legislative activity as is exemplified in the Mondale bill on lifelong learning and the interest of Senator Kennedy in continuing education for scientists and engineers

There is high interest and growing support of continuing education from employers Continuing education is such a large and fragmented enterprise that hard, differentiated data are almost impossible to obtain, but there is virtually unanimous agreement among interested observers that the investment is large and is increasing. Some data are cited in the *Interim Report* (Appendix G).

Professional organizations. universities, entrepreneurs, government organizations, private corporations and other such purveyors are trying to serve continuing education needs. This appears to be related to the factors discussed in the preceding section regarding the acceleration rate of growth of new knowledge and the slowdown of the inflow of new talent. This latter factor would appear to shift attention to the talent already in science and engineering,

Some states require continuing education for relicensing of professionals such as physicians, veterinarians, and pharmacists. For the moment, this trend appears to focus on professionals having direct one-to-one contact with the public and so has not greatly affected other scientists and engineers who typically work within organizations and do not have direct public contacts. However. as issues involving energy and the environment affect such things as housing design and space conditioning systems one can expect increased public contacts by scientists and engineers. Generally speaking, issues of public policy more and more have scientific and technical components which will also increase interactions between the public and scientists and engineers. One can speculate that as this is happening, licensing and re-licensing will expand to cover more and more professionals as will legal requirements for continuing education of more professionals.

4. PROGRAM PLAN

We begin this section with a general description of our program plan for FY 1978 which essentially reproduces the plan presented in the *Interim Report* (Appendix G). This is followed by a discussion of extensions to the basic plan that have been developed since the *Interim Report* was prepared. The latter discussion has three components. (a) research and development activities; (b) mid-range plans (through FY 1980); and (c) management and planning activity.

Program for FY 1978

The program plan and budget for continuing education is shown in the following table indicating a total of $5,767,000 for FY 1978 for continuing education of all types. There is an additional $6,000,000 in the FY 1978 budget for Pre-College Teacher Development. This program is designed for continuing education of elementary and secondary school teachers.

The College Faculty Short Courses are intended to provide a forum in which scholars at the frontiers of various disciplines communicate recent advances in their fields directly to college teachers of science. The primary aim is to enable college-teacher participants to keep their

Continuing Education in Science and Engineering
Obligations by Program Sub-element

Program Subelement	Actual FY 1976	Estimate FY 1977	Estimate FY 1978	Difference FY 1978/77
College Faculty Short Courses	$894,450	$977,000	$944,000	$-33,000
Science Faculty Professional Development	2,562,660	2,223,000	2,361,000	+138,000
Resources Improvement (CAUSE)	1,000,000	1,100,000	1,347,000	+247,000
Research and Development in Continuing Education for Scientists and Engineers	221,146	41,000	1,115,000	+1,074,000
Total	$4,678,256	$4,341,000	$5,767,000	+$1,426,000

teaching up to date and relevant. Courses operate in fifteen regional centers. In each short course, the course director meets with the college-teacher participants for a total of four days—two days in the fall and two in the spring. NSF funds support the instructional costs and expenses of participants for lodging while attending courses. Participants or their employers are expected to pay the costs of travel and meals (except that some travel assistance is provided for participants who are more than 300 miles from any of the 15 field centers). The FY 1978 funds would permit 40 short courses for approximately 3,500 college teachers during the academic year 1978–79.

The Science Faculty Professional Development program is designed to help experienced college teachers increase their competence in science by enabling them to spend up to a year at advanced study or research in either an academic institution or an industrial or non-profit laboratory. Approximately half the funds available to the program are used to support applications for affiliation with non-academic institutions. Funds available to the program in FY 1978 will support approximately 130 college science teachers.

The programs discussed so far are designed to provide individual scientists and engineers with services to prevent obsolescence. Some of our institutional support programs, in addition, contain continuing education elements. Experience with the CAUSE program shows that some of the funds are used for revitalization of the existing faculty. We estimate that approximately 10 percent of the funds available in the program are used for this purpose.

Research and Development Activity

We turn now to activities related to the matter of continuing education for scientists and engineers in non-academic employment. In the past, NSF-activity in this area has been largely oriented toward trying out alternative delivery systems, with some efforts in the development of teaching/learning materials. Direct support of the actual delivery of instruction to non-academic personnel, or direct support of individuals employed in industry to engage in continuing education programs, has not been a part of SE Directorate activity, and we do not believe that it should. It has become clear, however, that though it is an area in which many millions of dollars are invested annually (one estimate is $17 billion for *all* of CE; what fraction of that is *for* scientists and engineers, and what fraction of *that* is *in* science and engineering, is unknown), the entire enterprise is a highly fractionated, uncoordinated set of operations in which industry, academia, the professional societies, and the independent entrepreneurs pursue their own individual paths in response to what they perceive to be their own individual needs. It must be recognized that the interrelatedness of all of these educational activities calls for a kind of coherence not obtainable through the individual efforts of any one of the elements of the continuing education complex. The research and development program for FY 1978 is intended to be a step toward providing a framework in which coordination of the various elements of the system can be fostered. Specifically, we plan to implement two of the major recommendations of the expert panels regarding continuing education in the non-academic area in FY 1978. These are: (a) The support of *STUDIES* leading to greater understanding and knowledge of CE as it now operates, and (b) *CONFERENCE/WORKSHOP* support, as a mechanism for developing better relationships and rapport, and perhaps mutually beneficial cooperative projects, between working-level engineers and scientists employed by industrial and academic institutions. In addition, the door will be open to proposals covering proposer-generated *EXPERIMENTAL/PROTOTYPE* activities not falling into either of the "studies" or "conference/workshop" categories.

The three types of support indicated above are described in more detail in the Proposal Solicitation, *Continuing Education for Engineers and Scientists*, SE 78–58.

Mid-Range Plans

The research and development activity planned for FY 1978 should be seen as the initial steps in a continuing program. In order for this activity to have maximum utility: (a) in relation to NSF's decisions concerning its role in continuing education in the years beyond FY 1979, and (b) for the continuing education community, it will be necessary to synthesize and integrate what is learned from studies and the regional academic-industrial workshops Accordingly, the proposed goal for FY 1980 is the development of a documented, comprehensive overview of the then current state of continuing education for non-academic scientists and engineers Such a compendium would include results of the studies completed at that time, a set of descriptions of continuing education activities of active deliverers. The latter would be case studies covering 5 or 6 of the major, judged-to-be-effective, industrial deliverers (IBM, Bell Labs, GE, etc) and a like number of college/university, professional society, and entrepreneurial continuing education purveyors Having such information will facilitate NSF programming and field response.

In addition, steps should be taken to reexamine programming in continuing education for academic scientists and engineers This reexamination should be done in the light of needs and emerging practices in faculty development This reexamination would also be relevant to the steps taken in FY 1978 to establish meaningful coordination between academic and non-academic continuing education activities.

Management and Planning Activity

Implementation of the FY 1978 and mid-range plans will require in-depth monitoring and external advice. Accordingly, a program manager for continuing education will be designated and the Advisory Committee for Science Education will provide for the external advice. The program manager will be responsible for managing the studies, workshops, and experimental activities as described in the research and development plan for FY 1978. In addition, the program manager will be responsible for implementing the mid-range plan and for coordination of the internal staff review of continuing education for academic scientists and engineers.

The strongest single recommendation emerging from the August, 1977 meeting (see Part B.3 of this report) is for the establishment of a Commission on Continuing Education. This is a complex recommendation which needs to be studied carefully (in terms of its charter, its makeup, and its funding) before a decision is reached. An essential initial step is strengthening the continuing education expertise of the standing Advisory Committee for Science Education and asking it to address this topic.

The FY 1978 program budget for continuing education is approximately $6,000,000, most of which is for faculty development. No significant budget increases are projected at this time because no major increase in service delivery activity or subsidies for individuals appears to be warranted at this time. Rather, this plan focuses on fostering coordination and integration of a large and fragmented enterprise. Future budgets will be based on demonstrated needs in relation to the appropriate NSF role.

PART B: Steps Leading to the Present Plan

1. FIRST PHASE: THE INTERIM REPORT

The explanatory statement of the House-Senate Conference Committee related to the National Science Foundation Authorization Act of 1977 required a report on continuing education including:

a. recommendation for implementation in FY 1978,

b. analysis of information on the employment and availability of scientific engineering, and technical manpower,

c. an assessment of the extent to which a federally-supported continuing education program could alleviate unemployment and underemployment among scientists and engineers and lead to the greater application of their skills to the solution of problems the nation is facing in areas of civilian science and technology

The effort to respond to this requirement eventually became the joint responsibility of the Office of Program Integration and the Division of Science Education Development and Research of the Science Education Directorate of NSF. This report was prepared by staff members of these two units.

The first major milestone of this effort was a meeting of experts at NSF on December 13, 1976. There followed staff analysis of the situation which led to the *Interim Report* which was delivered to the Congress on February 28, 1977. A list of participants in the December meeting and a report of the outcome are contained in the *Interim Report* which is attached as Appendix G.

2. SECOND PHASE: COMMISSIONED PAPERS AND AUGUST MEETING

Discussions involving Congressional and NSF staff members led to additional plans for commissioning papers by experts and convening a second larger meeting.

On April 1, 1977, NSF staff members met with:

Dr. Samuel S. Dubin, The Pennsylvania State University

Dr. Morris E. Nicholson, Jr., University of Minnesota

Dr. Moses Passer, American Chemical Society

Dr. Howard Shelton, Sandia Laboratories

The purpose of the meeting was to discuss possible topics and authors for commissioned papers. The papers that resulted are attached as Appendices A through F.

A second purpose of the April meeting was to discuss possible participants for a meeting. A rather long list was generated, from which NSF staff members eventually drew up the list of those who attended the meeting which was held August 5–6, 1977 in Washington, D.C.

From the beginning of this effort last Fall, NSF staff members thought that the continuing education problem had two major components: one dealing with scientists and engineers employed in academic institutions and the other dealing with those employed by non-academic (primarily industrial) organizations. Because the Science Education Directorate has had extensive experience over the years with continuing education programs for academically employed scientists and engineers, but relatively little experience on the non-academic side, participant selection was weighted toward the latter. No claim is made that all the answers are available on the academic side; in fact, this is a significant problem area requiring further study. However, our need for assistance on the non-academic side was more acute under the circumstances. Because the non-academic side is dominated by concerns for engineers and engineering, this consideration was given weight in participant selection. Beyond the emphasis on non-academic employment and engineering, balance was sought in expertise, points of view, and geography. However, no claim is made that all interests and points of view were represented. Given the need to limit the group to a manageable size and the problem of operating within a severe time constraint, some necessary compromises were made. Additionally, this report is by no means presented as the definitive statement on continuing education in science and engineering. Indeed, one of the overwhelming conclusions is that the problem is so complex that a great deal more study over a relatively long period of time is called for.

The meeting was held on August 5–6, 1977 in NSF's offices in Washington, D.C. Appendix H contains the list of participants and the agenda. The next section reports the outcomes of the meeting.

3. REPORT OF THE AUGUST MEETING

On August 5–6, 1977 18 experts met at the NSF offices in Washington, D.C. with members of the Science Education Directorate's staff. The meeting was open to the public and about six observers attended. The purpose of the meeting, the agenda, and a list of participants appear in Appendix H. The meeting comprised three half-day sessions. The first sessions reviewed the six commissioned papers (Appendices A-F), the second was oriented to the identification of problems requiring study or action, and the third to recommendations for possible NSF program responses. This section reports each session in turn.

The following individual reports constitute The Friday Morning Session

Some Currently Used Mechanisms and Delivery Modes for Non-Academic Personnel

Joseph M. Biedenbach

Biedenbach, in reviewing the highlights of this paper, made the following points The use of media technologies in continuing education for scientists and engineers, after 10 years of neglect or opposition, is now just beginning to take off Colleges and universities are broadening the scope of their activities to provide more services to the region in which they are located, and professional societies are providing increased services to their members Though they don't *say* it, academic and the professional societies view themselves as competitive, when the real need is for greater cooperation In the meantime, it is industry that has really begun to move ahead in the use of multimedia programs in promoting the education of their employees For the *next* 10 years, video-tape will be the major vehicle used in continuing education for scientists and engineers

The greatest problem will be that of logistics, largely because of the need for "up front" money—i e , funds to develop the necessary course materials The second major problem will be selling the idea to the industrial personnel manager, for whom the continuing education of the company's engineering and scientific personnel is of secondary concern Currently the most successful media-based continuing education programs are those in management practices and other business administration-oriented topics, for topics in science or engineering, there is, at the present time, less, though growing, demand

Discussion developed on several of Biedenbach's points.

(1) The "level" of continuing education science and engineering courses required to meet industrial needs is lower than most people will admit- Biedenbach mentioned undergraduate review in science and mathematics–e g , statistics, quality control, differential equations–even welding–as ~~samples of the~~ level of materials needed. The value of investing in the production of television tapes on topics readily available in textbooks was questioned–it might be better to use the limited funds available for the production of material not so easily available. It was suggested that the greatest market is for (basic) materials that pay attention to job relevant applications.

There was agreement with Biedenbach that industrial programs tend more toward courses and materials dealing with management skills, less on science and/or engineering subject matter, but at least one conferee disagreed strongly on the question of educational level of the materials. Both at this stage and at other times throughout the meeting, he strongly advocated greater attention to materials at the "cutting-edge" of science and engineering research and development, insisting that it is individuals working in that area that are most in need of the help that properly designed CE programs can provide. This argument elicited relatively little support, since, it was argued, these are the people who have less need for outside help, not only do they have greater capability as "self-starters," but they function in a setting that provides greater opportunity for self-education. Clearly, whether "cutting edge," basic review, or other kinds of teaching materials are needed depends markedly on the nature of the employing organizations.

(2) Mode of presentation. Not everyone agreed that videotape will be the major technological medium for the next 10 years, the potential of audiotapes and videodiscs is not to be ignored. The opinion was expressed that, unless "motion" is involved or essential, videotape may provide no advantage over slide-tape presentations. Another conferee turned attention to a basic question—that of tape or film vs a live instructor—and pointed to the increased value of accompanying any multimedia presentation by a local live tutor, especially when the tutor is someone thoroughly familiar with the business of the learner's employer and is reasonably competent in the subject, though he need not be a "name" authority. He cited experience derived from presentation of courses in chemistry and related topics developed and presented under the education program of the American Chemical Society. Attention was also called to the question of cost-effectiveness. what an employer is willing to pay for an "instructional unit" depends on the number of employees to whom that unit will be useful and, even more important, on the significance of the unit to the economic success of the organization.

It was also pointed out that, in general, media-based instruction is not likely to become economically feasible in the absence of a national distribution mechanism.

(3) Small and/or dispersed industry. Attention was directed toward the "lonely employee." Many, if not most, of the larger firms can handle their own CE problems; there is, however, the need to think about scientists and engineers employed by smaller companies, or in the many companies distributed over the country in locations remote from major urban centers where educational facilities are readily available. Panel agreed that this is a major problem requiring attention.

The Updating Process

Samuel S. Dubin

The matter of keeping up to date is a far more complex process than "taking a course," "reading a book," or participating in "multi-media" presentations of "subject matter." Of at least equal importance is a whole set of psychological concerns—personal attitudes, motivation, etc.—and the atmosphere—especially the management practices—of the employing organization.

It is essential, therefore, that any serious attempt to maintain a vital, competent, up-to-date, corps of scientists and engineers take cognizance of a whole set of elements, beyond mere "subject matter" competence, that affect the productivity of the employed scientist or engineer.

First, there is need to understand the motivations of individuals, and to recognize their dependence on factors such as age, organizational status, responsibilities, etc. Second, there is need to understand the influence of the organizational climate, and the ways in which it may stimulate excellence—or lead to disinterest and boredom. There is need to understand the influence of company policy (and its system of rewards in the form of pay, status, and increased responsibility), of the nature of job assignments (are they routine or challenging, or how can they be made more challenging), of the opportunities for interaction with colleagues, and of management philosophy (is it supportive of an employees' aspirations toward further learning, or is that the employee's problem?). And there is need for the technical or intermediate level supervisor to understand that, in order to get his job done in furtherance of company objectives, he has to be a "people *developer*." The organizational climate, the challenge of the job, the role of the supervisor, interactions with peers, and management policies are all part of the work environment.

Discussion of Dubin's remarks indicated lack of unanimity among the participants not only on the question of the proper role of NSF in the area of continuing education in science and engineering for scientists and engineers, but also on the question of the breadth of the federal role. Mention was made of the IBM-San Jose program, in which much attention is paid to activities focused on personal vitality, lifestyle, etc This is in contrast to the views of another participant who urges that federally-supported CE programs focus on the question of what knowledge—substantive knowledge in the employee's occupational field—is needed, and on ways to get this knowledge into an academic program—or to provide it via post-academic (continuing education) programs. NSF was urged to clarify its proposed rôle in continuing education, particularly in relation to industrial programs and industrial employees. It was suggested that of greater importance than an NSF attempt to survey "knowledge needs" would be support of research or studies that would attempt to improve the precision of the processes by which organizations, including institutions of higher education, assess the needs of their engineers and scientists.

Several participants emphasized the importance of motivation to learn, and the need to develop this trait early in the educational process.

The Academic-Industrial Interface

George W. Hazzard

Hazzard's comments on his paper were:

If scientists and engineers are to perform adequately, in academic or non-academic careers, undergraduate education must be concerned with stimulating the student into a self-motivating mode; and must provide insights into the operations of both the academic world and the real world outside of academe. Close cooperation between industrial and academic institutions is of the highest importance, and pays off. Hazzard strongly recommended increased experimentation with cooperative industrial/academic programs—not massive, large-scale, national programs, but smaller, local or regional, cooperative efforts. He stressed also the need for a mixed, not a single, strategy. Hazzard's paper evoked a wide variety of responses, almost all supportive of his thesis. Although one or two called attention to the problem of getting institutions to work together, most of the comments dealt with ways to develop better rapport between college and industry, the advantages (on both sides) of small- or dispersed-industry involvement, and the impact such learning situations or instructional modes might have on undergraduate science and engineering programs, both in making instruction relevant to real life, and in the development of life-long learning habits. A goal of undergraduate education (indeed, of all education) should be helping students learn how to learn.

What are the implications for continuing education? One, clearly, is that if students, as undergraduates, really learned how to learn—if they were really stimulated into a self-motivating mode—future demands on a formal continuing education system might be remarkably reduced. But unless (or until) this goal is attained by a wide variety of undergraduate institutions, the need for continuing education programs remains—both continuing education for non-academic personnel, and continuing education (perhaps in some cases, reeducation) for academic faculties.

One of the participants brought into focus the need for greater attention to continuing education for *teachers* of science and engineering with the following comment: An important aspect of continuing education in the undergraduate arena involves keeping professors updated on the industrial and technological ramifications of their discipline. The professor cannot achieve what Hazzard proposes until he has an understanding of the academic/industrial interface and the techniques for its penetration, one of the most important of which is the actual knowledge—both scientific and technological—utilized by industry.

Non-Academic Audiences for Continuing Education in Science and Engineering

Israel Katz

Whereas there seems to be general agreement that, among academically employed scientists and engineers, those in major research-oriented institutions have less need for formally organized continuing education programs than do those in the less research-oriented (more teaching-oriented) institutions; it is, in Katz' view, the principal contributors to scientific and technical advance employed in high technology industry who, among industrial employees, have the greatest need for access to such programs. And with 20% of new knowledge being developed in academic institutions while 80% is produced in non-academic settings, it is the latter that is the locus of a major part of the knowledge that should, by some means, be transmitted to others already in science and engineering careers, or being prepared to enter those careers.

Unfortunately, few CE offerings of academic institutions are matched to the new knowledge needs of CE participants, most, across the nation, are watered-down graduate courses offered on a non-credit basis It is to this inadequate service to CE audiences that much of the non-participation in CE activities can be attributed By far the best courses offered, primarily at lower technological levels, are parts of company-conducted in-plant programs for employees.

There is, however, an important role for colleges and universities, in the harvesting and organizing of new knowledge, and in providing, on "neutral ground," a meeting place for industrially employed scientists and engineers and faculty members who participate as resource persons or as students The value of these interchanges between faculty and industry personnel cannot be over-estimated One of its major consequences is the breaking down of the wall between CE staff and the regular teaching faculty—and the effect this breakdown can have in introducing more relevance into the normal teaching programs.

Katz made one reference to programs aimed at reeducation or reorientation of unemployed scientists and engineers: "You can't educate the unemployed without a *visible job* at the end of the road."

Follow-up discussion by participants was limited but supportive Attention was called to the linkage between this paper and Hazzard's discussion of the Academic/Industrial Interface, and the great need to promote a tightening of the interaction between academia and industry The well-known practice in the medical education area of the use of "adjunct" faculty was mentioned as a possible means of getting knowledgeable industrial scientists and engineers more directly involved in "regular" as well as "continuing" education programs of colleges and universities.

It was pointed out, however, that the use of adjunct faculty is useful only if they are part of a carefully integrated program with distinct pedagogic objectives. Random talks by a series of industrial visitors may be interesting but of little value in providing the student with the overview he needs of industrial science and technology.

Factors Affecting the Relationships Between Continuing Education and Performance

H. G. Kaufman

Kaufman's thesis was that while private industry has allocated substantial resources to continuing education, few attempts have been made to assess adequately the value of continuing education either to the individual or to the employing company While some academically-based research in continuing education in industry has led to tentative indications about what a particular level or mode of presentation does for a particular level of participant under what conditions, there is, in fact, relatively little state-of-the-art knowledge about how to proceed with a dependable evaluation of the effectiveness of continuing education operations.

Perhaps most clearly established are the conclusions that the more competent engineers and scientists tend to enroll in university-sponsored courses, whereas the less competent turn to company-sponsored in-house courses. Graduate courses appear to result in improved performance, primarily in R & D environments but no clear cut results of in-house courses have been demonstrated When employees are given leave to devote full time for an extended period of studies, they are quite likely to experience major frustrations because of reentry problems—the employee's "spot" in the organization's network has changed or newly acquired knowledge is not used in the new assignment.

Additional discussion focussed on what is probably a major cause of the uncertain results of evaluations—the fact that the methodology, criteria and instruments used in evaluations are inadequate to the task. The greatest need at present is carrying out an adequate assessment of continuing education. This would require research designs using longitudinal studies and the development of instruments of evaluation based on criteria that consider the viewpoints of all parties concerned. the individual, the employer, and the purveyor.

Faculty Development in the Sciences and Engineering

William H. Bergquist et al.

Institutional recognition that it is responsible, at least in part, for continued development of faculty members is not new—witness: the age-old sabbatical leave programs which, though increasingly ineffective, still persist—at least "on the books"—in many institutions. Very recently, however, a new brand of faculty development has come into being, and is currently the object of the largest investment of all activities viewed as "educational innovation."

The reasons are many: student bodies are more heterogeneous, and on the average older, and more oriented toward job relevance; there is more concern for institutional accountability; college constituencies are drawn from a wider area, and competition for students has increased—and with all of these demands for reorientation, redirection, and change in college curricula, faculties are growing older, more stable, and less mobile. It is estimated that barring unforeseen overturning of the present situation, from 70 to 80% of the present faculty will still be just where they are now for the next 20 to 25 years.

Thus new kinds of programs, and new approaches to teaching and learning, are imperative. And even when a new idea is put forward, merely having that good idea is not enough; the idea is of no value until it is put into use. The approach used in the new brand of faculty development is, via conferences, workshops, and other devices, to lead the faculty to an understanding of the roles of research, development, dissemination, and use, and to foster implementation of the entire process to the end that effective changes are introduced into courses and curricula. And beyond this, to an awareness that some successes can lead to problems that are enormous—e.g., how to handle the organizations' problems that come from the installation of a new teaching technique, or how to gain acceptance by those not involved in the development. One conclusion is clear: when faculties do experiment with new teaching modes, there is less reluctance to face new kinds of students.

There were several comments to the effect that among academic institutions the problems of obsolescence are probably greatest in the two-year institutions, where budgets closely keyed to faculty work loads rarely permit even minimal effort to be directed at anything other than classroom teaching. One participant suggested that perhaps a solution lies in efforts to increase faculty productivity so as to yield a margin that would permit faculty development to occur. An associated question, of course, is whether increased teaching productivity would not result in counterbalancing budget reduction.

It was asserted by one participant that many two-year institutions do a better job of faculty development than do the major research institutions if the faculty functions of "helping others learn" is considered to be the focus.

General Comments

Throughout the course of the meeting there were additional comments made or questions raised which, though not directly related to any particular paper, did bring into the discussion other pertinent topics:

(1) The role of continuing education as it now functions, or should function, within the broader range of "lifelong-learning" or "recurrent education."

(2) The role of (and in particular the Foundation's role in) continuing education in science and engineering subject matter content within the broader area of acquisition of other kinds of knowledge—budgeting, logistics, planning, management practices, interpersonal relations, and personal development—needed by practicing engineers and scientists.

(3) The role of colleges and universities, professional societies, and industrial programs in fostering continuing learning by scientists and engineers, and the need for coordination of these activities within the framework of some clearly understood unified approach to attainment of the overall goals of continuing education.

(4) Questions as to the motivation of some academic institutions in developing and promoting continuing education programs—especially when CE is viewed as an opportunity to increase the institution's revenues and/or use continuing education offerings as a safety valve against pressures brought on by a faculty size geared to once-higher enrollments.

(5) Questions about the proper sources of support for CE. Who pays? Who benefits?

(6) The role of the major consulting firms whose one- to three-day conferences are a significant factor in CE for employed scientists and engineers.

(7) The problem of the awarding of "credit" or some other form of recognition of participation in continuing education activities, handled in such a way as to provide assessment of both the quantitative, and particularly *qualitative*, contribution to the participants' knowledge and understanding of work-related subject matter.

Report of the Friday Afternoon Session

This session was oriented to the identification of problems requiring study or action. A list of the 36 recommendations abstracted from the six commissioned papers was circulated (Table 1, attached, is this list) to the participants organized into three discussion groups. Group I was asked to consider the problems or needs of scientists and engineers employed by academic institutions, while Groups II and III were asked to consider those of scientists and engineers in non-academic employment. After discussion, each of the three groups reported to the plenary session. Summaries of the reports follow.

Group I

Group I stated its conclusions in the following way:

A. The basic purpose of faculty development is to maintain intellectual and professional vitality in science and engineering and instructional technology.

B. There is a need for data regarding professional development: What is going on? Who needs it and why? Who should pay? What is the need for longitudinal studies? How do professional development activities correlate with faculty career stages? What are reliable conceptual models for faculty career stages?

C. Success models and action programs are needed to help integrate academe and industry, and to integrate teaching and research in colleges and universities.

Among the needs and problems leading to this formulation are:

A. 1. The fundamental need for colleges and universities is to maintain intellectual vitality and faculty excitement to insure high quality science and engineering education, and professional exposure to insure relevance of curricula to today's and tomorrow's problems.
   2. Demographic trends will force teaching faculties in science and engineering to reconsider and redirect career directions.

B. 1. There is a need for knowledge—an inventory—of what is going on in faculty development.
   2. More understanding is needed of the relation between continuing education and the career status of an individual (e.g., What is the relation between age, status and need for revitalization?).
   3. Clarification is needed on: Who needs faculty development, who benefits from it, and who should pay for it.
   4. There is a need for studies in continuing education—including longitudinal ones—bearing on the utility of different strategies for professional development. For example: Are sabbatical leaves effective? Under what conditions? Against what criteria do we measure?

C. 1. How does one resolve the tension between the research and disciplinary orientation of scientists and engineers as they emerge from graduate schools and the teaching requirements imposed as they take on responsibilities as faculty members at various types of institutions? How do these activities relate to the overall institutional (faculty) mission(s)?
   2. There is need to stimulate interaction and integration between academic practice and industrial needs and realities. Industry's help is needed to improve both the faculty members' understanding of the industrial environment, and the quality and relevance of prevocational and continuing education offered by colleges and universities. Industry needs to understand the constraints outside the control of academe.
   3. There is a need to increase the effectiveness of faculty members in using new instructional techniques and methods.

Group II.

Group II adopted the working definition that continuing education includes those activities which supplement on-the-job learning. It grouped its conclusions into two major categories.

A. There is a need for obtaining a better understanding of growth and development of people in their careers and of the role that continuing education plays in that process.

B. There is a need for better understanding of how adults learn and how they should be taught.

Further subdivision in terms of the abstracted recommendations (indicated by numbers in parentheses referring to Table 1) were:

A. 1. Needs assessment and the way knowledge patterns change with time (e.g., the ways in which knowledge is accumulated and dissipated during the career life of engineers and scientists) and the relation to the phenomenon of obsolescence. (12), (17), (28), (30), (34), and (35) concern this.
   2. Motivation. (15d) and (18) concern this.

B. 1. The Educational processes involved including the evaluation and measurement of continuing education. (1), (3), (4), (5), (11), (13), (14), (16), (19), (21) concern this.

2. Delivery systems involved. (15a), (15b), (20), (31) concern this.

Group III

The group was particularly concerned with the matter of utilization of knowledge—how well students learn was seen as being less important than how well it is utilized.

The problems identified were:

A. What should be delivered in continuing education? How do you get at the needs of professionals? What are the priority issues?

B. How should it be delivered? How do you determine how much CE is used? How do you measure?

Among the needs and problems leading to this formulation are the following ones (with numbers in parentheses referring to Table 1).

A. 1. Needs assessment techniques from the point of view of marketing techniques to determine what to offer (17), (30).
   2. Evaluation of how to use industrial advisory committees to improve effectiveness of continuing education (22).
   3. Foster interchange of information between academe and industry (28). This bears on faculty obsolescence in relation to industrially generated knowledge.
   4. Develop criteria for use in evaluations of continuing education (4), but in terms of how well knowledge is utilized.
   5. Study rates of change of scientific and technical knowledge (12), interpreted in terms of the matrix concept, page 8 of Katz's paper.
   6. Develop comprehensive data, including baseline data, on the current status of continuing education (15). This would include cataloging current activity.

B. 1. Study assessment of continuing education for scientists and engineers; including long term, longitudinal study (3); influence of organizational structure and climate (on motivation) (6); and establishing baseline data (5).
   2. Research on how adults learn—specifically in the area of science (16).
   3. R&D on alternate modes for the delivery of continuing education (20), (21), (32).
   4. Teaching components of professional societies (29).

Table 1.—Summary of Recommendations and Suggested Activities

Research or Studies:

(1) Research on educational processes (support to educational research journals; search for non-traditional methods of dissemination of research results)	Bergquist
(2) Research on developmental needs and motivation of faculty	Bergquist
(3) Study: Assessment of CESE longitudinal study	Kaufman
(4) Develop criteria for CESE evaluations	Kaufman
(5) In connection with CESE research, require collection of baseline data; specify population to which applicable	Kaufman
(6) Study aspects of organizational structure affecting impact of CESE	Kaufman
(7) Study federal stimulation of CE through legislation making education a fringe benefit for every technical worker	Katz
(8) Study to encourage education/industry cooperation to enhance faculty capability to serve as instructor or resource person in CESE	Katz
(9) Study means to upgrade CE in a university as a valid activity for full-time activity	Katz
(10) Study feasibility of a federal subsidy of CESE as a recognized part of higher education	Katz
(11) Study means of evaluating non-academic CESE offerings and participant performance (*without* participant testing)	Katz
(12) Study rates of change of SE knowledge	Dubin
(13) Test empirical model for measuring updating	Dubin
(14) Behavior-anchored scale for defining and measuring updating	Dubin
(15) Study: Current status of a TV video tape used b. Professional society CE programs c. CE in academic environment d. CE in industry	Biedenbach
(16) Research on how adults learn	Biedenbach
(17) Needs assessment: CE for the practicing engineer	Biedenbach
(18) Study: Motivation to participate in CE individuals, industry, college	Biedenbach
(19) Study: Development of effective evaluation instruments	Biedenbach
(20) Study: Delivery of CE to dispersed industry	Biedenbach
(21) Study criteria-referenced CE program	Biedenbach
(22) Monograph on how to use industrial advisory committees for CE program development	Biedenbach
(23) Study effect of mandatory certification—recertification, etc., on CE programs	Biedenbach
(24) Study status and future of Professional Development programs	Biedenbach

Faculty Training and Development:

(25) Investigate alternatives to sabbaticals (short-term sabbaticals? Provide assistants to professor in first terms of a new course?)	Bergquist
(26) Small-college faculty support for "community" service	Bergquist
(27) Training for Faculty Development practitioners	Bergquist
(28) Foster interchange of information between industry and college/university faculty	Hazzard

Conferences or Symposia:

(29) Fund teaching components of professional societies to explore new approaches to science education, e.g., conference including prof. and eng society representatives and practitioners in faculty development	Bergquist
(30) Support regional workshops to determine grass roots perceived needs—working level S & E's from industry and colleges/universities	Biedenbach
(31) Workshop on techniques of offering CE programs	Biedenbach

Experimental Projects:

(32) Fund disciplinary organizations to experiment with alternative delivery systems	Bergquist
(33) Establish an "Experimental Institute" dealing with design and implementation of programs for faculty who must undergo significant career transitions	Bergquist
(34) Pilot project to test effects of improved management practices as a deterrent of obsolescence	Dubin
(35) Pilot project: An Assessment-Development Center for S & E's at mid-career	Dubin

Information Dissemination:

(36) An annual catalog of CE programs available to industry	Biedenbach

Report of the Saturday Morning Session

This session was intended to produce recommendations leading to NSF program responses.

Early in the session, one of the participants recommended the establishment of a 'Commission on Continuing Education for Engineers and Scientists' for a period of 3–5 years. The reaction of the group to this recommendation was unanimously favorable, although there was considerable discussion over the specific purpose, organization, and function of such a commission. After 90 minutes or so of discussion, it was decided by the group that each participant should provide the NSF staff with written comments on the proposal by August 15. Appendix I contains the proposal and an analysis of these written comments.

It was agreed that even if the 'commission' concept takes shape and becomes a reality it would be some time before the effect might be felt. Therefore, the 'commission' ought not be the only response, but that other parallel activities are required.

The remainder of the Saturday morning session was spent discussing other recommendations. A major one presented was that:

- NSF fund three regional conferences to develop regional pilot programs in continuing education. These regional conferences would have three major characteristics (a) foster two-way exchange between academe and industry; (b) be self-designed by participants using broad guidelines provided by NSF; (c) be funded for a 3-year period.

This proposal generated extensive discussion. The reaction of the group was cautiously favorable—the caution arising implicitly from a number of different problems arising in regard to how precisely the proposal would be carried out. These problems involved such things as: how the different needs of different industries would be addressed; whether the conferences would be more process than content oriented; whether organizational decision makers, line personnel, or some combination would attend.

Three other proposals were advanced in brief:

1. Fostering collaboration of industries and professional associations;
2. Foster utilization of faculty from four-year colleges as visiting professors to teach in-house continuing education courses;
3. Experimentation with innovative delivery systems to reach scientists and engineers isolated by geography or job situation from activities fostering professional development.

While time did not permit the group to reach closure on these particular proposals, one participant offered his interpretation of the final consensus recommendations, and the group as a whole agreed. These consensus recommendations fall into four categories as follows:

1. The Commission on CEES.
2. Specialized Research Study Projects:
   - e.g., Longitudinal studies of the benefits of continuing education to individuals,
   - Program evaluation techniques
   - How do professional engineers/scientists learn?
   - What do engineers do? What do scientists do?
   - Needs assessment techniques
3. Innovative Delivery Systems:
   - Support of open learning experiments for scientists and engineers,
   - Support of innovative consortia arrangements,
   - Experiments in the use of libraries,
   - Experiments in the use of modern interviewing (telephones, etc.) techniques to achieve maximum learning.
4. Faculty Development:
   - To find out what engineers do on the job: OTJ Faculty Internships in Business, Industry, Government,
   - Faculty development in teaching techniques, and other emerging educational techniques such as counseling, facilitating, etc., to reflect future societal needs and correction of past failures.
   - Curriculum updating studies,
   - Studies on Faculty Development Processes (e.g., Which ones work for which engineering and science faculty?),
   - Changing university governance rules to promote CEES as an appropriate faculty activity, by educating legislators, trustees, university administrators and the faculty.

FACULTY DEVELOPMENT IN SCIENCES AND ENGINEERING

Prepared By
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FACULTY DEVELOPMENT IN THE SCIENCES AND ENGINEERING

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A. INTRODUCTION

Faculty development has gained wide acceptance during the past five years in American higher education as a vehicle for the improvement of teaching and learning. Currently, about one half of the colleges and universities in the United States that responded to a nation-wide questionnaire offer some form of faculty development services (Centra, 1976). Furthermore, we estimate that at least $50 million has been given by governmental agencies and private foundations during the past five years to support the creation or expansion of faculty development programs in this country. Several years ago, the Chronicle of Higher Education reported on an "explosion" in the field of faculty development. This trend has continued and apparently will continue for at least two or three more years. Even more important, faculty development probably will become imbedded as a permanent academic service of most colleges and universities.

The increased interest in faculty development can be attributed to at least four causes. First, students are becoming increasingly heterogeneous. They now come from lower socio-economic classes, from an older age group and from different racial and ethnic backgrounds. The "nontraditional" student enters the collegiate institution with a different set of needs and expectations, and different learning styles. Faculty must respond to this heterogeneity with a more diverse and flexible set of instructional goals, attitudes and strategies.

Second, colleges and universities can no longer operate in splendid isolation. They have become increasingly accountable to the general public, trustees, or a sponsoring church. Within the institution, evaluation of professional performance reflects this increased sense of accountability. If faculty are to be evaluated, then they must also be given an opportunity—and the resources—to improve this performance in areas where deficiencies are noted. If they are not provided with these opportunities and resources, the evaluative process becomes inherently unfair and destructive.

Third, faculty are becoming less mobile as more of them become tenured and fewer of them find an opportunity to move to another college or university The majority of faculty in American higher education will be teaching at the same institution for the next twenty to thirty years. Colleges and universities must devise professional development programs that help these entrenched faculty remain vital and excited about their work. Since we have become more fully aware of the stress associated with stagnation in one's career (Levinson et al., 1974) the challenge of rejuvenating faculty in "mid-career crisis" (Hodgkinson, 1974) is even more pressing.

Fourth, as enrollments in traditional liberal arts colleges and universities drop off, there is increasing competition for students among these institutions. This competition has already produced many significant curricular changes (for example, external degree programs, competency-based instruction and new work-study arrangements) These pressures for change in the basic educational structures of many colleges and universities require a program within the institution which supports and assists faculty in accommodating to and even helping to bring about these changes. Such a program must be responsive to the needs of the faculty member as a professional (instructor, advisor, educational designer), a person (life and career planning, interpersonal skills) and a member of an organization (team building, conflict-management) (See Appendix A).

Like their colleagues in other disciplines, faculty in the sciences and engineering must face these demands for change and renewal. Furthermore, since many areas in the sciences and engineering are not now growing in terms of student enrollment or public financial support, these demands for change and renewal must be met without significant external support (money, people, time, machines). Furthermore, very few external incentives (major pay increase, promotion, career advancement) are available to promote change and renewal, for many faculty in the sciences and engineering are already at the top of the academic career ladder (tenured, full professor), having achieved this status at a young age in the post-Sputnik era. Science and engineering faculty must find resources for change and renewal from among themselves and must find reasons for change from new sources that are often internal in nature (renewed interest in teaching, new developments in the discipline or between disciplines, reawakened interest in students).

Practitioners in the field of faculty development face an imposing challenge in working with faculty from the sciences and engineering. This paper is directed toward the review of strategies and resources that are now or could be used to meet this challenge. We will first provide a general perspective on faculty development practices, then specifically examine the developmental needs of faculty in the sciences and engineering. From a third perspective, we will discuss differences in faculty development practices at small and large, private (independent) and public (state-supported) institutions. Fourth, faculty development will be discussed as it has been conducted by regional and national higher education agencies. Finally, we will consider several ways in which faculty development has been supported by national-level funding agencies. We conclude the paper with a brief listing and discussion of eight recommendations to the National Science Foundation.

B. GENERAL PERSPECTIVES ON FACULTY DEVELOPMENT

Faculty development is not a new area of activity in American higher education, though it has taken on new dimensions and emphasis during the past decade. Traditionally, faculty development has been equated with faculty leave policies and sabbaticals, the allocation of funds for travel to conferences, the provision of support (financial, time, personnel) for research and scholarship, or the purchase of instructional equipment (audio-visual aids, teaching machines, instructional software for computers). None of these approaches has seemed to be satisfactory, given the changing conditions described above.

Faculty have been notably [illegible] to make use of instructional technological breakthroughs—even if they themselves are faculty in technological fields. As a result, some instructional technologists in the early 1970's began more actively to assist faculty in the design of instructional units or entire courses that effectively integrate the technologies that are available (Diamond *et al.*, 1975). In this way, the "instructional development" field began to expand and gain credibility. Though instructional development has generally grown independently of the faculty development movement, the two are now becoming interrelated and interdependent.

Many faculty and administrators have also become dissatisfied with the research and resource allocation programs. They want a developmental program that crosses disciplinary boundaries and emphasizes instruction and broad intellectual growth This attitude has been most forcefully and influentially articulated in a publication by Change Magazine entitled *Faculty Development in a Time of Retrenchment* (Astin, *et al.*, 1974). A summary description of the contents of this brief report conveys something about the field of faculty development in 1974

1. *The Need for Faculty Development*—Professional stagnation among American faculty is in danger of replacing faculty mobility. Wringing more out of declining resources makes adequate teaching supports on a major scale all the more essential to assure faculty development through the end of this century.

2. *Kinds of Reform*—Why some old devices to encourage good teaching don't work, and what strategies may be used to achieve substantial improvements in the quality of college teaching. Some practical and reasonable departures from current practice can substantially enhance the professionalization of teaching.

3. *Teaching as a Performing Art.*—Teaching, unlike research and publishing, remains very much a private professional act, rarely open to collegial scrutiny. Effective teaching remains a stepchild in the hierarchy of academic goals and values. It could be greatly improved by opening up the process to sensible and substantive criticism.

4. *Knowledge About Learning.*—Self-reflectiveness about the processes of teaching and learning can become a viable instrument for teacher and student alike. Such awareness is rarely present today An institutionalized intellectual concern for the nature of learning may represent the last remaining bit of common culture in the modern, diffused multiversity.

5. *Training Future Professors.*—Few graduate schools prepare their students for teaching in any practical sense, leaving classroom performance largely to change. A new teaching practicum, new teaching degrees, and the encouragement of intellectual work directed toward the classroom are some devices to upgrade current teaching effectiveness

6. *Campus Programs on Teaching.*—Most campuses suffer from an anemic pedagogical culture. New institutionwide programs for teaching would counteract the present undernourishment. Campus teaching institutes may be one remedy. If they are carefully planned, such teaching centers can produce a number of benefits of long-range significance both to participants and institutions.

7. *The Role of Experts.*—Pedagogic development through teaching institutes may be further enhanced by teaching consultants from the outside, used in a suitable mix with the campus faculty. Expertise in this area should be utilized wherever it is available.

8. *Evaluation for What?*—The great game of grading offers relief from the ambiguities of learning, but the two should not be confused. Good learning presumes a vulnerability, which grading as a sorting-out process often prevents. A separation of the two is possible, with third-party assessment of both students and teachers performed in an atmosphere of confidentiality.

9. *Grants for Teaching.*—National resources for enhancing pedagogical competence are woefully lacking, and grants should be provided similar to those given for research. The dual hierarchy of quality teaching and intellectual work and research needs to be legitimated, with grant dollars attached to both.

10. *Intellectual Mobility.*—It is harder to improve an existing job than to move to a new one, but diminished faculty mobility may provide opportunities for inplace enhancing of professional competence. Multiple professional identifications, rather than identification only with one's own discipline, is a break with academic traditions that would provide networks of interests and intellectual integration.

11. *Mid-Career Transitions.*—Providing insurance mechanisms to allow mid-career transitions into nonacademic work could make a very large difference to academic institutions in the late twentieth century. Intercampus faculty exchanges and provisions for mixing academic with nonacademic employment would also enhance academic performance in a period of contraction.

12. *Ways to Begin.*—Seven key recommendations, and a discussion of how they would work. Strategies on how to begin revitalizing campus teaching, their hazards and their pay-offs. If the sixties was the decade of growth, the seventies and eighties can well become the decades of resourcefulness.

1 Colleges and universities should organize regular campus programs on teaching coordinated by an institute . . .
2. . . the campus institute (at universities which grant advanced degrees) should supervise a teaching practicum undertaken by graduate students in the course of their work for the Ph.D. or other degrees that lead to work in college teaching.
3. Graduate students should be able to have their teaching officially evaluated for the record by methods that aim to be as sophisticated as those used to judge their scholarship . . . Entirely separate from these official evaluations, the teaching institute should provide confidential assessments of work done by graduate students and professors alike.
4. . . . college students should be graded for the record by people other than their own teachers.
5 Professors should have access to small grants for special teaching projects.
6. Institutions should loosen the present monopoly departments now hold over both professional time and the "fields" of knowledge.
7. In mid-career some professors develop nonacademic ambitions, want to switch to another field within academic life, or become

> disinterested in teaching . . . we need a system of insurance for mid-career changes . . .

These recommendations, while valuable, are incomplete. They inadequately touch on the significant personal and organizational changes that must accompany or even precede significant changes in the teaching and learning processes of a college or university. Furthermore, since most collegiate institutions no longer are hiring many new faculty, an emphasis on the development of graduate students as teachers may be misplaced. attention should be directed toward those faculty who are now teaching and will be teaching for another twenty or thirty years.

An effective program for faculty development must be respectful of three different strategies for change (Lindquist, 1977). (1) the creation and demonstrated applicability of new knowledge (research and development) (2) the creation of channels for the dissemination of this knowledge (social interaction) and (3) the establishment of conditions within organizations that promote the effective use of new knowledge (problem-solving). Specifically with regards to faculty development, some programs should emphasize research and development: the study of instructional processes in the college classroom or a test of new approaches to the improvement of instruction. Typically, this type of faculty development program resides in an institute at a prestigious, research-oriented university. This dimension of planned change is fully compatible with the rational and empirical norms and mission of American higher education, hence is readily accepted by most faculty and administrators. In isolation, however, this strategy will have only limited impact on the daily professional lives of faculty.

A programmatic emphasis on the dissemination of new knowledge usually involves workshops and conferences where faculty are brought together to hear about or discuss new ideas and experiences, or networks through which faculty are linked with relevant and knowledgeable resources (people, books, programs). While this strategy for change is essential if faculty are to be kept informed and intellectually alive, it does not adequately address the problem of use: how does a faculty member employ these ideas, experiences, or resources back in the classroom or laboratory?

The third strategy, problem-solving, primarily touches on the process rather than substance of change. how can we create settings in which new ideas and the experiences of other people become readily integrated into the life of an organization or institution? Faculty development programs can employ this strategy by training faculty in the use of new methods, helping an academic department prepare for a major instructional innovation or determining why a curriculum committee is unable to take action on a new plan. This third dimension is essential to significant planned change, yet it is not sufficient. Without the other two strategies, there are no new ideas to be used by a college or university in confronting changing student needs and societal conditions. One must, therefore, create a faculty development program which links and integrates research, development, dissemination and use.

At a somewhat more specific level, several different sets of strategies and components for faculty development programs have been identified. Bergquist and Phillips (1975) listed eleven such strategies (See Appendix B):

1. *Training*. giving faculty new skills that can be used in the performance of specific tasks, like teaching, or in the accomplishment of change itself.
2. *Consultation:* assisting faculty to define a problem, to discover resources to use in solving this problem, to use these resources and to evaluate the effectiveness of the problem-solving effort.
3. *Personal and organization development:* helping a faculty member to plan for and manage change.
4. *Method-promotion:* encouraging faculty to use specific instructional methods or technologies.
5. *Instructional design:* helping faculty to plan for and implement new instructional programs.
6. *Equipment:* providing faculty with new resources for instruction.
7. *Discussion:* providing a setting in which faculty can readily talk about their teaching.
8. *Evaluation:* developing and/or administering instruments for the assessment of instructional performance by faculty.
9. *Reward systems:* developing a policy for equitable and objective assessment of job performance, a set of resources for improvement of performance and tangible rewards for the improvement.
10. *Career transitions:* helping faculty to move to a new discipline or job outside higher education, and
11. *Comprehensive institutional development:* coupling faculty development with other programs that assess and/or confront the needs of the institution.

Several other attempts have also been made to identify the diverse activities that comprise a faculty development program. David Brown and William Hanger (1975) offer a list of 142 self-development activities that can be employed to "stimulate the faculty members and to strengthen the institution" (See Table 1). John Centra (1976) identified forty-five faculty development practices when constructing a survey questionnaire for the determination of frequency and effectiveness of these practices (See Table 2).

In a somewhat more systematic manner, Sikes and

Barrett (1976) classified faculty development practices on the basis of level and type of activity (See Table 3). They identified three different levels: personal/individual, interpersonal/group and intergroup/organization. The types of activities include: facilitative/process (helping faculty improve the way they relate to one another, students or other members of the institution), structural/technical (providing faculty with time, space or physical resources), expert/knowledge (giving faculty new and more information) and research and development/demonstration (generating new information or proving the validity of existing information).

Another systematic listing of activities (See Table 4) has been provided by Bergquist and Phillips (1974, revised: 1976) based on their three-fold distinction between instructional (professional), personal and organizational development (See further: Appendix A). This list recently has been updated (See Table 5) to incorporate a broader list of activities and to reflect the observation that some of the most effective faculty development practices incorporate a community development approach to change (See further: Appendix D) or involve change at an institutional or multi-(meta)-institutional level (See further: Appendix C).

What do these various lists and categorizations tell us about faculty development? First, they tell us that faculty development is many different things, and therefore is difficult to clearly define or label. These lists also tell us that we now have a rich source of ideas and learnings from which to borrow when confronting complex institutional problems. Because of the disorderly condition of these sources of information about how to effect faculty growth and development, we are faced with the difficult task of training faculty (and administrators) to become practitioners of faculty development in our colleges and universities: Trial-and-error learning no longer seems appropriate, for we are no longer ignorant about how to do faculty development. We cannot yet be sure, however, about how a faculty development practitioner can best be prepared to meet a diversity of conditions and needs. At this point, practitioners face the prospect of continuing—though not substantial—support for faculty development activities Several years ago, Jerry Gaff (1975) described the current and ideal status of faculty development programs (See Table 6). His conclusions still seem to hold true: there are significant discrepancies between current and ideal conditions.

In several ways, the National Science Foundation can help sustain and expand the developmental services offered to faculty in the sciences and engineering. In setting the context for these recommendations, we will first identify those needs of science and engineering faculty and different kinds of colleges and universities that appear unique and require specialized faculty development practices. We then will examine the support of faculty development activities by regional and national agencies.

C. FACULTY DEVELOPMENT IN THE SCIENCES AND ENGINEERING

Generalizations about faculty in the sciences and engineering are not easily drawn given the great diversity to be found among these faculty in instructional and professional goals and concerns When contrasted with faculty in other areas of academic life (for example, the humanities and arts), however, science and engineering faculty do seem to share certain characteristics, problems and sources of gratification.

Perhaps most important, there is a dominant concern among faculty in the sciences and engineering about the content of their discipline. These faculty face a constantly changing discipline, as knowledge continues to explode and new areas of specialization emerge. Whereas a faculty member in literature can at least "get by" teaching a course on Shakespeare without having read anything new in the past five years, a faculty member in physics, biology, psychology or electrical engineering would be unable to remain inactive for even one year. Thus, scientists and engineers are forced to keep up in their disciplines. This dominant concern yields several important implications.

First, in order to keep pace, many faculty in the sciences and engineering attempt to become increasingly specialized—learning more about less. In small colleges and teaching-oriented universities, however, the luxury of specialization cannot be afforded. Faculty must be generalists—they are responsible for introductory courses, and in recent years often primarily provide service courses for students who are majoring in other disciplines or are preparing for a profession (medicine, social work and so forth). The task of keeping up for these faculty becomes even more difficult; many faculty must resort to reading the latest edition of an introductory textbook in order to keep abreast of new developments in their discipline. There should be better ways for a faculty member to remain knowledgeable in his field. The traditional delivery systems for new knowledge (annual conventions, journals) apparently are not adequate for keeping faculty up-to-date.

In the minds of many, there is an appropriate sequence to specific disciplines (e.g., mathematics); students need to learn certain information, in certain sequences, in order to become satisfactorily prepared for work in the discipline. If students don't acquire a very specific background in a course then they will not be able to advance to the next course in the sequence. Thus, there is little room for educational innovation or freedom of choice among students in the order and manner in which they learn new material.

During the 1970's, the emphasis on time-shortened degree programs, such as those advocated by the Carnegie Commission, were viewed with great apprehension by many science and engineering faculty. A full four or five years are needed to adequately prepare a professional scientist or engineer. Similarly, these faculty now tend to resist a reemphasis on the liberal arts and an expanded core curriculum. This trend represents an intrusion into the essential curriculum of the sciences and engineering.

The third implication of the emphasis on content concerns the dominant role played by the disciplinary organization and by prestigious researchers and scholars in the field. These are not only the primary sources of new knowledge, and primary disseminators of this new knowledge, but are also the legitimizers of instructional innovations. If one examines the major changes in the teaching of science or engineering during the past decade, one finds that these changes have usually been supported by one of the major disciplinary associations and/or by one or more faculty members at major research-oriented universities who are held in esteem by faculty in the field. Typically, a successful researcher becomes interested in science or engineering education. He gets a large grant to try out a new (or unacknowledged) instructional innovation. Other faculty soon pick up on this innovation—usually through attendance at a national conference—and try it out in the classroom or laboratory. Faculty development must be supported by major leaders in the field and by disciplinary organizations if it is to be successful.

Fourth, the dominant concern for keeping up-to-date in the discipline has generally led to a neglect of instructional and interdisciplinary issues—the major thrust of faculty development in the mid 1970's. As a result, faculty in the sciences and engineering have generally been less receptive to faculty development than have been faculties in many other fields. Many of the disciplinary organizations are only now beginning to ask the basic questions about the need for and goals of faculty development (questions that were asked several years ago in many other disciplines). The American Association for Engineering Education, for instance, is only now beginning to organize a committee on faculty development. Much of the work that could be described as faculty development in the sciences and engineering can be attributed to the National Science Foundation.

Finally, the emphasis on content seems to either attract or create a certain type of student/teacher relationship. Both students and faculty are primarily interested in content: a search for information and "truth" rather than alternative perspectives and relativistic analyses. In general, the students are not being taught—nor seem to want—open-ended material. Below the senior or graduate level, problems are presented which usually have a right and wrong answer. Students are taught to view problems in a specific way (the "scientific method"). If a problem cannot be viewed in this way, it is ignored. In a very real sense, faculty in both the sciences and engineering are engaged in skills-training. Students want to be told, rather than discover (though this feature is certainly not unique to science and engineering education).

Science and engineering faculty also tend to be oriented toward the analysis rather than synthesis of the content they are conveying: students learn to study and understand the pieces or components of a phenomenon without necessarily being able to recognize and appreciate the phenomenon in its totality. A majority of scientists seem to be convinced of the objectivity of science, while often failing to recognize its subjective aspects. As a result, faculty and students often fail to view their discipline in the relativistic context of history and culture (Kuhn, 1962).

During the past five years, this perspective has been increasingly challenged by the "new" and "nontraditional" students: minorities, women and older people. These students are often viewed as ignorant, ill-prepared or ill-equipped by the faculty, for they tend to view scientific or engineering problems in different, and often broader, contexts. Even scientists and engineers who are returning to campus for continuing education are often viewed with suspicion (and fear) by the faculty. In general, faculty teach most effectively to the same kind of student that they are. As the student population becomes more heterogeneous, faculty must become increasingly concerned with instructional and attitudinal issues, thereby at least temporarily abandoning their dominant concern for the rational and objective accumulation of knowledge in their field.

A second major area of unique concern to faculty in the sciences and engineering concerns the purchase, use and justification of equipment for research and instruction. Quite clearly, education in the sciences and engineering is more expensive than education in most other fields. As in the case of the performing arts, the sciences and engineering often require small student-faculty ratios; in addition, however, they require laboratory equipment and supplies, laboratory assistants, space that cannot readily be converted for other purposes, and lengthy class periods. A comparison with the course on Shakespeare can again be drawn: Shakespeare can be taught almost anywhere, at very little cost (a copy of the work), whereas most courses in the sciences and engineering can be taught in only certain settings, at considerable cost. Several implications arise from this condition.

First, faculty in the sciences and engineering must justify costs of instruction by demonstrating that this instruction yields significant benefits. While these benefits were rather easily demonstrated and accepted in the post-Sputnik era, they no longer are—especially given declines in student enrollment in many of the sciences and engineering, and declines in the demand for new practitioners in some fields.

The costs of instruction requires that science and engineering faculty be able to clearly document the success of their students in acquiring essential competencies in the field. Furthermore, science and engineering education (particularly the latter) are uniquely accountable to the professions for which students are being prepared:

the professional associations have a definite say about the content and process of instruction. Thus, faculty in the sciences and engineering must be able to demonstrate benefit to not only the college or university community that is worried about high costs, but also the professional community that is worried about the quality of new entrants into the profession

The teaching scientist or engineer must confront a second equipment-related problem as well. Sophisticated research equipment could be used for instructional purposes. However, for whatever reason faculty members lack the use of theory in applying these pieces of equipment to instruction. Frequently, faculty do not know how to design an effective laboratory experience. They fall back on "cookbook" approaches to laboratory education that teach a student how to follow instructions, but do not teach him how to think or solve problems. Faculty must be provided with opportunities and resources to learn about alternative approaches to laboratory education (for example, individualization of laboratory education through the use of audio-tutorial devices) and the instructional use of equipment (for example, the use of computers to simulate laboratory experiences).

As a means of reducing instructional costs for laboratory education, many colleges and universities have reduced the number of hours credit that faculty receive for conducting or supervising the laboratory. As a result, many faculty do not have adequate time to prepare for the lab or must assign most laboratory work to undergraduate or graduate teaching assistants. The reduction in institutional support for laboratories often is interpreted as a depreciation in the value of this type of learning. Consequently, the science and engineering laboratory has become a "second-class citizen" at many colleges and universities.

High instructional costs have also restricted the type of institution that can offer instruction in the sciences and engineering (especially the latter) An engineering faculty is necessarily rather large, for the capital investments required for a minimal laboratory can only be provided if the program will accommodate many students. Similarly, many of the laboratory sciences cannot be adequately serviced in small colleges One of the unfortunate side effects of this restriction is the absence of science and engineering faculty in those environments (small colleges) which are most conducive to interdisciplinary dialogues among faculty as well as a pervasive concern for the integration of values and course content—two areas of development which are clearly needed in many of the sciences and engineering.

Small colleges must be given assistance in finding the capital resources for development of science and engineering programs. We must find new ways, as well, of reducing laboratory costs (for example, through use of laboratory facilities in industrial settings) or of integrating or exchanging the resources of small and large collegiate institutions (for example, faculty exchanges between small, liberal arts colleges and large, research-oriented universities).

A third area of unique concern for faculty in the sciences and engineering relates to their professional self-definition First, many faculty in these fields quite rightfully view themselves as being at the top of the academic pecking order. These disciplines (especially the physical sciences) are usually viewed with respect by colleagues in other fields The science and engineering faculty member often feels that he could master any other field with the tools of his current discipline. Members of other disciplines borrow terms from the sciences and engineering to gain respectability for a concept. Students in the sciences and engineering are usually viewed as more "serious" and are generally regarded as "better" students than are those enrolled in other majors.

Being at the top of the heap, many scientists and engineers seem unwilling to risk alternative approaches to instruction or interdisciplinary studies. Furthermore, many of these faculty reached their creative and productive peak in the early 1960's. They are still relatively young men and women (40–50 years of age), yet perceive themselves as being on the decline in their professional lives. While many faculty in other fields are similarly past a period of peak production and creativity, this fact is not as obvious or painful, for they have not known a position of high esteem in the academic community as have the science and (to a lesser extent) engineering faculty.

Faculty in the sciences often do not perceive themselves to be teachers, but instead view themselves as scholars or researchers: they tend to identify themselves as "cellular physiologists", or "developmental psychologists", rather than as "faculty members", "teachers" or "educators." Faculty in engineering, as in other professional training programs, tend also to perceive themselves as members of the profession rather than as members of the higher education community. Since they usually sacrificed salary and even prestige to become teachers, however, the engineering faculty often seems to be more amenable to concerns about instruction than are their colleagues in the sciences.

While this last feature—the self-definition of faculty as members of a discipline—is not unique to science and engineering education, it takes on new significance when coupled with the previously-discussed features. To the extent that faculty in the sciences and engineering are concerned about instruction, they tend to be concerned about mastery of content that they are teaching or about obtaining adequate financing to keep a laboratory program afloat. These concerns could translate into significant instructional innovations, yet such innovations usually require support from those faculty and disciplinary organizations that are primarily oriented toward research and scholarship. A faculty development program in the sciences and engineering must be responsive to these complex conditions by being respectful of traditions and the disciplines, yet seeking to establish a new awareness of and support for the broader, interdisciplinary issues of teaching and learning.

If we examine the faculty development activities that are currently found in the sciences and engineering several of these unique features become even more apparent. First, most faculty development for scientists and engineers has been provided through a program specifically designed for faculty in these fields. Furthermore, faculty in the sciences and engineering generally have not been among the most active participants in these campus-wide programs.

Second, as one might expect from our previous discussion, most of the faculty development programs specifically for the sciences and engineering focus on content updating within the discipline (for example, the NSF Chautauqua conferences) or on the use of new instructional designs or technologies (for example, Postlethwaite's program at Purdue University for the training of science faculty from throughout the country in the use of audio-tutorial procedures). There has been much less concern about the diagnosis and improvement of instructional skills, the examination of faculty attitudes about instruction or career development, or the improvement of departmental or program planning and implementation to effectively accommodate instructional innovation.

Some of the most significant and thoughtful innovations in science and engineering education have failed not because the idea was without merit but because the idea was not effectively introduced into the institution and/or because the faculty who were to employ this innovation were not brought into the process at an early point or were not effectively prepared for the use of the innovation. Appendix E contains a case history of just such a failure: the discontinuation of a new PSI program in the introductory physics courses at the Massachusetts Institute of Technology. Alternative approaches to faculty development in the sciences and engineering must be explored and integrated with concerns for content and instructional design.

D. FACULTY DEVELOPMENT IN DIFFERENT TYPES OF INSTITUTIONS

Just as there are important differences in the developmental concerns and needs of faculty in the sciences and engineering as compared to faculty in other disciplines, so there are significant differences among faculty in different types of colleges and universities. We will be able to touch on only a few of these distinctions. A volume now being written by several of the authors of this report will describe these differences in more detail.

The most important difference seems to be between faculty from small and large institutions, regardless of whether or not the institutions are public (state-supported) or private (independent). First, in the small college there is usually a greater sense of community than is found in the large university. There is often a greater sense of alienation and "commuterism" among faculty in the larger universities. Conversely, more resources are available to faculty in the large university, and these faculty are exposed to more diversity and are usually freer to explore their own individual interests and concerns. Faculty in the small college are more likely to be isolated and parochial in their intellectual and instructional perspectives. There is also a greater chance for conformity and stagnation among faculty in the small college. While faculty in large universities are more likely to experience anomie, small college faculty are more likely to sense an invasion of privacy.

In general, there is a greater potential for programmatic or institutional change in the small college: faculty development can and often has made a significant difference in the lives of faculty at these colleges. On the other hand, the individual faculty member in a large university can usually "get away" with more than can the small college faculty member, especially if he is tenured. He also has more resources and expertise available to make this change successful than does the faculty member in the small college. In the large university, one finds that faculty development usually has only sporadic and unpredictable impact on faculty who are often already involved in innovation and instructional experimentation.

A comparison between independent and state-supported institutions reveals several important differences among faculty. The independent college or university often has a clearer sense of mission, especially if church-related, than does the state-supported institution, which must be responsive to multiple constituencies. As a result, faculty in independent institutions usually have a somewhat clearer sense of what is expected of them and what they should do to improve the quality of teaching and learning at the college or university. A clear mission statement also allows these faculty (and administrators) to more readily bring about significant curricular or institutional change.

Secondly, the independent college or university is generally more amenable to an integration of values and education, or personal and professional needs and interests. The state-supported institution must be more sensitive than the independent to diverse values-systems in the community. To the extent that faculty development involves the exploration of educational values and/or the exploration of personal dimensions in one's professional life, the independent college will generally be more supportive of faculty development, and the environment of this college more conducive to this type of service.

The state-supported college and university must generally be more responsive to the changing needs of students and society. The state or community college usually must be open to a more diverse student body than the independent college. As a result, program and curricular offerings must be more diverse at the state-supported institution. These colleges and universities are also more directly accountable to off-campus constituencies: disciplinary associations, business interests, union interests, legislators, judges and so forth. Both public policy and governmental regulations also have a significant impact on the programs and curriculum of a state-supported institution—though independent college and universities certainly are not immune to these policies and regulations.

These differences between independent and state-supported institutions yield something of a paradox. the state-supported college and university faculty probably are more in need of professional developmental services since these institutions are more vulnerable to pressures for change and renewal; yet, conditions in the independent college and university are more amenable to faculty development and faculty in these institutions are generally more supportive of this type of activity.

Given the problems and potentials associated with faculty development in each of these different types of institutions, it is essential that regional and national agencies cooperate in their provision of services to these colleges and universities. An increased sharing of expertise and resources between small and large, independent and state-supported institutions cannot help but be of benefit to all members of the higher education community. We now turn to an examination of these and other services that can be provided in the area of faculty development by regional and national agencies.

E. FACULTY DEVELOPMENT THROUGH REGIONAL AND NATIONAL AGENCIES

The role played by any regional or national higher education agency in the area of faculty development is necessarily limited, for the integrity of the institution and the autonomy of the individual faculty member must be respected. Staff or consultants representing a regional or national agency should rarely work in the classroom of an individual faculty member—unless for demonstration purposes. This type of on-site consultation should be provided by colleagues or an in-house specialist. Similarly, a regional or national agency representative should rarely be involved in on-going work with faculty on personal, career or organizational problems outside the classroom, unless, once again, this service is being provided for demonstration purposes (a notable exception is the excellent career-counseling done by Fred Gaige when he was a member of the staff at the Kansas City Regional Council for Higher Education).

A wide variety of activities and services, nevertheless, are still open to a regional or national agency. We have identified eight such activities or services: (1) providing direct consultation to college and universities on broad organizational or institutional issues, (2) providing intensive residential workshops for faculty from two or more institutions, (3) helping to arrange for inter-institutional exchange or sharing of human or physical resources, (4) assisting a college in planning for and implementing a faculty development program, (5) training faculty or administrators from colleges in the use of faculty development methods and instruments, (6) providing conferences and workshops on topics of common interest to faculty from several colleges, (7) helping colleges to evaluate and disseminate learnings from an on-going faculty development program, and (8) conducting inter-institutional research projects to further the higher education community's general understanding about teaching and learning, and faculty growth and development. Following is a brief description of each type of activity with one or more examples of a program of this type being conducted by a regional or national agency.

While individual consultation with faculty on a campus is usually not appropriate, a regional or national agency can be of significant assistance in providing consultation to an academic department or division, a program staff, a faculty committee or even an entire faculty. At the College Center of the Finger Lakes (CCFL) in Corning, New York (a consortium of small, independent colleges) this type of organizational consultation has been offered by both staff and consultants with considerable success. In many instances an external person can provide more effective and objective consultation on problems that involve many people in the institution than can an internal person.

This type of service may be more appropriate for a consortium than a national higher education association or funding agency; however, virtually any direct service by a national agency will inevitably involve some small or large group problem-solving (organizational development). The Council for the Advancement of Small Colleges (CASC) has effectively provided this type of service through its faculty development mentorships (See Appendix F) and its Title III Comprehensive Institutional Development program (the Small College Consortium). The national-level Strategies for Change and Knowledge Utilization (SCKU) project, which was funded by the National Institute for Mental Health in the early 1970's, also provided direct organizational development consultation to participating colleges (Lindquist, 1977).

Perhaps the most successful activity provided by inter-institutional agencies has been the intensive, residential workshop for faculty (see Appendix G for a description of this type of workshop). Several regional consortia offer this service: CCFL, Great Lakes College Association (midwest colleges) and the Seattle Area Faculty Development Consortium (newly-formed group of small, independent colleges and large, state-supported universities). At a national level, CASC, the Project for Institutional Renewal through the Improvement of Teaching (PIRIT) (Jerry Gaff, Director; Washington, DC) and the Association for Innovation in Higher Education (Edward Stevens, Director, St. Petersburg, Florida) offer week or two-week long workshops that faculty attend to improve their own teaching as well as gain new skills as faculty development consultants.

This type of workshop is most effectively initiated by a regional or national organization, for such an agency is uniquely able to bring together faculty from a variety of institutions, develop a cost-sharing process that significantly reduces per-institution expenses, and attract major, national consultants. The intensive, residential workshop is one of the few services that such an agency can provide which will have a tangible and personal impact on individual faculty members in their daily professional lives. If such a workshop is followed up with on-campus services being provided by local resources, then the impact of the intensive workshop can be even further amplified.

One of the traditional and certainly most important activities which regional and national agencies in higher education can provide is the promotion, planning and implementation of programs for the exchange of human and physical resources Many consortia have provided mechanisms for the exchange of faculty, student credit hours or equipment across campuses. Cooperative inter-campus programs have also been established that further the development of both students and faculty. CCFL, for instance, offers courses in the Bahamas on such topics as marine ecology, field archeology and the cross-cultural study of values. These courses could not have been financed by any one of the CCFL colleges.

CASC has recently initiated an inter-campus exchange program which will even more effectively promote faculty, as well as student learnings. Several times per year, CASC will offer an experimental college that is created for a short period of time (two weeks to two months) then is dissolved. The learnings of faculty (from CASC colleges) who will teach in the experimental college are as important as the learnings of students (also recruited from CASC colleges). The CASC Experimental College becomes a testing ground for new curricular ideas or a training ground for the development of new instructional skills. Students will serve not only as learners, but also as diagnosticians, co-designers and evaluators. The Experimental College faculty, in collaboration with other members of their home college, will develop a plan for the on-campus dissemination and use of learnings from the experimental college.

Several national agencies have supported the creation of networks for the dissemination of information about human and physical resources, thereby promoting the exchange of these resources and faculty development in general. NEXUS (American Association for Higher Education: AAHE), Resources for Planned Change (American Association of State Colleges and Universities) and the National Consulting Network (CASC) exemplify this approach.

The fifth service, assistance in planning for and implementing faculty development programs, has been provided by many national associations. AAHE offered a series of national and regional conferences on faculty development in 1974 and 1975 which served as catalysts for the faculty development movement in subsequent years. CASC and PIRIT provide not only national conferences, but also on-campus consultation to colleges in their design of faculty development programs. A national agency can provide a staff member or consultant who not only holds a detached perspective about the needs and resources of the college or university, but also can bring prestige (legitimization) and insight from knowledge of numerous other faculty development programs.

While assistance in the planning and implementation of a faculty development program can be of value, a regional or national agency can be of even more help if it assists in the design and implementation of a training program for faculty development practitioners. The state-of-the-art, as noted above, is sufficiently advanced (though disorganized) that a new practitioner can make significant use of existing knowledge in the field and training in skills associated with faculty development. CASC has offered an extensive training program for forty-five faculty from CASC colleges (See Appendix F for a brief description of this program). Other training programs are now available through the Professional and Organizational Development (POD) Network for Higher Education (Mary Lynn Crow, Director, University of Texas at Arlington) and, to a more limited extent, the NTL Institute (Washington DC). Training programs of a more specific nature (instructional design and development) are offered by Syracuse University (Robert Diamond, contact person) and Michigan State University (Larry Alexander, contact person).

A national association or funding agency can influence the quality of professional development services for faculty through a training program. Extensive evaluation of the CASC training program reveals that faculty and administrators at the participating colleges tend to respect the newly-acquired knowledge and skills of the faculty trainee and make effective use of this person. CASC also discovered that it was able to have a significant impact on the teaching-learning processes at many of the participating colleges.

Another faculty development service which many regional and national agencies provide is the conference or workshop on a topic of interest to faculty from several different institutions. CASC, for instance, has offered a series of regional and national conferences on curricular reform which have been attended by CASC college faculty. The NSF Chautauqua conferences also fit into this category, as do the regional curricular conferences conducted by AAHE under the sponsorship of the National Endowment for the Humanities (NEH). Both the NSF and NEH conferences have been particularly successful because they are regional and reflect the current interests of faculty.

The final two services to be described concern the promotion of research and development activities in the field and the establishment of effective vehicles for the dissemination of learnings from these activities. First, a regional or national agency can help a college or university evaluate and learn from its faculty development program. CASC has provided "illuminative evaluation" (Parlett and Dearden, 1977) services to twenty-eight of the colleges participating in its Advanced In-Service Faculty Development Program. This "formative" model of evaluation focuses on what the impacts of the program (expected or unexpected) have been and why they occurred, rather than on the issue of whether or not a particular desired outcome has occurred. Jerry Gaff and consultants to the PIRIT project are providing similar services to participating colleges through the provision of expert advice on evaluation design and instrumentation, and on-campus interviews with key administrators, faculty and program participants.

A regional or national agency can also help a college or university disseminate its learnings about faculty development through many different forums: national or regional conferences, publications, resource networks, intercampus exchange of program participants and/or faculty development practitioners, short-term consultations at other colleges by members of the program staff, low-cost off-campus consultation (via telephone or satellite-transmitted closed-circuit television), or a training-of-practitioners program.

Finally, the promotion of faculty development services can take place if a national agency supports, sponsors or funds an inter-institutional research project on faculty development. The most notable project of this type to date is SKCU. Jack Lindquist and his colleagues studied planned change and knowledge utilization at more than a dozen colleges and universities of widely divergent size and character, in order to derive general principles concerning these processes. Such a project, of comparable scope and with an equally talented staff, is needed to study faculty development practices. A recent ETS project, conducted by John Centra (1976) and sponsored by the Exxon Foundation, represents a first step in this direction, but certainly is not adequate as a final statement. Long-term longitudinal observations (even participant-observations) are needed to build on the Lindquist work. Such a research base would be helpful to on-campus practitioners, regional and national organizations and funding agencies as they plan for future directions in faculty development programming.

F. SUPPORT FOR FACULTY DEVELOPMENT BY FUNDING AGENCIES

At present, several general observations can be made about the role played by most national-level funding agencies in the promotion of faculty development efforts: (1) the funding agencies tend to provide funds for *projects*, based on the merit of the proposal, rather than for *people* or *organizations*, based on the past or potential ability of this person or organization to effect needed change in the institution; (2) the funding agency rarely intervenes directly in the life of the funded institution except to provide "summative" (judgmental) evaluations; (3) some funding agencies conduct or sponsor national or regional conferences on faculty development for the dissemination of information about funded projects, for the presentation of new concepts, or for the discussion of issues that are of concern to the agency; and (4) several funding agencies are becoming increasingly concerned about the dissemination and use of learnings from and products of faculty development projects that they have funded. We will briefly discuss each of these four general observations, then briefly discuss current NSF programs.

Virtually all funding agencies that currently support faculty development programs have primarily if not exclusively funded programs rather than individuals or organizations. Probably the most notable exception has been the Danforth Foundation Fellows program which provides individual faculty members with conferences and funds for the development of campus projects.

From research on diffusion-of-innovation (Lindquist, 1977) we know that people often are more important than ideas when it comes to implementing a new program. Funding agencies should therefore consider assessing the capacities of institutions or individuals to effect desired changes. If a person is at a critical point in an informal communication network, holds exceptional credibility with a certain faculty population, is skillful in understanding the complex dynamics of a specific kind of organization or institution, and/or is skillful in planning for or implementing a certain kind of change, then he might receive funds for a specific project or support (training, release time, assistance) for his current work. Alternatively, the foundation might support an apprenticeship program so that other people can learn from this individual, or an evaluator-researcher might be assigned to this individual to determine the nature of his impact and the reasons for his effectiveness. A similar case could be made for the funding of a specific college or university which is situated at a critical juncture in a knowledge dissemination channel (not necessarily at the entry point to this channel—as is usually the case with prestigious research-oriented universities).

A second general observation concerns the lack of direct intervention by the staff of funding agencies. While it is usually inappropriate for a funding agency to become directly involved in the daily operations of a program, it is equally inappropriate for the agency to limit its interventions to summative evaluations. The agency staff, or consultants to the agency, should be involved in formative evaluation: they should provide members of the program staff with observations, diagnoses, recommendations and hypotheses that can be of value in the improvement of the program.

The formative function enables members of the agency staff to gain a more accurate and detailed understanding of the program they have funded than is possible when they only read a yearly or final report of the program staff or when they make a summative on-site visit once a year. With more frequent, formative visits, the staff can become increasingly insightful about the processes of change and knowledge utilization on a college campus, thereby becoming more effective in the assessment of new proposals and, in turn, more effective in subsequent formative (and summative) evaluations of programs that are funded.

Formative evaluations of faculty development programs have been conducted for the Lilly Endowment by Malcolm Parlett (Parlett and Dearden, 1977). Using "illuminative evaluation" procedures, Parlett was able to provide the foundation and program staff with new insights into the dynamics of the program and its relationship to the milieu of the institution. This evaluative process might have been even more profitable if one or more members of the foundation staff had joined Parlett in conducting the evaluation.

The chancellor's office of the California State University and Colleges system has recently hired one of the authors of this report (William Bergquist) as a part-time consultant-evaluator for several innovative programs that it has just funded. Bergquist will provide evaluative services to the campuses while also being actively involved in helping each program staff plan for and design its innovative program. Members of the chancellor's office staff will occasionally work directly with Bergquist during his visits to the funded campuses, in order to learn more about the program, to add their own considerable insights, and to break down the typical isolation and alienation between a program staff and representative of the funding agency.

Our third observation, that national and regional conferences are fairly common faculty development activities of national funding agencies, reflects the dominant concern of these agencies with the dissemination of new ideas and innovations. Conferences and workshops are certainly an essential ingredient in any dissemination process, as are publications and demonstration projects. The most important step in a dissemination process, however, does not take place at a conference, in a book or on another campus; rather, it takes place on the home campus of the person who has heard about or read about the idea. This person needs help in developing and implementing strategies for effective on-campus dissemination. Funding agencies must become increasingly sensitive to this on-campus follow-up. By devoting part of a conference to planning for backhome implementation, the dissemination process becomes more effective. Low-key, on-campus or off-campus (telephone, closed-circuit television) consultation is often even more useful. There must also be increased concern for the problems of use, once the new idea or innovation has been disseminated—which leads us to the fourth observation.

Funding agencies are becoming increasingly concerned about the fact that many of the projects they support as experiments or demonstrations have not had a significant impact on programs at other colleges and universities. Among agencies that support faculty development programs, the Kellogg Foundation has probably done the most about this concern. This foundation has initiated a major program to assist the staff of successful faculty development projects (that Kellogg previously funded) with the effective dissemination and use of learnings from and products of these projects. The staff for this Kellogg program (headed by Jack Lindquist, University of Michigan) is trying to understand the ways in which new faculty development practices gain acceptance and become integrated with the ongoing activities of a faculty development program.

When we turn specifically to the National Science Foundation, several general observations can be made. First, the activities of NSF clearly reflect the dominant interest of science and engineering faculty in keeping up with their discipline and restructuring their courses. The TIAS program is oriented toward the preparation of young scientists in their discipline. The Chautauqua short courses are primarily concerned with new developments in the discipline and with new instructional designs. The CAUSE, ISEP and LOCI programs are primarily concerned with course or curricular redesign and/or with the use of new equipment or more effective use of traditional equipment.

Second, NSF programs are primarily focused on the professional development of faculty. These programs relate to faculty as instructors, researchers, and scholars, but seem to be less involved with personal and organization development aspects of faculty development. Only in the case of the Women in Science program does there appear to be a dominant concern for the more personal aspects of the science or engineering faculty member's professional life. There is also apparently no NSF program which deals directly with organizational and institutional dysfunction as it effects the faculty member's professional performance or the implementation of instructional innovations.

Third, the National Science Foundation has clearly opened the door to new and innovative approaches to the evaluation of programs it has funded. The 1977–78 program evaluation proposals that have been requested by NSF will hopefully meet the need for flexible and formative approaches to the study of a complex social process—faculty development. If the NSF staff can be actively involved in at least some of the formative evaluations, then potentially both they and the program staff will gain new insights into the nature of change and instructional innovation in contemporary colleges and universities.

G. RECOMMENDATIONS FOR THE NATIONAL SCIENCE FOUNDATION

In writing this paper, we have not viewed our primary task as being one of making specific recommendations to NSF. This would be presumptuous, given our lack of knowledge about the emerging goals and priorities of this agency. Rather we have tried to provide several different perspectives on faculty development which are suggestive of new program initiatives for the NSF The NSF staff and advisors must draw out those implications that seem most appropriate to NSF given its context and mission Several concerns, however, stand out as we bring this paper to a close. These concerns should be given serious consideration by NSF and should be directly related to NSF program initiatives and priorities We have summarized these concerns in the following list of eight program recommendations:

Recommendation One —In recognition of the influential role played by disciplinary organizations, we suggest that NSF encourage these organizations to experiment with alternative delivery systems (other than conventions, conferences and publications) for disciplinary updating The delivery systems might include video cartridges, audio cassettes (for home, office and car), satellite-transmitted closed-circuit television (now used for continuing education in medicine) and public television

Recommendation Two —The National Science Foundation should provide more support for those professional societies that are dedicated to education, for example, the American Association of Physics Teachers, the National Association of Biology Teachers, the Education Division of the American Chemical Society and the Association of Education of Teachers in Science These associations should be encouraged to explore new approaches to instructional development, to become acquainted with advances in the field of faculty development and to work more closely together A recent conference was held at the Wingspread Conference Center in Racine, Wisconsin, on the role of faculty development in the humanities (co-sponsored by the Johnston Foundation and the Society for the Study of Values in Higher Education) A comparable conference might be conducted on the role of faculty development in sciences and engineering (co-sponsored by NSF and the Johnston Foundation) Participants might include representatives from the professional science and engineering education societies as well as practitioners in the field of faculty development.

Recommendation Three —NSF should continue to sponsor research on educational processes in the sciences and engineering Educational research in the disciplines must gain more status It is entirely appropriate for a teaching-oriented college or university to sustain and encourage research on the educational processes of the institution. NSF support for some of the journals on research in science teaching might be helpful Perhaps of even greater value would be NSF support for articles on educational research that are published in the major, research-oriented disciplinary journals There must also be program initiatives that encourage non-traditional means for the dissemination and use of the findings from this research.

Recommendation Four.—Alternatives to the traditional sabbatical programs for faculty must be explored Faculty often do not want to leave their home town for a year, nor are sabbaticals very frequently found to be of significant value, unless carefully planned by both the faculty member and colleagues who might make use of learning from the sabbatical. Professional-growth contracts can maximize the value of the sabbatical. Shorter sabbaticals might be tried. For example, the one to two-week intensive workshops that are described above and in Appendix G, if carefully designed, can yield as significant an impact as the loosely planned semester or year-long sabbatical. Instead of a sabbatical a faculty member might be given support for an assistant to help out in the first semester of a newly-designed course or to evaluate the effectiveness of this new design.

Recommendation Five.—NSF can help faculty in small colleges and teaching-oriented universities to increase their self-esteem and be of increasing value to their community, by promoting their use in solving problems of the local region. In the State of California, for instance, small college faculty who specialize in horticulture could help towns to select plants for parks and roadways that need little water. Also, engineers could be used on a regional basis for designing solutions for rather local problems.

The small colleges and teaching universities that cannot afford expensive equipment might, in turn, be assisted by business or public service organizations that have equipment and laboratory space available at certain times for use by faculty and students. NSF could help get these exchange programs off the ground and sustain them for a year or two until logistical problems are solved, and mutual trust and credibility is established.

Recommendation Six.—NSF should consider a program for the training of faculty development practitioners in the sciences and engineering. Highly respected faculty from different kinds of institutions could be identified and recruited, based on their central position in a college, disciplinary association or informal communication network, their professional interest in science or engineering education, and their personal commitment to working actively with other faculty members. These potential practitioners, with demonstrated support from their home institutions, would be provided with training in a variety of faculty development practices (for example, instructional diagnosis and instructional design consultation) and would apprentice with another faculty member (mentor) from a comparable institution who has already become a successful practitioner. The training program should incorporate personal and organizational as well as instructional development practices.

Recommendation Seven.—NSF should help finance research on and discussions about the developmental needs and motivations of faculty in the sciences and engineering. We are still ignorant about these issues, and will never be able to adequately design faculty development programs to meet these diverse and complex needs unless we more fully understand them.

Recommendation Eight.—Over the next ten years, the greatest challenge that will be faced by faculty development practitioners, and other faculty and administrators who are interested in the welfare of faculty, is the design and implementation of programs for faculty who must undergo significant career transitions. There are at least five levels of change that many science and engineering faculty will face during the coming decade (See Table 7). While the first two or three of these levels can be handled within the context of current faculty development practices (with the assistance of an agency such as NSF), the last two or three levels require new programs and even new institutions.

Retraining institutes probably will have to be established independent of existing colleges and universities, for the politicization and resistance associated with a retraining program would immediately destroy or distort this very subtle process. The institute staff will have to develop or help a college initiate processes for the assessment of current and potential faculty resources and needs. If faculty are to be encouraged to shift disciplines (level four) or leave higher education entirely (level five), then their skills, aptitudes and interests must be assessed to determine which other disciplines or occupations might be most compatible.

Disciplinary and occupational retraining must incorporate rapid and highly efficient procedures for the acquisition of the essential knowledge and skills in the discipline or occupation; in addition this new expertise must be fully integrated with past experiences and expertise so that the faculty member might provide a distinctive and highly valued interdisciplinary perspective, as one who is knowledgeable in at least two fields. Disciplinary retraining should also include a series of sessions on course design and instructional methodology. Even though the faculty member might be able to use the same designs and methods that he used in his previous discipline, this retraining period provides an excellent opportunity for the faculty member to consider new instructional strategies and thereby become even more effective as a teacher and valuable to his new colleagues.

The institute must provide the faculty member (and family) with a supportive environment for the retraining process. Life and career planning and supportive counseling should be offered to those faculty who want or need it. The institute should be designed to maximize the faculty member's sense of self esteem, as well as the esteem that will be assigned to him by his new colleagues. The faculty member should be introduced to some of the most prestigious and exciting thinkers in the new field and should be encouraged to become a creative thinker in his new field (with the valuable perspective of his second discipline).

This type of retraining program will be very difficult to design and implement. Members of the institute staff will have to work closely with not only the faculty member who is being retrained, but also the academic department or new employer with whom the faculty member will be working. NSF should seriously consider the sponsorship of a demonstration program of this type for faculty in the sciences and engineering.

These eight recommendations represent some of the more interesting or particularly important directions in which NSF might move in its attempt to assist science and engineering faculty in their continuing development. Some of the recommended programs can be rather easily implemented; others, such as the last one on faculty retraining, will take considerable time and resources. Hopefully, some of these recommendations and recommendations that emerge from the previous general discussion will be both feasible and significant.

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Table One.—List of Faculty Development Activities*

TO FACULTY MEMBERS:

For an individual, the strategy is to change environments, to risk new exposures, to alter habitual patterns, to undertake new challenges.

Take on a new job temporarily:

1. Exchange within your college (a sociologist and a historian switch jobs for a term)
2. Accept a visiting professorship
3. Exchange with a departmental colleague in another college
4. Negotiate a three-way exchange (e.g., an economist from College A to B, a physicist from B to C, and a political scientist from C to A)
5. Exchange with business or industry (e.g., a professor of finance with a corporation's trust officer)
6. Exchange with a governmental agency (e.g., a geography professor with a state planning officer)
7. Exchange with a foundation (e.g., a professor of education with a foundation project director)
8. Accept a limited term appointment with business, government, or a foundation
9. Arrange a special administrative assignment within your college

Seek new patterns of interaction:

10. Participate in departmental colloquia
11. Participate in departmental colloquia outside your discipline
12. Attend Chautauqua-type short course programs
13. Audit courses in your field or cognate fields
14. Participate in improvement of instruction seminars
15. Enroll in a continuing education course
16. Team with a colleague for pure or applied pedagogic research
17. Enroll in a new degree program
18. Participate in national and state conferences
19. Organize and participate in luncheon sessions on the improvement of instruction
20. Share the first draft of research papers with colleagues at a departmental colloquium
21. Affiliate with a research institute on a part-time basis
22. Arrange a joint appointment with two departments and/or two separate institutions
23. Seek out professional colleagues familiar with objective test design, essay test construction, evaluation strategies, etc.
24. Make an item analysis of answers to identical examinations given to two classes taught by two different instructors.
25. Visit facilities on other campuses and invite them to your campus
26. Visit secondary schools
27. Organize a panel on career opportunities within your discipline
28. Develop a contract between the department and yourself on a specific area of personal development that you wish to pursue in the year ahead
29. Participate in consortia activities—teach through the consortium in other departments; write a grant proposal for support of a consortium project
30. Set up monthly meetings with practitioners in an area (e.g., the faculty of accountancy to visit with the personnel at a public accounting firm, the faculty of marketing to lunch regularly with the marketing department of department stores)
31. Join a committee about which you know very little, or resign from a committee that is not contributing to your growth or that does not find you offering new ideas
32. Schedule brown bag sessions to discuss life and careers of persons such as Benjamin Franklin
33. Sponsor a session at the professional convention on teaching techniques within your discipline
34. Enroll in an education vacation program
35. Form a group to view films or go to plays
36. Join a group to watch a prearranged series on public television
37. Attend the artists series on your campus
38. Make a concerted effort to attend 30 of the special lectures on your campus in the year
39. Participate in the "outward bound" program
40. Take an educational tour of your own campus

Read:

41. The professional disciplinary literature
42. The literature of higher education (e.g., *Educational Record Chronicle on Higher Education*, the Jossey-Bass series on New Directions for Higher Education, the "Yellow Pages of Undergraduate Innovations," "Innovative Improvements Within the C.I.C.," "Future Talk")

Write:

43. Submit a faculty development or grant proposal to an outside funding agency
44. Author a new degree program
45. Publish articles, monographs, books, book reviews, poetry
46. Form paper institutes that provide a mechanism for scholars from different disciplines to identify together in an interdisciplinary effort such as statistics, genetics, human development, ecology

Experiment while teaching:

47. Prepare to teach a new course in your discipline or in a cognate discipline
48. Team teach with a colleague or student
49. Utilize audio-visual support systems
50. Try one of the new teaching technologies (e.g., computer-assisted instruction, individually guided instruction, television, simulation, gaming)
51. Teach a continuing education course
52. Teach an in-service workshop for practicing professionals (e.g., teachers, business executives, lawyers)
53. Talk with booksellers and manufacturers about equipment and other new items available in your discipline
54. Take over a colleague's class in another discipline when he or she is away
55. Teach an innovative class during the summer such as a one- or two-week course in a residence hall, an inter-disciplinary summer session, an intensive

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*From: David G. Brown and William S. Hanger, "Pragmatics of Faculty Self-Development," *Educational Record*, 1975, 56, 201–206.

class in a particular discipline utilizing longer blocks of time

56. Teach a high school or grade school class for a few, days
57. Write and distribute to students behavioral objectives of the courses you teach
58. Redesign courses along the modular or sprint curricular pattern
59. Experiment with the lecture method of instruction if you are using the discussion approach, and vice versa
60. Learn a new nonacademic skill—painting, sculpture, photography, swimming; hiking, family camping, pert charting, small engine repair, the metric system, computer programming
61. Try the case study method

Develop advising skills:

62. Solicit current information about employment possibilities for students
63. Study counseling techniques and/or human development theories
64. Advise a campus group (e g., fraternity, political group, campus newspaper)
65. Invite a student to live with you for 24 or 48 hours
66. Live for two days with a student in his or her residence hall
67. Entertain students in your home
68. Interact with the professional advisers and counselors on your campus to learn the deterrents to success in the classroom such as differing life-styles, drug abuse, sexual conflict, domestic afflictions
69. Act as an adviser for registration, change or schedule
70. Develop an understanding of patterns of discrimination
71. Host a foreign student for a year
72. Relearn rules and regulations and curriculum options outside the department

Seek feedback:

73. Utilize student evaluations
74. Invite a media specialist to sit in on your class and offer constructive advice
75. Video-tape your instruction and have a group of peers evaluate it
76. Analyze how you spend your time
77. Ask each faculty member teaching a multiple section course to xerox lecture notes and share them with all other instructors in the same course
78. Develop a peer evaluation system with a few colleagues in your discipline or in another discipline

Serve:

79. Run for elective office
80. Serve on local and/or state governmental committees and councils
81. Pursue volunteer work with a hospital board or charity
82. Consult
83. Serve on a national or international commission such as the White House Conference on . . ., a United Nations Conference on . . ., or the Carnegie Commission on . . .
84. Participate in academic fairs, workshops, or other activities for secondary and elementary schools and counselors
85. Explain the university to groups of parents
86. Prepare recruitment materials and publications
87. Agree to assist in the norming of exams such as CLEP subject matter exams
88. Serve on accreditation teams such as North Central, NCATE, etc.
89. Call on perspective donors of gifts and bequests, asking for time, money, equipment, artifacts, etc.
90. Lead a group to Europe, Mexico, Asia

Utilize your summers:

91 Attend a summer research institute
92. Intern in business or industry
93. Apply for a summer research grant
94. Take a leave without pay to travel
95 Work at another profession

TO ADMINISTRATORS:

For a college or university the strategy is to reinforce, motivate, and enable self-development:

96. Introduce a resolution to your university senate on faculty development as a faculty right and responsibility
97. Establish a faculty committee on the improvement of instruction—which can in turn develop a visiting scholar program (campus hosts eminent scholars for a week), research grant programs (zero teaching load assignments), administrative internship programs, outstanding teacher or master teacher programs, and faculty exchange guidelines
98. Provide person power to support faculty enrichment colloquia, in-house seminars and conferences on the improvement of instruction; graduate seminars on the improvement of instruction, colloquia with newly hired faculty sharing new insights on disciplinary and pedagogical topics
99. Establish a program which causes faculty to become aware of instructional resources on campus such as the audio-visual facilities, the business computation laboratory, the music listening center, the instrumentation laboratory, the speech and hearing clinic, the language laboratory, the micro-teaching laboratory
100. Organize a program and invite faculty colleagues to participate in "know your registrar's office," "Know your admissions office," "know your physical plant"
101. Sponsor an all-faculty workshop immediately prior to the beginning of the fall term
102. Ask each department to sponsor a "two-hour discipline" specifically directed toward faculty colleagues in other disciplines
103. Sponsor a workshop on research grant opportunities including successful grant letters and presentations by government officials and foundation executives
104. Urge your president to support faculty development programs and individual faculty development efforts
105. Ask alumni to make specific contributions for faculty development
106. Fill a vacancy in, say, statistics with a visiting professor
107. Hire a consultant to visit campus for two days and suggest what next steps you should take for a faculty development program

108 Pay the tuition for a faculty member who wishes to enroll at another university in the summer

109. Fill certain vacancies with "practitioners" (e.g., vacancy in business law with a practicing lawyer)

110. Establish a summer grant program for the improvement of instruction

111. Increase travel funds in the departments for faculty members

112. Urge deans to utilize discretionary money for faculty development and enrichment

113. Increase the colloquia and lecture budgets

114. Hire postdoctoral teaching and research fellows

115. Provide $20 to each faculty member so that he/she might for one year subscribe to a professional journal

116. Provide a free lunch to any group of five or more faculty members who wish to come together and share scholarly papers with each other

117 Streamline the procedures by which an individual may request and secure leave of absence and make explicit that salary increments will be calculated to an individual even while on a leave of absence without pay

118 Sponsor a program of departmental retreats by providing financial assistance for meals

119. Provide special opportunities for faculty spouses

120 Sponsor an educational tour to the same departments in a series of nearby colleges and universities

121. Set aside the hours of noon to 1.00 P.M., when no classes are meeting, for general sessions on faculty development

122 Award a reduced teaching load competitively on the basis of submitted proposals for innovative teaching

123. Make available a faculty office building where faculty may come together from different disciplines to be housed next door to one another

124 Assign a professor from the statistics department to teach a course in statistics to the social science faculty

125. Invite a practitioner to be "in residence" at the university for a week

126. Facilitate the publication of classroom aids, especially expanded syllabi, for use in local classrooms

127. Provide lecture funds on a competitive basis to proposals that originate from more than a single academic department

128. Identify a faculty development facilitator in each department as a means of reorganizing a communication network regarding faculty development information

129. Submit evidence of self-development to promotion and tenure committees

130. Encourage and recognize faculties who seek outside funding for a "developmental year"

131. Make available a "quality audit" team that could be available for invitation to an academic department and include the possibility of securing individuals from other campuses to join in the evaluation

132. Identify a faculty member to act as a consultant for one term and charge that faculty member with visiting the meetings of each department to discuss test construction, small group discussion techniques, the application of statistics to the discipline, etc.

133. Make a member of the faculty or staff available to assume responsibility for becoming fully knowledgeable about faculty development opportunities and the types of activities which are ongoing and for sharing these with departments

134 Twice a year publish a list of faculty development ideas in newsletter form

135. Circulate film library catalogues to faculty and indicate a willingness to consider renting films

136 Provide a rotating library of audio and video tapes for playing at departmental meetings

137 Publicly brag about the unusual successes that faculty colleagues have had in the "faculty development area"

138. Publicize and facilitate opportunities for fellowship grants such as the Social Science Research Council, the Guggenheim Fellowship, etc.

139. Subscribe to institutional publications describing innovations at local campuses such as the Institute for Improvement of College Teaching at the University of Michigan, the Higher Education Institute at Berkeley, the CIC monograph on teaching innovations, the California Colleges "Future Talk"

140 Send a packet of vita from a department to the same departments at all the colleges and universities within 40 miles

141. Provide audio tape playback for college and university automobiles plus cassettes on instructional techniques, etc.

142. Ask every outside speaker to comment on what he or she does to keep abreast in the field.

Table Two.—Faculty Development Practices*

A. **Workshops, Seminars, Programs:**

1. Workshops or presentations that explore various methods or techniques of instruction.
2 Workshops, seminars, or short courses that review subject matter or introduce new knowledge in a field.
3. Workshops or seminars dealing with new or different approaches to develop curricula.
4. Workshops or seminars on testing and evaluating student performance.
5 Workshops, seminars, or program to acquaint faculty with goals of the institution and types of students enrolled.
6 Workshops or program to help faculty improve their academic advising and counseling skills.
7. Workshops or seminars to help faculty improve their research and scholarship skills.
8. Workshops, seminars, or program to improve the management of departmental operations.
9. Workshops or presentations that explore general issues or trends in education.
10. Workshops or program in faculty *affective* development—improving their interpersonal skills or their ability to work effectively in groups, exploring educational values, and similar topics.

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*From: John A. Centra, *Faculty Development Practices in U.S. Colleges and Universities*, (Princeton, New Jersey. Educational Testing Service, 1976), Appendix D.

B. **Analysis or Assessment Practices:**

1. Systematic ratings of instruction by students used to help faculty improve.
2. Formal assessments by colleagues for teaching or course improvement (i.e., visitations or use of assessment form).
3. Informal assessments by colleagues for teaching or course improvement.
4. Systematic teaching or course evaluations by an administrator for improvement purposes.
5. System for faculty to assess their own strengths and areas needing improvement.
6. Classroom visitation by an instructional resource person (i.e., a development specialist). upon request. followed by a diagnosis of teaching.
7. Analysis of in-class video tapes to improve instruction.
8. Faculty with expertise consult with other faculty on teaching of course improvement
9. "Master teachers" or senior faculty work closely with new or apprentice teachers
10. Professional and personal development plan (sometimes called a growth contract) for individual faculty members.

C **Media, Technology, Course Development:**

1. Specialists on campus to assist faculty in use of audio-visual aids in instruction, including closed-circuit television.
2. Assistance to faculty in use of instructional technology as a teaching aid (e.g., programmed learning or computer-assisted instruction).
3. Specialists to assist faculty in constructing tests or evaluating student performance.
4. Specialists to assist individual faculty in instructional or course development by consulting on course objectives and course design.
5. Specialists to help faculty develop teaching skills such as lecturing or leading discussions, or to encourage use of different teaching-learning strategies such as individualized instruction.
6. Simulated procedures which enable faculty to learn and practice specific teaching skills (e.g., microteaching).
7. Special professional library readily accessible to faculty dealing with instructional methodology, teaching skills, psychology of learning, and similar topics.

D. **Miscellaneous Practices:**

1. Use of grants by faculty members for developing new or different approaches to courses or teaching.
2. Visitations to other institutions (or to other parts of this institution) to review educational programs or innovative projects.
3. Faculty exchange program with other institutions.
4. Faculty take courses offered by colleagues.
5. Personal counseling provided individual faculty members on career goals, and other personal development ar[illegible]

Table Three.—Level and Type of Activity

LEVEL	TYPE Facilitate Process	 Structural Technical	 Expert Knowledge	 R&D/ Demonstration
Personal/ Individual	Diagnosis Counseling Coaching Personal Growth Plans, Contracts Grants	Leaves Two Week Personal Growth Contract New Evaluation System Reading Room Provide Baby-sitters	Conferences Readings Visiting Expert w/Indiv. Teaching Clinic PSI training Exxon Tapes	Send Indiv. to Demo. of PSI "Teaching Fairs"
Interpersonal Group	Team workshops Parties Retreats for Depts. Support Groups Group Process Training Fac. Seminar	Lounge Redesign Depts. Classrooms Establish F.D. Teams TV Taping Set up forum, Fac. Seminar	Expert Present. to Group FLICS training	Experimental Inner Colleges Training Teams for Campus Chg. Project
Intergroup/ Organization	Retreats for Total College Community Goal Setting, Problem diagnosis, Planning Chg. Committee Processes Norms, Climate Task Forces Surveys of Fac. Needs. desires	Chg. Class schedules Chg. No. of Courses Chg. Require. Foreign Study; Co-op plans Chg. Job Desc. Unionization Redesign Fac. Meetings	Chg. to Competency-Base curr. NCHEMS Work load Analysis	Centers for Improve. of Instruction Support for Research FIPSE centers Liberal Arts Chg. Project Institutional Change Project

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*From Walter Sikes and Laurence Barrett, *Case Studies on Faculty Development* (Washington D.C : Council for the Advancement of Small Colleges, 1976)

Table Four.—Organization, Instructional, and Personal Development

ORGANIZATIONAL DEVELOPMENT

- **Management Development**
  - Personnel
  - Leadership
  - Fiscal
- **Team-Building**
  - Departmental
  - Inter-Departmental
  - Institutional
- **Problem-Solving**
  - Assessing
  - Proposing
  - Implementing
- **Decision-Making**
  - Group Dynamics
  - Governance
- **Conflict-Management**
  - Studied Goals
  - Divergent Goals

INSTRUCTIONAL DEVELOPMENT

- **Evaluation of Instruction**
  - Self
  - Peer
  - Student
- **Diagnosis of Instruction**
  - Observation
  - Questionnaire
  - Videotaping
- **Instructional Training**
  - Traditional Methods
  - Nontraditional Mthd
- **Instructional Technology**
  - "Software"
  - "Hardware"
- **Curriculum Development**
  - Course
  - Department
  - Institution

PERSONAL DEVELOPMENT

- **Discussions about Teaching**
  - Interviews
  - Seminars
- **Personal Planning**
  - Life
  - Career
- **Interpersonal Skills Training**
  - Communicating
  - Helping
  - Solving
- **Personal Growth**
  - Expressiveness
  - Creativity
  - Awareness
- **Personal Counseling**
  - Supportive
  - Therapeutic

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*From: William Bergquist and Steven R Phillips, "Components of an Effective Faculty Development Program", *Journal of Higher Education*, 1975, 46, 1977–211.

Table Five*.—Meta Scheme

FOCUS OF INTERVENTION		STRUCTURE	PROCESS	ATTITUDE
	Individual	*Instructional Development* Consultation and training on course design, curriculum reform and educational technology *Organizational Development* Evaluation of faculty Faculty reward system	*Instructional Development* Classroom observation, diagnosis and training Training in interpersonal and small group skills Training in out of class skills associated with faculty roles	*Instructional Development* Promotion of alternate instructional methods Discussions about teaching Values Clarification *Personal Development* Life and career planning Counseling
	Group	*Instructional Development* Curricular and course design consultation Interdisciplinary and team teaching *Organizational Development* Departmental reorganization Use of space and time	*Instructional Development* Discipline or department centered instructional training programs Peer observation and feedback *Organizational Development* Group process observation	*Instructional Development* Knowledge utilization Departmental/divisional retreats *Organizational Development* Team-building Support groups
	Institutional	*Community Development* Communication and support networks *Institutional Development* Research and development center *Faculty Development* Program governance	*Community Development* Intergroup negotiation *Institutional Development* Implementing development programs *Faculty Development* Program planning and implementation	*Community Development* Community building *Institutional Development* Development of support for change *Faculty Development* Generating program support
	Meta-Institutional	*Meta-Development* Funding Establishment of formal networks and consortia	*Meta-Development* Define and clarify new change oriented professions Continuing education for educational change agents	*Meta Development* Publication of books, periodicals, etc. Demonstration projects Cooperative research projects

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*From: William Bergquist and Steven R. Phillips, *A Handbook for Faculty Development*, Volume II (Washington D.C. Council for the Advancement of Small Colleges, 1977), p. 9

Table Six.—Current Status and Potential Future of Instructional Improvement

Current Status	*Potential Future*
Few institutions have programs.	Most institutions have programs.
Few faculty are involved.	All or more faculty are involved.
Participants are primarily volunteers.	Participants feel some external pressure to participate.
Faculty participation is limited and irregular.	Faculty participation is regular and continuous.
Participation is an "overload."	Participation is provided for in normal workload.
In-service development is a peripheral activity.	In-service development is a central activity.
Budgets and resources are modest.	Budgets and resources are adequate.
"Soft" grant monies are a major source of funds.	"Hard" institutional monies are the major source of funds.
Few institutional policies support teaching effectiveness or professional development.	Many policies support teaching effectiveness and professional development.
Few permanent instructional-improvement centers conduct professional development.	Instructional-improvement centers providing professional development are permanent.
Few staff members have training and experience in consulting with colleagues.	Many staff members have training and experience in consulting with colleagues.
Little evidence of effectiveness of programs exist.	Convincing evidence of effectiveness exists.
Impact is limited to selected institutions and faculty members.	Impact is widespread among institutions and faculty.
Modest reforms aimed at better teaching are underway.	Extensive improvement in instruction and organizational operations are made.

Jerry Gaff, Toward Faculty Renewal (San Francisco: Jossey-Bass, 1975).

Table Seven.—Five Levels of Change for Faculty

Level of Change	Nature of Change	Consequence of Change	Resources for Change	
			Institutional	Faculty Development
One	• Change in one segment of a new course *or* • Use of new instructional method	• Faculty member experiences new challenge: renewed interest, excitement, performance anxiety • Faculty member must learn some new content and skills • Faculty member likely to temporarily experience some failures, student dissatisfaction and confusion.	• Mini-Grants ($50–500) • Mini-Sabbaticals (1–2 weeks) • One-time "experimental" courses • "Error-embracing" environment and reward system: tolerance of temporary increase in error rate of faculty member	• Short-term design consultation • Instructional design and methods workshops • Teaching laboratories • Instructional innovators' support group • Classroom diagnosis • Peer consultation
Two	• Change in the design of an entire course *or* • Use of new instructional strategy	• Faculty member often changes image of self (role): becomes instructional designer or manager rather than information-giver. Temporary feeling of no longer being valuable to students • Faculty member is temporarily more busy, than less busy. • Faculty member is likely to temporarily experience some failures, student dissatisfaction and confusion	• Release time (one month or one course) • Equipment • Content-Consultation • "Error-embracing" environment and reward system	• Long-term design consultation • Instructional innovators' support group • Peer consultation • Organization development (department)

Table Seven.—Five Levels of Change for Faculty (continued)

Level of Change	Nature of Change	Consequence of Change	Resources for Change	
			Institutional	Faculty Development
Three	• Faculty member changes primary teaching responsibility to new area within same discipline *or* • Faculty changes to new interdisciplinary program (making use of knowledge in current discipline)	• Faculty member must redefine role in discipline. • Faculty member must learn new content • Faculty member must learn new instructional methods and designs • Faculty member is temporarily very busy Faculty member is likely to feel temporary rejection from some colleagues in discipline • Faculty member is likely to temporarily experience some failures, student dissatisfaction and confusion	• Sabbatical (at least one year) • Books, content, consultation, instructional materials • Money for conferences, travel, visits to other programs, etc.	• Long-term course design consultation • Instructional diagnosis • Instructional design/methods • Instructional innovators support group • Life and career planning • Organizational development (department)
Four	• Faculty member changes discipline: begins to teach in a new field	• Faculty member must redefine self and life purpose • Faculty member must learn new field (and hopefully integrate with previous field) • Faculty member must learn new instructional and research methods, designs, and language • Faculty member is likely to feel overwhelmed for extended period of time	• One or two-year sabbatical • Financial support for new agencies and institutes for retraining and renewing faculty • Safe environment for faculty member to try out new discipline on campus • Support of faculty in new discipline for new colleagues	• Help faculty acquire knowledge in new field quickly and effectively • Help faculty integrate new knowledge and instructional methods • Organizational development (Inter-departmental) • Supportive counseling to faculty member and family.

Table Seven.—Five Levels of Change for Faculty (continued)

Level of Change	Nature of Change	Consequence of Change	Resources for Change	
			Institutional	Faculty Development
Five	• Faculty member changes to a profession outside higher education	• First major institutional shift for many faculty • Variable consequences depending on nature of shift	• Development of skills and attitude matrix • Collection of information about manpower needs outside of higher education • Match up faculty matrix with high demand fields	• Career planning • Supportive counseling to faculty member and family

APPENDIX A

William H. Bergquist and Steven R. Phillips, "Components of an Effective Faculty Development Program," *Journal of Higher Education*, 1975, 46, 177–24.

COMPONENTS OF AN EFFECTIVE FACULTY DEVELOPMENT PROGRAM

William H. Bergquist and Steven R. Phillips *

Since piecemeal efforts to improve college and university teaching have generally proven ineffective, we must turn to a comprehensive approach to faculty development, through which we can develop new methods of evaluation and diagnosis, find viable ways of introducing new technology and curricula, and explore new approaches to instructional improvement. Faculty development must give serious attention to the impact of change on the faculty member himself and on his institution. Organizational and personal development thus become essential to faculty development. It is only through such a comprehensive approach that efforts toward improvement can have lasting impact.

THE STATE OF THE PROBLEM

Faculty development has become an increasingly prominent concept for a growing number of faculty and administrators in American colleges and universities. Institutions of higher education face the harsh realities of decreased funding, steady-state or declining enrollment, and declining faculty mobility, together with demands for accountability voiced by students, parents, and state and federal officials. Confronted with these conditions, faculty must consider the prospect of significant reevaluation of personal and professional attitudes toward classroom instruction and student-teacher relationships. Faculty must also consider extensive retraining in new classroom procedures, as well as profound reorganization of departmental structures and governance systems.

Over the past decade, numerous articles and books have been written about faculty development [35, 31, 39, 38, 18, 4]. Furthermore, most college officials can point to the existence of one or more "faculty development" programs on their own campus, which range from new faculty orientations to one-year sabbaticals, from student classroom evaluations to instructional technology centers. In almost all instances, these books and programs have reflected two basic yet conflicting propositions: (*a*) teaching is an important aspect of the college faculty member's professional role and hence should be highly valued, and (*b*) teaching is frequently not a serious concern in the training or hiring of college faculty and is often neglected in issues of promotion and tenure. Most faculty development programs take note of these two propositions by offering some activities that acknowledge the validity of the first, while really doing little to have an impact on the second.

PAST APPROACHES

The experience of the past 20 years provides few cues concerning how faculty development might best be conducted. Past approaches to improving teaching and learning—"change the curriculum," "get brighter students," "recruit new Ph.D.s from the best graduate schools," "reduce the student/faculty ratio," "develop an instructional resources center," "establish a new governance system," "undertake a comprehensive self-study"—have, in isolation, fallen short of meeting the challenges posed by the dramatic changes taking place in higher education. This failure is particularly disappointing when one considers the amount of money available to colleges and universities in the early and mid-1960s. Three of the most widely used past approaches to faculty development, (*a*) the reduction of student/faculty ratios, (*b*) the purchase of such costly new instructional technology as videotape systems, instructional computers, and learning machines, and (*c*) the recruitment of new Ph.D.s with supposedly fresh ideas, merit consideration in greater detail.

When confronted with a reduced student/faculty ratio, many faculty members will automatically respond with a

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* The authors wish to express their appreciation to Ms. Nancy Barber and Ms. Jennifer Grimes for their valuable suggestions in the conceptualization and composition of this article Many of the ideas contained in this article were developed and implemented as part of a faculty development program sponsored by the College Center of the Finger Lakes (CCFL) in Corning, New York. Consequently, we would also like to acknowledge the important part Dr. Gary Quehl, then executive director of CCFL and currently president of the Council for the Advancement of Small Colleges, and Dr John C. Noonan of Virginia Commonwealth University and Dr. William Barber of Eastern Washington State College, two of the major consultants to that program, played in the realization of this article.

William H. Bergquist, formerly of WICHE, is presently a private consultant based at 819 Hermes Avenue, Leucadia, California. Steven R. Phillips, member of the humanities division, Alfred University, this summer will become coordinator of faculty development at the University of Puget Sound, Tacoma seminar. This method is so revered in higher education that to speak against it as an effective teaching device is heresy. Yet, in most instances when candor is possible, many faculty members and students will describe their seminar experiences as both disappointing and frustrating. Seminar leadership necessitates the acquisition of sophisticated skills in group dynamics. The effective seminar leader must be able to move a discussion without directing it, to bring rational processes to bear upon a conflict of ideas without prematurely dampening this conflict, and to bring out the quiet members of a group without goading them. Very few people possess such skills.

This situation is at times compounded by the faculty member who, when confronted with a smaller number of students in a class, will assume that class preparation is that much less important and, hence, will concentrate a greater amount of energy on research and publication.

While the student/teacher ratio may provide the opportunity for several types of instruction which are not possible with large classes, lowering the ratio does not necessarily improve the quality of teaching. A teacher must not only receive training in small group dynamics and in one-to-one teaching, he must have: in addition, an opportunity to discuss the significant changes occurring in his relationships with students as a result of small courses. Finally, the faculty member must be rewarded for developing these new skills, lest he interpret reduced ratios as a rationale for reduced teaching responsibility.[1]

The second approach to faculty development used widely during the 1960s involved the purchase of new instructional hardware. In the years following Sputnik, greater emphasis was placed on solution of educational as well as other social problems through technology: we should be able to move students as well as rockets with new technologies Yet technology has neither moved faculty to use it for instruction nor helped students toward dramatically improved learning.

There are a number of reasons for the failure of the new instructional technologies in higher education. First, few academic institutions have the financial, artistic, or technical resources to produce educational programming that can compete with the products of commercial television or motion pictures. Students who have grown up as consumers of sight-on-sound rock concerts, commercial games (from *Monopoly* to *Diplomacy*), and stereophonic tape decks must be forgiven if they find the technological efforts of many of their professors rather amateurish.

Second, many college teachers, either by their own interest or by the default of their institutions, have developed little acquaintance with the potentials of instructional technology On many campuses, the new audiovisual center is a source of pride to the administration and a must stop for visiting state legislators. Unfortunately, the center is rarely visited by faculty. Finally, and perhaps most fundamentally, the introduction of instructional technology can have profound and even threatening implications for the faculty member. If the teacher views himself primarily as a dispenser of information, he may feel that his position is directly threatened by the new technology. Rarely has instructional technology been introduced by an administration that has also given the faculty member an opportunity to examine his attitudes toward teaching and to explore alternative roles.

Faculty development has also been attempted by bringing in new faculty—men and women with new ideas and fresh perspectives. Such people, it is hoped, will serve as catalysts and stimulants, keeping their departments flexible and constantly changing. Two assumptions underlie this strategy: first, colleges will continue to grow and hence there will always be positions for new faculty, and second, these new faculty members will be sources of instructional innovation. The first of these two assumptions is short-sighted, as are most solutions in our society that are based on the assumption of continuous growth [36]. Most colleges and universities in the 1970s are confronted with the prospect of little or no growth in the size of their faculties.

Even if colleges and universities were not presented with the inevitable reality of little or no growth, they would soon have to face up to the fact that new faculty members are not necessarily, or even usually, a primary source of instructional innovation. In recent years, a large proportion of the faculty entering the college teaching profession have graduated from prestigious, research-oriented institutions. Coming from such an institution, the young faculty member is often an inexperienced teacher; moreover, his only teaching models in graduate school are likely to have been senior, research-oriented faculty. The young faculty member is almost by definition an individual who could satisfactorily adapt to a traditional academic setting. Since innovation in curriculum or course design often requires a certain amount of risk taking on the part of the innovator, it is unrealistic to expect a new faculty member, without tenure, informal power or influence, knowledge of organizational roles or norms, or even conditional peer acceptance, to take the innovative step. While there are certainly exceptions to this rule, the expectation must be that the newcomer will first "learn the ropes" and then innovate—if the innovative ideas have not been lost in the process of learning organizational survival.

In the recent past, efforts at faculty development have been largely cosmetic in nature or based, at least in part, on faulty assumptions about the way in which faculty, as well as students, learn, change, and grow. We are left with very few guidelines for new programs in faculty development, even though such programs appear to be essential ingredients in the educational reforms of the

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[1] An increasing student/teaching ratio may, in some circumstances, actually be a challenge for innovation Exciting instructional techniques such as simulations, buzz groups, fish bowls, and project teams work most effectively in a large class Large group settings often generate openness to new learning and willingness to take risks Large group dynamics can, with appropriate group leadership and instructional skills, become assets to learning and intellectual growth

1970s. The following section of this article represents an attempt briefly to conceptualize some of the components that might be incorporated into an effective faculty development program. This component-analysis is not meant to represent either a definitive statement of faculty development or a radical departure from the conceptualizations of such authors as Morris [39], Sanford [46], Eble [18], Milton [38], or Freedman [22]. Rather, the following section of this article provides a summary statement of many observations and suggestions made by colleagues and also provides a new conceptualization of these several reference points in a single, comprehensive model.

NEW APPROACHES

In the 1970s we are faced with new and difficult issues in higher education. With decreases in enrollment and increases in such alternative educational avenues as external degree programs, proprietary institutions, and CLEP [15], the college professor must be able to present courses that are meaningful and instructionally attractive.

To prompt the significant change in faculty and instruction demanded by these conditions, it is essential that a faculty development program be both comprehensive, touching on most aspects of the teaching-learning enterprise, and based on a set of diverse, though related, strategies.

The proposed model is based on the assumption that significant changes must take place at three levels: (*a*) attitude, (*b*) process, and (*c*) structure [52]. A change effort focusing on only one of these levels will rarely achieve success. In the case of faculty development, primary attention is usually given to the process of instruction, most often to instructional methods and technology, curriculum development, and student evaluation of instruction. While these instructional issues are vital for the improvement of the quality of the institution's educational environment, they do not constitute the full range of activities involved in an effective faculty development program.

Frequently, when introduced to methods of college instruction, a faculty member will turn away or adopt a stance of passive resistance. Central to this resistance is the attitude of the faculty member toward teaching. If he does not value teaching, or does not perceive himself as being primarily a teacher, he will not spend time learning new techniques or exploring alternative instructional methods. At the same time, he may be fearful of displaying his shortcomings as a teacher or may be resisting the values and philosophies of education that underlie many new methods or curriculum proposals. Frequently, he has neither an articulated value system concerning teaching nor a coherent philosophy of education, and the new method or proposal may inevitably find itself at odds with ill-defined values or philosophies. An effective faculty development program, then, must deal with the attitudes of the faculty member, as well as with related values, philosophies, and self-perceptions.

On the other hand, even when the college teacher has had a chance to develop his own philosophy of education and has embraced new methods and technologies compatible with his now clearly articulated attitudes and values, he may encounter restrictions and barriers resulting from institutional and/or departmental policies, norms, and procedures. He confronts, in other words, the structural constraints of the organization within which he operates. As is the case with personal attitudes, organizational structures can rapidly and thoroughly blunt the thrust of a faculty development program that neglects the structural dimension.

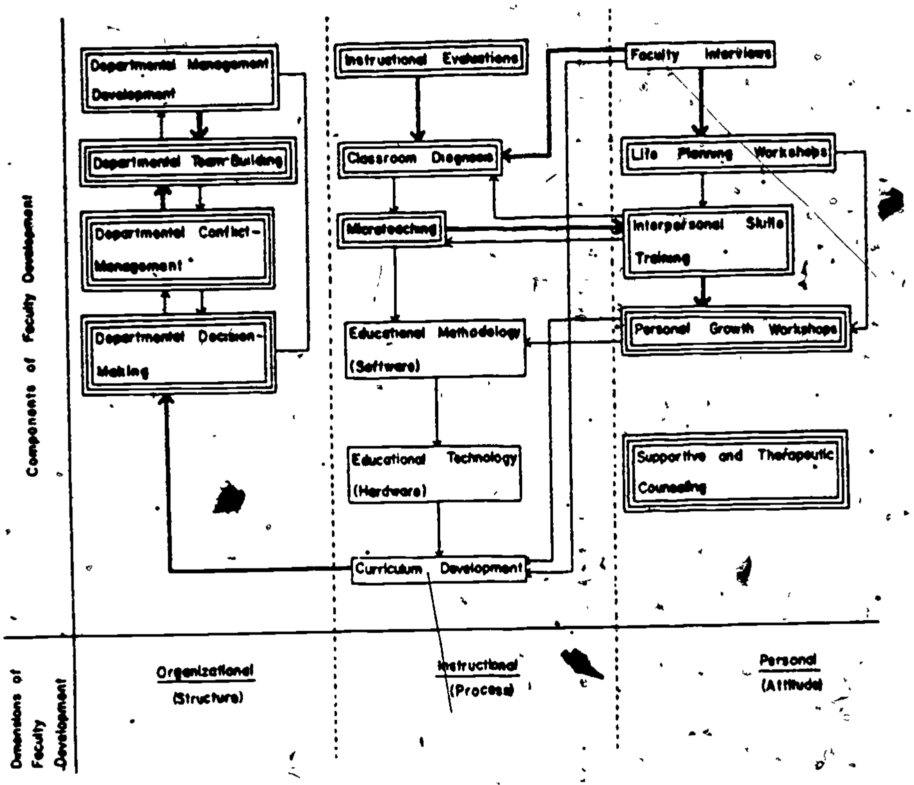
These basic assumptions concerning structure, process, and attitude have been translated, in graphic form, to a model of faculty development (see Figure 1). This model is composed of specific programmatic components (each being represented by a box) which bear some relationship to one another (represented by lines and arrows). Some of these components are based primarily on issues of attitude change or personal development. Other components are based primarily on issues of process change or instructional development. The third set of components is based on issues of structural change or organizational development.

Lines between two components of the model indicate that activities in one of these components lead frequently and "naturally" to activities in the other component. The arrow indicates the usual direction of this movement between program areas. Instructional evaluation programs, for instance, tend to develop and move toward classroom diagnosis services, much as training in classroom methodology should (and usually does) precede training in the use of specific technologies.

Another dimension of faculty development is also represented in the graphic model, the dimension of threat and its accompanying behavior, resistance. The components tending to be least threatening and which, therefore, tend to provoke least resistance, are represented by boxes with single-lined edges. Those programmatic components that tend to be most threatening and are resisted by the greatest number of faculty are represented by boxes with three-lined edges. Two-lined boxes represent components of intermediate threat and resistance.

Similarly, in those instances in which movement from one component to another is usually accomplished with very little resistance, thin lines are drawn between the two boxes. In some cases, high threat and resistance tend to accompany the movement between components, or the development of one component from another, even though such movement is quite logical with reference to change processes. In such instances, thick lines are drawn between the components. In those situations in which two components are not linked by a line, it is assumed that these two components are rarely "spun

Figure 1.—A Model for Effective Faculty Development



off" from one another, but are instead related in some indirect way under the broad concept of effective faculty development.

Case histories and personal experiences of the authors in conducting faculty development programs have contributed to the insights contained in this model, as have the contributions from a number of books, research articles, and theory papers. In the following sections, brief descriptions are presented for each of the components contained in the model. Subsequent to these descriptions, attention is given to the implementation of a faculty development program.

INSTRUCTIONAL DEVELOPMENT: CHANGE IN PROCESS

An effective faculty development program must contain components that have immediate face validity, that is, have specifically to ~~do with~~ the primary function of the faculty member, instruction in the classroom. In this sense, instructional development components are primary, and the personal and organizational components are secondary. In a parallel fashion, most effective change programs begin at the "process" level of professional relationships and day-to-day activity, for this is the level where most people experience immediate systems stress and are hence most willing to consider change. Following are brief descriptions of each instructional development component that seems to be of primary importance to faculty development.

A. Instructional Evaluation

The role of evaluation in bringing about change in an organization is widely recognized and accepted. Any organization that wishes to change in a systematic and thoughtful manner must continually assess the discrepancy between current operations and desired outcomes. Such an assessment procedure is necessarily evaluative in nature, since values and preferences are inherent in any statement of desired outcomes. Student evaluation is probably the most commonly used method of attempting to instigate change in faculty teaching performance. Two other sources of evaluation, by the instructor himself and by his peers, are used more sparingly, though most faculty acknowledge the value of both and in many instances prefer such evaluation to student evaluation. A brief discussion of each of these modes of evaluation follows.

[illegible]-Evaluation

The faculty member himself is, of course, the most critical factor in any effective program designed to improve instruction. An attempt at instructional improvement on the part of the faculty member will take place only if he evaluates his own performance as inadequate or below his own personal standards. Several of the components of the faculty development model are designed primarily to help a faculty member become fully aware of such possible discrepancies in a way that will reduce them through insight and training.

Another way to conceptualize this aspect of change can be borrowed from Kurt Lewin [32], who describes the "unfreezing" phase of change. An individual must have experienced some discrepancy, dissonance, pain, or stress before he will commit himself to the difficult task of change. Lewin believes that this unfreezing must precede any significant learning experience if change is to occur. Without this unfreezing an individual will either proceed "pro forma" through the change program without really being affected by it or will resist the program before it is even begun.

An effective faculty development program should contain a phase in which faculty are asked to assess their own strengths, weaknesses, and areas for improvement. One procedure that can be followed is to have the faculty member fill out the same evaluation instrument that is being completed by his peers or students. Discrepancies can thus be noted between not only the faculty member's own actual and ideal ratings, but also between them and the ratings of others. This "consensual validation" [51] procedure is essential to personal growth as well as to instructional development.

2. Peer Evaluation

This form of evaluation is rarely found in faculty development programs, though several instances of peer evaluation are cited by Eble [18]. The evaluators in these cases were not actually "peers" in the strict sense of the word, since they were either senior and usually tenured faculty observing untenured faculty or were untenured faculty observing graduate teaching assistants. The reluctance of many academic institutions and departments to develop a peer evaluation program is quite understandable given the shortage of time and the low level of trust found in many academic organizations. These factors must be faced and managed if peer evaluation is to succeed.

One effective way of reducing the time factor is to encourage team teaching. By attending another team member's classes, one can provide informal peer observation and evaluation while participating in a course for which one is partially responsible and compensated. Alternatively, if a department regularly rotates class assignments, then it will benefit a faculty member to sit in on a colleague's course, knowing he will eventually be teaching it. Designating one member of the department as a master teacher is another means of encouraging peer evaluation. This person would be chosen on the basis of such widely accepted criteria of success as course enrollment, student performance on standardized tests, reputation, or teaching experience. This master teacher could, in turn, be assigned a reduced teaching load, so that he or she might attend colleagues' classes. This assignment should probably be rotated among several faculty on a yearly basis.

The trust factor in such peer evaluation is difficult to deal with, for it really merges with both the personal and organizational development efforts to be discussed below. The individual faculty member must, first of all, be relatively nondefensive about evaluative feedback concerning his teaching. In preparation for such feedback, many teachers should receive some personal-growth and interpersonal-skills training, though such training itself is often somewhat threatening. Alternatively, the individual who is offering the feedback can try to present it in as nonevaluative, descriptive, and helpful a manner as possible, which is usually much easier for the faculty member to receive and absorb. Interpersonal-skills training for the individual who is offering the feedback is therefore valuable—if not essential. Alternatively, one can develop the kind of training program for classroom observation and diagnosis discussed below.

Trust may be increased through various organizational efforts. Structures can be changed to increase communication, and status differences, such as having peer evaluation of only nontenured or graduate student teachers, can be reduced. Awards for good teaching can be developed, and team-building efforts can be undertaken at the departmental or divisional level. Of potential benefit at both a personal and an organizational level is the peer faculty interview, discussed below, which helps to create interpersonal trust, while establishing an organizational norm for openness about teaching.

Once established as an acceptable, relatively low-threat means of improving instruction, peer evaluation can be conducted by either formal or informal means. The faculty member can invite a peer to sit in and make comments on one or two class sessions, or a department can establish a balanced program of exchange, using a structured observation schedule. Peers might quite profitably be asked to evaluate on the basis of categories that are being used by students and/or the faculty member himself.

3. Student Evaluation

A great deal has recently been written about student evaluation of college teaching [37]. An attempt will not be made here to review the methods of student evaluation or the research that bears upon its validity. Rather, attention will be given to the actual (or potential) role of student evaluation in faculty development. Consideration will first be given to several of the more positive aspects of student evaluation.

While the primary reward structures of many colleges and universities are directed toward research, student evaluations of teaching draw attention directly to instruction. Research-based criteria for promotion, salary increases, and tenure are popular, precisely because they are fairly easily objectified and even quantified. Such criteria are rarely found in assessments of teaching, except in the case of published textbooks and various kinds of teaching aids [13]. Student evaluations allow for such criteria and hence give teaching a "fighting chance" against research as a basis for evaluating faculty performance.

Research is also given first priority in many institutions because it is a prized enterprise with tangible results. Teaching, on the other hand, does not allow for comparisons. Precisely because most classrooms are autonomous and because most professors grade either on the basis of a curve or on some subjective standard, one is unable to compare the production of two or more teachers. If effectively conducted, student evaluations produce data that allow for valid comparisons between teaching performances, even if the differences in quality of production are not directly measured or compared. In other words, the student evaluation can help increase the teacher's "accountability" in the classroom, thereby increasing the balance that might be assigned to documented effective teaching.

Student evaluations may also provide a new medium for student-faculty interaction, thus hopefully assisting the faculty member in the development of instructional skills. The student becomes an active participant in decisions concerning classroom instruction and serves in a "helping" role by providing the instructor with performance feedback. The instructor, in turn, assumes a temporary "recipient" role. He is being provided with new information, emanating from a consumer population, concerning his own capabilities and style. The instructor, then, becomes accountable to the students who, in turn, become responsible for providing the instructor with valid and useful information about this classroom performance.

Accountability is also enhanced by student evaluation. Frequently, when teaching is used as a primary basis for performance evaluation, either because research is deemphasized (as in many private and community colleges) or because the faculty member has been trained specifically for teaching purposes (often in nonresearch-based humanities disciplines), the primary criteria for this evaluation may too often become hearsay, orthodoxy, or politics. In each instance, the faculty member's performance in the classroom is not being directly or justly assessed. The student evaluation provides fair, though limited, input concerning instructional performance in the classroom and hence can be useful in both faculty evaluation and development.

The negative aspects of student evaluation should not be ignored. First, a negative evaluation may result in defensive behavior, which can only block the process of change. One of the paradoxes inherent in change is that both people and institutions are least likely to change when someone tells them that they should change [44]. Thus, when presented with negative evaluations, many instructors are inclined to rationalize away the information ("The students don't know what is good for them," "The instrument isn't valid," "That isn't really an important dimension of teaching anyway") or simply to ignore it, particularly if the information is at odds with their sense of their own teaching ability. One way of possibly avoiding a defensive response on the part of the faculty member is to develop the kind of multilevel evaluative instrument discussed below, which would provide general and summary information for use by administrators and department chairmen but would reserve specific diagnostic and evaluative data for the use of the faculty member alone [50]. Such an evaluation would provide both administratively useful and diagnostically helpful information.

A second limitation of student evaluation is that the usefulness of the information generated by most instruments is often questionable. A typical course evaluation instrument will include items such as "the teacher establishes a warm rapport with the students" or "the teacher presents a clear, coherent lecture." What can a teacher learn from low ratings on either of these items? Neither item provides the type of discrete, concrete information that leads to change. Furthermore, most items of this sort are highly correlated with general evaluative items (ratings of overall course quality) and hence may not be in fact measuring anything other than how much the student liked the course content and/or course instructor.

Third, student evaluations are also a disservice to the development of faculty when, as is often the case, they are used as the only means of feedback to the instructor. While student evaluations are important, they provide only one type of information while ignoring the usefulness of self and peer evaluations, classroom diagnosis, behavioral outcomes, and postcourse followup. Student evaluations are very seductive: they are inexpensive, they involve student time (expendable) rather than faculty time (valuable), they are easily quantified and computerized. Consequently, many administrators and some faculty may assume they are an adequate and sufficient means of evaluation. No information may be better than partial information, but when such crucial decisions as those of promotion, salary, and tenure depend on such information, it would seem the development of reliable and helpful student evaluations is essential.

Finally, mechanical issues may cloud the picture. The student populations being sampled by the instrument are often biased. Those students for whom the course is a failure will frequently not be in attendance to complete the instrument. Furthermore, the instruments developed and used by many campuses are psychometrically naive. While they may possess rather high interitem reliability (often because the general evaluation factor is being tapped by most of the items), they usually are inefficient (too many items to measure one dimension) and rarely have been shown to be valid with reference to widely accepted, external criteria.

Several steps can be taken to improve the quality of student evaluation procedures: (*a*) the instrument can be reduced to a minimal number of items by means of factor analyses and related statistical techniques, (*b*) the instrument can be designed to be minimally evaluative and maximally descriptive, using checklists and precise situational descriptors ("under condition X, the teacher is likely to do *a, b, c*, or *d*"), (*c*) the instrument can be designed so that some items are primarily designed for tenure, salary, and promotion decisions, while other items are primarily designed for instructional improvement. The items on the former should be evaluative and the data should be made available to department chairmen and deans; the items on the latter should be descriptive and should be made available only to the instructor. The student evaluation procedure should also be closely integrated with other segments of a faculty development program. Any category of instruction being evaluated must be an area in which training opportunities are available; otherwise the evaluation procedure becomes a weapon rather than an instrument for change: a teacher is told he is doing an inadequate job yet is given no way to improve that job.

4. General Conclusions

The strengths and weaknesses of evaluative approaches have been discussed at length because they highlight a number of key issues occurring in other components of a faculty development program. First, self, peer, and student evaluation can be useful aspects of faculty development. In isolation, however, each of these approaches is potentially more destructive than not and consequently should be integrated into a comprehensive, multistrategy approach to faculty development. Secondly, change is a subtle and complex process. It is not encouraged by the use of an insensitive, often arbitrary, reliance on evaluative ratings of performance. Preparation for change ("unfreezing") in instructional performance occurs when the teacher is confronted with information that is discrepant with his self-image but which does not deflate his self-esteem This information is requested by the instructor, rather than forced on him; it is descriptive, rather than evaluative; it is concrete, rather than general; it is presented in a context of trust, rather than threat. The process of change takes place only when the instructor is presented with information, training, and consultation directly related to perceived needs. It is to these components of instructional development that we now turn.

B. Instructional Diagnosis

This component is directly related to such widely held academic values and enterprises as objectivity, empiricism, and problem analysis. Nevertheless, instructional diagnosis has become a recognized component of faculty development only within the last five years. It still is not used by many collegiate instructional improvement centers. Extensive diagnostic programs, to date, have been developed only at the University of Massachusetts, the University of Idaho, and the University of Cincinnati.

Instructional diagnosis consists of three primary activities, each of which is essential to any consulting process [32]. These three activities are: (1) contracting, (2) data collection, and (3) data feedback.

1. Contracting

The instructor must first determine what type of information concerning his teaching he wishes to receive. The consulting team must, in turn, decide if this type of information can be collected, given their own limits in time, money, and expertise. The mutually agreed upon areas of information form the basis of a contract between the client (instructor) and consultant (diagnostician). Without this contracting phase, a diagnostic team is forced to make assumptions about what the instructor wants or needs. Such assumptions may prove incorrect and result in a waste of time and money. Furthermore, if the instructor is not involved in decisions concerning the type of information to be collected, then he cannot sense any "ownership" for either the data-collection process or the actual collected data. He is consequently more likely to dismiss or resist this information when it is presented to him.

Generally, an instructor will choose to receive information about areas in which he is moderately competent. Such selectivity is productive, for areas which are highly threatening are probably also areas in which little learning will actually take place. Once an instructor has received and made use of information in less threatening areas, he will be more inclined to accept information of a potentially more threatening nature.

2. Data Collection

While each diagnostic contract must be tailormade for the instructor who requests the service, some basic instruments should be available, and members of the team should have a grasp on some basic conceptual categories. Among the basic resources that should be available to a diagnostic team are (*a*) observational instruments related to such basic microteaching categories as questioning skills, set-induction, and closure [1]. These instruments, used primarily in traditional lecture-based courses, should be directly linked with a microteaching program, as has been done at the University of Massachusetts Clinic for the Improvement of Teaching. (*b*) Interaction analysis instruments should be available to the diagnostic staff. Ideally, the team should be trained in the use of several different interaction analysis instruments, like the Flanders IA and the Reciprocal Categories Systems [41]. Additionally, the basic Bales Interaction Analysis should be available for potential use in a diversity of instructional settings. (*c*) A variety of student evaluation instruments should be kept on file, so that new instruments can be easily developed that assess students' attitudes on a number of different dimensions. (*d*) The diagnostic team should be trained in the use of small and large group data gathering techniques. Members of a diagnostic team, for instance, might use a force-field analysis to define elements of the classroom that facilitate or hinder movement toward some specific instructional goal. In using this analysis, members of the diagnostic team would interview members of the class, either individually or in a group, concerning their perceptions of the facilitating and hindering forces. With advanced training, a diagnostic team could conduct more complex intergroup (teacher-student) [11] or even large-group [5] data collection procedures. (*e*) For use in instructional settings outside the classroom, the diagnostic team should be prepared to deliver or develop a series of "field-instruments" related to small group functioning (seminar groups, project teams, "buzz" groups, etc.) Similar instruments should be developed for observing students in off-campus placements, and students and faculty in advising settings. Instruments to diagnose small group functions are available in abundance [21, 47, 49]. The team need only choose or redesign tools related to such dimensions as leadership styles, communication patterns, group norms, and group roles. Instruments which can be used to assess field settings, especially instruments which measure actual behavior rather than attitudes about behavior, are less readily available. A diagnostic team might quite profitably look [illegible] some of the new performance-based teacher education programs for guidance. (*f*) Finally, a diagnostic team should be able to produce a verbatim transcript of a classroom, seminar, or advising session, and/or an audiotape or videotape of an instructional session. The information gained by an accurate performance replay is, in and of itself, diagnostic to the instructor, especially if accompanied by more condensed, descriptive data. The major problem associated with the use of transcriptions and tapes is the "richness" of the data. An instructor who makes use of this data should go through it slowly and carefully to avoid the risk of "information overload." The primary advantage of this type of information is its almost totally nonevaluative character. Only in the camera angle that is chosen or in the selection of a particular medium for collection and feedback will bias enter the process. When dealing with a highly defensive faculty member, or when first offering its services, a diagnostic team should make rather extensive use of this procedure. The written transcript or videotape can prove quite valuable in the training of diagnostic team members. Furthermore, these recordings can be of assistance to a diagnostic team member who may not be able to record all necessary observations during the actual classroom seminar or advising session.

3. Data Feedback

Change processes are usually quite subtle, necessitating an interpersonal sensitivity to the strengths and weaknesses of the client (instructor), as well as to his areas of high and low threat. Interpersonal skills are of primary importance at the point of data feedback.

In most instances, a written report should be presented to the instructor within two or three weeks after a specific observation is made; out-of-date feedback is practically worthless. The report should be brief, with all major conclusions carefully documented and based on observations and analysis that can be clearly articulated and justified. Jargon should be kept at a minimum; moderate informality is usually effective. The self-esteem of the instructor must be preserved throughout the report.

The written report should be followed by a diagnostic meeting in which the report is thoroughly discussed. Verbatim transcripts, audiotapes and/or videotapes may be presented at this time to justify or illustrate conclusions reached by the diagnostic team. In the early stages of a specific diagnostic program, the meeting may consist almost exclusively of a review of these recordings.

The sequence of contracting, data collection, and data feedback will often recycle. The faculty member who has gone through one sequence may wish to recontract for information of a different type or for information of greater depth in some specific area. The diagnostic procedure will often lead the instructor to consider further instructional training, new instructional methods or technologies, and ultimately new designs for the curriculum of his department. These newly emerging concerns should be supported by the diagnostic team. The team members should also be able to offer the instructor specific suggestions as to where appropriate assistance can be obtained. Without the followup resources of a comprehensive faculty development program, the instructor who has received the diagnosis is likely to become disillusioned with the entire diagnostic procedure.

Instructional diagnosis is probably most effectively implemented with a team of from six to twelve students and faculty (for a campus of 3,000–8,000 students). The team should be composed primarily of students or salaried staff, if the budget allows. Volunteer faculty members normally do not have extensive time to allot to such a project.

Once the student is trained to be an effective diagnostician and instructional consultant, then he or she will be a valuable resource to the instructor. Under such conditions, the instructor is confronted with a situation in which he can learn from the student, thereby reversing the usual roles of students and faculty. Confronted with this role reversal, many instructors will begin to change their overall orientation toward students and, more generally, their conceptualization of the learning process.

Initially, it is helpful if faculty are included on the diagnostic team, as diagnostic input from students will probably not be immediately acceptable to many faculty. A faculty member on the team can also bring a different perspective to bear on the diagnostic procedure. As an instructor himself, he can empathize with his colleagues' problems. Furthermore, if the faculty member of the diagnostic staff is not affiliated with the behavioral sciences or education, he is more likely to be accepted by faculty outside those fields. A chemist, electrical engineer, or historian is not burdened with the jargon-ridden language a behavioral scientist is inclined to use. Furthermore, if the faculty member (and some of the students) are acquainted with the subject matter being offered by the observed instructor, then a wider range of comments can be made about the instructor's performance. The team may be even more positively received if the more visible members (faculty or students) are identified as being "neutral" with reference to campus (and national) politics, as being "objective" and empirically oriented, and as being educationally "moderate."

So far, the description of the "ideal" instructional diagnostician appears impossibly bland. However, there are more interesting and complex qualities and skills needed by this individual. He should not be exclusively a technician. Rather, he should be a consultant skilled in the use of interpersonal, as well as data-gathering and data-analysis, skills. The diagnostician must be flexible in adapting standard instruments and procedures to the particular needs of the client (instructor). Contracting skills are essential in assessing what an instructor wants in the way of feedback, as are diagnostic skills that enable him to collect valid information so that it is useful [3].

C. Microteaching

This training procedure was first developed by Dwight Allen and Kevin Ryan [1] for use with undergraduate and graduate students entering primary or secondary school teaching. While the procedures found in a microteaching program appear to be applicable, in modified form, to most instruction at a collegiate level, they have not been extensively used to train faculty. Currently, an excellent instructional improvement program has been developed at the University of Massachusetts, under Allen's supervision. Microteaching is a significant component of this program.

The primary limitations of microteaching reside not only in its origins outside of higher education but also in its focus on rather traditional student-teacher settings. Without rather extensive modifications of, and expansion on, its current structure, the microteaching program can have significant impact only in the traditional classroom. On the other hand, if the traditional classroom lecture or discussion leader can be trained to be more effective in this setting, then he may be more inclined to try nontraditional approaches to instruction. If the microteaching program is preceded by an effective classroom diagnosis incorporating microteaching-based categories, this component can be particularly valuable in the early stages of a faculty development program. Microteaching, on the other hand, should probably not be the first stage of the program, for it tends to be threatening to faculty when considered in isolation.

Even though the microteaching program, as it is currently structured, is somewhat limited with reference to nontraditional instruction, the basic assumptions underlying the program are directly appropriate to all forms of instruction. Microteaching is based on the assumption that teaching can be subdivided into relatively autonomous skills, each of which can be separately taught using demonstrations, practice teaching, and feedback. Comparable training programs should be possible with other instructional procedures such as seminars, simulations, and laboratory training. Microteaching procedures are already available in the area of student counseling [29].

The microteaching program, through its analysis of teaching skills, can also provide college instructors with an introduction to alternative educational methodologies. Allen and Ryan [1], for instance, introduced the concept of "set induction" as a preinstructional technique to be used by teachers. A number of specific methods can be used to induce a set for students: a class can begin with a brief simulation or role play, or with excerpts from a popular television program that illustrate the value of common occurrence of a particular phenomenon. The "unfreezing" phase of change [32] is in many ways comparable to Allen and Ryan's concept of "set induction." Other microteaching concepts have similar applicability in higher education instruction.

D. Educational Methodology and Technology

When offered in isolation, the availability of educational methodology and technology will usually not accomplish significant classroom change. Most faculty view themselves as already being excellent teachers, or may not view themselves as primarily being teachers at all. Conversely, a few may place considerable value on teaching but view themselves as irredeemably bad teachers who cannot make effective use of traditional methods and technologies let alone new ones. Consequently, training in educational methodology and technology should always be cnducted with the attitudinal and structural supports that are needed to sustain experimentation in the classroom. Often instructors will come to training sessions in order to learn a few tricks for the classroom, hoping that these tricks will save a course or an instructional style that is actually in need of much more profound reconsideration.

As one of a series of components in a comprehensive faculty development program, training in educational methods and technologies is essential. An instructor may have critically examined and even changed his values with reference to teaching and student-faculty relationships. He may have received helpful feedback and training with reference to classroom instruction. At a certain point, however, he will want to explore new ways of presenting the material for his course and will want to design a course in such a way as to make it more compatible with his new-found style of relating to students. New educational methodologies will provide him with the needed information. Knowledge of contract learning systems, self-paced courses, and experience-based learning programs allows the instructor to tailor-make his course to the students he is serving, to the educational environment in which he and the student are operating, to the learning objectives of the course, and to his own preferred teaching style. Similarly, in acquiring knowledge of new technologies, an instructor will experience greater freedom in planning courses and in making himself available to students in a variety of roles.

Methodological and technological resources are of course available in colleges of education throughout the country. Many of the means and mechanisms that have been developed for primary and secondary education can be adapted for use in higher education. We should also look to nontraditional educational institutions for assistance in these areas. In particular, the armed forces educational and training programs offer vast technological resources that are increasingly available to civilian educational institutions. We should not forget that "simulations," as instructional devices, were first developed and used by the military. Innovative methodologies and technologies are also available in many proprietary schools and in the training and educational program of many large corporations. At present, American higher education seems to be less in need of new ideas than in need of mechanisms for learning about and using the innovations emanating from other educational and training institutions in the society.

An effective faculty development program should also provide consultation on methodological and technological problems for faculty. Furthermore, campus resources should be identified and made available to faculty for the design of specific learning programs, as has been done at Syracuse University. Experts in the design of simulations or in the production of multimedia presentations can also provide a valuable service, provided the faculty have made use of other resources and experiences that make these technological resources something more than pedagogical bandages.

E. Curriculum Development

From a long-range perspective, the greatest impact on the educational process will probably come from curriculum development. Consequently, one of the greatest challenges to a faculty development program is influencing the design of curricula in the various departments of the college or university. Curriculum development should not only move the institution toward more relevant and interesting instruction, but it should also make the institution and its curriculum more responsive to the changing population of students and their changing educational needs [16]. Certainly in training faculty members for curriculum development, attention should be given to educational philosophies and theories of student development [14, 19, 34].

Departmental and divisional curricula, however, are deeply embedded within the structure of the organization itself, for they reflect not only a number of assumptions about how various professional fields are organized and should be taught but also a sense of organizational entity and autonomy. To tamper with a department's curriculum is to become involved in its very existence as an organizational unit. Consequently, consultation should be provided to individuals and departments on not only specific curricular matters but also on the process whereby those decisions will be made. In other words, as faculty development moves from issues of instruction to issues of curriculum, it moves from instructional development to organizational development. Colleges and universities are complex, many layered institutions, and serious and careful consideration must be given to the ways organizations work—or do not work—if faculty development is to have long-term success.

ORGANIZATIONAL DEVELOPMENT: CHANGES IN STRUCTURE

A faculty member seeking to develop innovative courses based on nontraditional perceptions of student needs, faculty roles, and institutional objectives will soon encounter the powerful and demobilizing resistances of his colleagues. Even the best-planned instructional or faculty development program will frequently run aground at this point. Like the junior corporate executive who returns from a two-week sensitivity training session to find that his new skills are neither understood nor accepted by his colleagues, the faculty member who has just returned from an exciting two-week workshop on faculty development will often be immediately confronted with the barrier of skepticism, suspicion, and even open antagonism. To deal directly and effectively with this issue, a faculty development program must be designed to deal with organizational development issues and the process of change in traditional decision-making procedures.

With a few notable exceptions, the use of organizational development as a tool in higher education is basically untested. These exceptions include the work of Walter Sikes at the Center for Creative Change in Higher Education, of [redacted] Lindquist at the Strategies for Change and Knowledge Utilization Program, Saratoga Springs, New York, and of several instructional development centers around the country, such as the Institute for Research and Training in Higher Education at the University of Cincinnati and the Center for Human and Organizational Research and Development at the University of Idaho. Organizational development has been more widely used in primary and secondary education [49, 26, 27], in business and government [8, 7, 6, 23].

The organizational development components of faculty development are: departmental (*a*) decision-making, (*b*) conflict management, (*c*) team building, and (*d*) management development The division of organizational development into these four components is somewhat arbitrary Each of these elements more accurately represents alternative perspectives on a single entity, the organizational functioning of the department. Departmental decision-making, for instance, can be conducted most effectively if the academic unit adopts methods and relevant norms for the management of conflict. Similarly, departmental team building is a useful precursor of conflict management Conversely, if a department has adequately addressed the problem of departmental decision-making, then it has indirectly dealt with issues of conflict management and has probably also conducted informal team building Nevertheless, it may be useful to discuss these components separately.

A. Departmental Decision-Making and Conflict Management

These components are relevant to the curriculum development component mentioned in the previous section A department can make significant changes in the curriculum only if it is willing to tolerate conflict and is able to make decisions in relatively short periods of time. Academic departments are frequently unable to change curricula because departments are simply incapable of making significant decisions involving high levels of conflict. Instead, departments often dwell on such relatively trivial matters as whether or not a particular course should be offered to juniors or to seniors, or if particular courses should have certain prerequisites.

The organizational ineffectiveness of many academic departments is intensified by the diversity of goals and missions in the institution itself and by the enduring norm of intellectual autonomy. Given these complex, disruptive forces, it becomes essential that academic departments receive training and consultation in decision-making and conflict management.

Several models of decision-making seem to be particularly appropriate to academic departments, one being Jay Hall's [25, 24] adaptation to decision-making of the managerial grid [11, 12]. Hall [25] describes the two primary concerns of any decision-maker as (*a*) concern for the adequacy of the decision and (*b*) concern for the degree of commitment of members of the organization to the decision Hall differentiates among decision-makers who are primarily oriented toward decision adequacy, toward commitment of the group to the decision, toward compromise, or toward withdrawal He believes that it is both theoretically and practically possible to combine both decision adequacy and the commitment of the group to the decision made One of the limitations of traditional decision-making is that decisions are frequently not made by the people who have to carry them out The original decision may have been a perfectly good one, but if it is one that does not command the commitment of the group which must implement the decision, its chances for success are distinctly limited In identifying a decision-making model that combines adequacy and group commitment and in linking this model with "consensual" modes of decision-making, Hall has defined a particularly appropriate objective for academic departments, for the very individuals who make decisions in many departments—the faculty—are also the individuals who must directly implement these decisions in the classroom.

A useful conflict-management model for academic departments has been developed by Fosmire and Wallen [20]. They identify different types of conflict through examining several steps to be taken in any effective analysis of a problem. A person or group must define and examine *situational* variables that impinge on the problem, *target* variables that define the problem goals and directions, and *proposals* whereby the person or group can move from its current situation to the defined target(s). Fosmire and Wallen believe that conflicts emerging from situational issues can be resolved through the collection of additional information, whereas target conflicts can be resolved only through equitable compromise. Given the clear statement of current situational variables and targets, Fosmire and Wallen believe that conflicts surrounding proposals can be adequately resolved using consensual modes of decision-making. In departmental decision-making, situational variables may include accurate assessment of student needs, departmental strengths and weaknesses, and available supporting resources. Target considerations may include a clarification of departmental goals, of personal values and attitudes, and of desired behavioral outcomes for students. Members of the department involved in proposals arising from these situational and target considerations will tend to feel more ownership for these proposals and, perhaps, work more actively for their implementation.

Departmental decision-making and conflict management can be improved through training programs and/or consultation. Training can be received from many different institutes, though most, like the Sloan School of Management at MIT and the UCLA School of Business, are primarily oriented to nonacademic institutions. The Center for Creative Change in Higher Education (Yellow Springs, Ohio) has offered an organizational development training program specifically designed for academic institutions. The Western Interstate Commission for Higher Education (WICHE) (Boulder, Colorado) has offered a "Management of Innovation" program for higher education that provides training and consultation services to schools within specific regions of the West. The Strategies for Change and Knowledge Utilization program offers training programs for campus-change teams from selected colleges and universities throughout the United States.

B. Departmental Team Building

In the past decade many organizations in the United

States have recognized the value of preliminary team building for any task group, especially if the group must function over a short period of time as a "temporary society" [9]. Like any task-oriented group, team building for academic departments can lead to improved decision-making. Such team building might include discussions of future directions for the department or departmental roles, feedback to the chairman on ways in which he helps or hinders departmental functioning, and extensive organizational diagnosis, usually by an outside observer. At a different level, a team-building effort often focuses on the emotional climate of the department. Members of a department are encouraged to establish more open and meaningful contacts with their colleagues as a means of breaking down barriers often associated with isolated college teaching and research. In summary, a team-building effort requires the academic department to pause in its current deliberations in order to focus on its own operation.

Team building has not been widely used in campus organizations. As in the case of departmental decision-making and conflict management, this component of faculty development tends to be highly threatening to faculty, and often erroneously seems irrelevant to the improvement of instruction.

C. Management Development

This particular activity is probably the least threatening component of organizational development. Most faculty accept the value of management training, especially if it is for their department chairman rather than for themselves. Furthermore, management development has high face validity with reference to the daily functioning of the department, as it often involves training in such tangible skills as fiscal planning and administration.

The management-by-objectives (MBO) training program is widely used in management development [17, 42, 28, 30]. Given the diffusion of mission and goals in most academic departments, the MBO program may be particularly helpful in providing clarity and consistency in the often chaotic management of academic departments [30]. MBO programs are currently being offered to academic administrators through the National Laboratory in Higher Education (Durham, North Carolina). The Managerial Grid [11, 12] and Teleometrics programs (Austin, Texas) also provide valuable and somewhat different training resources to academic administrators, though the programs are primarily designed for corporate executives. Similarly, many of the executive-level management training programs of the National Training Laboratory are of potential use to the college administrator.

A management development program might alternatively focus on the financial aspects of administration. The chairman or other administrative members of the department can readily benefit from training in the management of budgets. With the increased emphasis in higher education on fiscal accountability, and with the availability of new cost-finding instruments such as the RRPM programs of the National Center for Higher Education Management Systems (NCHEMS), department chairmen and other middle-level administrators will become increasingly anxious to avail themselves of fiscal management training. NCHEMS (Boulder, Colorado) currently offers training programs throughout the country in the use of their planning and management systems instruments.

The relevance of management training to a faculty development program may not seem to be immediately apparent, yet with some reflection on the linkage between the several components of the model, the direct relationship of fiscal management to faculty development becomes clear. A faculty development program can begin at many places and arrive at many goals that are not immediately identifiable when the program begins.

PERSONAL DEVELOPMENT: CHANGES IN ATTITUDES

An effective faculty development program often causes a faculty member to reexamine his own life goals and values. He may try to improve his interpersonal skills and his ability to be creative and risk-taking in his design and execution of course programs. Such changes in personal style inevitably have a profound effect on other aspects of his life. In designing a faculty development program, one must be fully aware of the spin-off effects from a successful program, which, by definition, changes people. All too frequently, we compartmentalize our images of change, neglecting the fact that when we change the professional performance of an individual we have usually touched his family life, his relationship with his colleagues and students, and perhaps even his life goals.

An effective faculty development program may temporarily produce feelings of isolation from his colleagues for the new educational innovator. This isolation can be very difficult to cope with, especially if one of the primary forces previously preventing the individual from experimenting with new ideas was his fear of rejection. On the other hand, the professor who has suddenly found teaching to be personally gratifying and has found his relationships with students to be satisfying may find that such changes are viewed with mixed feelings by his own family, who previously held a much larger proportion of the professor's attention and interest.

The personal development dimension of faculty development makes three basic assumptions. First, one must be prepared for events which superficially may indicate that the program has been at best unsuccessful or at worst destructive. Faculty members who have participated in a faculty development program may experience emotional problems that reflect the difficult steps usually associated with significant personal growth. Such "prob-

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lems" point to the second assumption, namely, that a faculty development program must provide personal assistance to the individual who is struggling with personal issues On a preventive level, informal discussion sessions led by trained counselors or personal growth leaders should be provided. Preferably, the program should offer life planning laboratories, in which faculty members can deal constructively with personal issues in a low-threat and supportive environment Given the unfortunate fact that some instructional styles are elaborate defensive structures covering serious emotional problems, it is also necessary that corrective, supportive, or therapeutic services be available to individuals participating in a faculty development program. Any workshop or personally oriented training session being conducted as part of a faculty development program should be designed in consultation with a clinical psychologist, counselor, or psychiatrist, who should be consulted concerning both the level of stress in the workshop and the means of dealing with any pathologies that might possibly develop Furthermore, the training staff should be knowledgeable about clinical referrals, since participants who have gained trust in the faculty development staff may wish to ask for referral assistance A third assumption, however, must be made, a faculty development program is not a therapeutic enterprise To concretize the distinction of the program from psychotherapy, each participant in the program should indicate, when signing up for the program, that he fully recognizes that the program is neither psychotherapy nor a substitute for psychotherapy.

Personal development in almost any form may be somewhat threatening to many faculty and may have rather low face validity as a means of improving instruction. Consequently, faculty development programs are perhaps best not built around a personal development component, although that component must nevertheless be present if the need arises There is, however, another component of faculty development that has the advantage of encouraging faculty to explore personal aspects of their teaching profession and is usually not threatening and has high face validity This component is the faculty interview procedure developed by Nevitt Sanford and his colleagues at the Wright Institute (Berkeley, California) [46] We shall turn, first, to this component before considering life planning workshops, interpersonal skills training, personal growth workshops, and supportive and therapeutic counseling.

A. Faculty Interviews

This particular procedure was first used in a study of values and attitudes of college teachers Like most effective "action-research" projects [45], however, the interview procedure proved to be of value not only to the data collectors but also to those faculty members who were interviewed. When asked to examine their values and attitudes concerning teaching, college professors found the task to be both enjoyable and beneficial. The faculty members, according to Sanford [46], "are given a chance to reflect on important matters that have been little in their attention." Given the self-definition of most faculty as members of specific disciplinary groups, the information that is produced by directing questions to them concerning their teaching and not their discipline can be insightful to both the professor and the interviewer.

The faculty interview has usually been administered by a trained professional or student in a one-on-one setting. The interview may last from one to four hours. Questions range from "How did you decide to become a teacher?" to "If you were not a teacher, what do you think you would like to be?" The one-on-one interview procedure has been tried at a number of different colleges and universities in the United States, and has been incorporated as a significant component of several recent interinstitutional programs [40]. Alternatively, the questions contained in the Wright interview schedule can be introduced in a small group setting. Members of the group reflect on each question for several minutes, then discuss their answers with other members of the group. While this latter procedure does not usually allow for in-depth investigation of any one member's answers, each participant can compare his own responses with those of the other members, thereby providing a social reality against which to compare values and attitudes.

The faculty interview, focusing as it does on teaching and learning, is usually acceptable to most individuals, especially if it is perceived by the faculty member being interviewed as part of a research project and if the interviewer is genuinely interested in the responses that are requested. The faculty interview thus becomes a valuable introduction to a faculty development program. By focusing the attention of a faculty member on his own assumptions about teaching, one can awaken him to a vast array of issues and concerns: "Why am I teaching?" "Do I really value teaching if I spend so little time thinking about it?" "Are there other faculty who are also interested in talking about teaching?" If the faculty interview is combined with the other components that have been identified in this paper, then the process of change may eventually extend in many different directions. The rapport that can develop between interviewer (a representative of the faculty development program) and interviewee may sustain further explorations by the interviewee of the available options in the program.

B. Life Planning Workshop

This procedure can be a very effective means of facilitating the faculty member's critical reflection on the personal aspects of his own professional life. The life planning workshop model is based on the assumption that many life decisions are made from an inadequate base of information. Life planning enlarges this base by identifying relevant personal feelings, attitudes, values, and experiences, and using them as part of the decision-making process. This model has been used quite extensively with students through student life and counseling centers.

The faculty member who participates in a life planning workshop will find it to be a logical extension of his faculty interview. He will be asked to reflect on a number of questions concerning both his past (e.g., "Describe a peak experience in your life") and his future (e.g., "Briefly describe a typical day in your life ten years from today"). The life planning workshop also focuses on the participant's assessment of current resources and liabilities, and provides opportunities for him to explore and express some interrelationships between feelings, attitudes, and fantasies that he experiences. A final step in most life planning workshops is the development of a specific project related to newly acquired perspectives.

C. Interpersonal Skills Training

The profession of college teaching involves a great deal of interpersonal contact in a number of highly complex settings. Given these demands, the role of interpersonal skills training in a faculty development program becomes quite apparent. Though this type of training program is somewhat less personal than either life planning or faculty interviews, it can be highly threatening, especially for the faculty member who has never been openly confronted with the effects of his interpersonal behavior. This component should not, therefore, be among the first steps of a faculty development program but should follow those components like the faculty interview and the life planning workshop which provide personal support for examining difficult interpersonal issues and those components like classroom diagnosis and microteaching which provide the faculty member with interpersonally oriented feedback on his performance as a teacher.

Several different interpersonal skills are of particular importance to the college teacher. Paraphrase is a very important communication skill, as are perception checks and descriptions of feelings [49]. A college teacher could also profit from experiences in unstructured interpersonal settings like T-groups [48] and from such structured interpersonal training exercises as role reversal, "shadowing" (trying to follow the thoughts and feelings of another person), and "fish-bowling" (one group of participants observing and providing feedback to another group), to mention but a few [43]. A wide variety of interpersonal theories can also be profitably introduced, ranging from transactional analysis [10] to the Johari Window [33].

The individuals who are conducting these workshops must not only be familiar with the theoretical basis for the training but must also be skilled in the translation of these theories into training modalities. Unfortunately, on most campuses there are many individuals who are very conversant with communication theory or transactional analysis but are inexperienced in workshop design and implementation. Conversely, many individuals on college campuses have participated in numerous T-groups, encounter groups, gestalt groups, and so forth, yet are not in a position to convey their learnings from these experiences in a helpful manner to other people. The individual who has command of theory, as well as expertise in conducting workshops, at times for skeptical populations, will be a valuable asset to any faculty development program.

D. Personal Growth Workshop

When first considered, this component of the faculty development model is probably the most controversial. For many faculty members, personal growth workshops conjure up the image of a small huddle of people babbling in an incoherent manner about their loneliness, frustrations, or sexual inadequacies. Phrases such as "strip and crawl" and "grope group" are bandied about in a humorous but nervous manner when personal growth groups are discussed in conjunction with faculty development. Unfortunately, these prevailing attitudes are founded on ignorance of the substantial and positive impact that competently run personal growth workshops can have. While personal growth workshops are not the panacea for all social ills as some "groupies" would have us believe, they can be vehicles for significant personal learning and are, at their best, safe places for an individual to explore new dimensions of his personal life and resources.

Several specific personal growth workshop models are particularly valuable for college teachers. The personal growth workshops conducted through NTL by John and Joyce Weir offer a personal growth model of "self-management" which would seem to be very appropriate for instructors or advisors who wish to loosen their control on (or by) other people. The NTL "Centering" workshops also offer the potential of increasing an individual's command of personal, creative resources. Similarly, some of the gestalt workshops, if chosen with care, can be useful personal growth experiences for the college teacher.

With proper training, members of a faculty development staff could specifically design a personal growth workshop that focuses on instruction-related issues. These workshops must, of course, be conducted under a strict code of ethics, with adequate clinical consultation. Furthermore, this segment of a faculty development program must be considered "advanced"; it should be opened only to faculty who have participated in other aspects of the program and have exhibited emotional stability and an absence of pathology.

E. Supportive and Therapeutic Counseling

A faculty development staff should make counseling and therapeutic resources available to faculty members who have found, through the faculty development program, that they have significant emotional problems which are preventing them not only from being effective teachers but also from leading fulfilling lives. In many instances the counseling component will precede the other components for those individuals who exhibit some pathologies. The faculty member who has benefited from supportive or therapeutic counseling may, subsequent to this treatment, wish to make use of the other resources of the faculty development program. With personalized and professional attention, most faculty should ultimately be able to benefit from all aspects of the faculty development program.

IMPLEMENTING A FACULTY DEVELOPMENT PROGRAM

The various components which have been discussed by no means encompass all activities that may comprise a faculty development program. These components, however, are among those that have been shown in diverse settings to produce the greatest impact on the teaching-learning environment of a campus. In constructing a program that incorporates these components, one must face the limitations in time and resources. A comprehensive faculty development program is certainly not a part-time responsibility for one faculty member or administrator, nor is it a program that can be carried out exclusively with volunteer help. A faculty development program begun with serious intent must be adequately staffed by professionals, with additional support provided by other available campus resources, including both faculty and students.

A critical decision for any faculty development program comes when an entry point into the system is identified. Although this decision may have already been made as a result of previous programs, the most appropriate entry points are probably faculty interviews, evaluation (especially self and student), and management development. The first of these entry points is preferred, because it is both of low threat and of direct relevance to teaching and learning. The second entry point is rather threatening, while the third entry point is not directly related to instructional improvement, although it can be an effective first step if the faculty are more immediately concerned with administrative than instructional issues.

Critical decision points are also often found in the movement from one component or aspect of the program to another. Movement between components may be difficult either because one component does not lead logically to the next or because one component does not adequately prepare the faculty member for the next. Though all of the components should be defined at the start of a faculty development program, they should be publicly introduced only when they seem to be appropriate from the developmental perspective of the participants in the program and the institution being serviced by the program. Thus, components such as personal growth and departmental team building should not receive high visibility at the start of a faculty development program, but should instead emerge as the participating faculty members recognize the need for these services.

CONCLUDING COMMENTS

The processes of change, as they involve any person or institution, are always subtle and ill defined, and a successful faculty development program will not necessarily answer all of the problems of the institution in which it has been conducted. The fact that some changes in faculty attitudes, processes, or structures have taken place, however, is itself justification for the program. But a faculty development program that is successful will usually have a broader impact on the campus than may have been initially anticipated. Faculty development may merge into academic community development. Under such conditions, we will be confronted with new challenges as well as new insights into the problems of higher education. If such is the case, then our efforts at faculty development may be of greater significance than any of us may now hope or imagine.

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APPENDIX B

William H. Bergquist and Steven R. Phillips, "Designing a Faculty Development Program," *A Handbook for Faculty Development*, Volume I (Washington, D.C.: Council for the Advancement of Small Colleges. 1975). Chapter 15.

CHAPTER FIFTEEN

DESIGNING A FACULTY DEVELOPMENT PROGRAM

"Faculty Development" is a term which encompasses a remarkably diverse set of assumptions, activities, and goals. While every faculty development program should hold increased student learning as its primary goal, there are many justifiable ways to enrich the quality of learning that can take place in higher education for both students and faculty.

A. Components of Faculty Development

In examining these various approaches. it would perhaps be useful to identify and interrelate the various components which constitute faculty development. The expository sections of this handbook have provided a discussion of some of the more important components in a training or consultation-oriented faculty development program. To summarize this list of components. we suggest the following organization:

I. Instructional Development is composed of
  A. Evaluation
  B. Diagnosis
  C. Training: Traditional Methods
  D. Training: New Methods and Technologies
  E. Curricular Development
II. Organizational Development is composed of
  A. Team-Building
  B. Decision-Making
  C. Conflict-Management
  D. Problem-Solving
  E. Managerial Development
III. Personal Development is composed of
  A. Discussions about Teaching
  B. Career and Life Planning
  C. Interpersonal Skills Training
  D. Personal Growth
  E. Therapeutic and Supportive Counseling

While each of these components can play a potentially major role in creating a successful faculty development program, the sequence in which they are presented may be even more important. Some of these component should be introduced before others, either because one develops logically out of another or because some are less threatening or more easily implemented than others. Early success can build a basis of credibility for the program that will allow for the introduction of other components.

As an example of a developmental sequencing of components, consider the relationship between instructional diagnosis and training. Frequently, faculty development programs provide training in basic teaching skills or in the use of new instructional methods, without having first provided the faculty member with information about his current performance. In essence, this sequence asks the instructor to make decisions about significant changes in his style or method of teaching without adequate information about his current performance in the classroom. A diagnostic component clearly should be introduced along with or before a training component. Conversely, an evaluation or diagnostic component should not be left standing alone in a faculty development program, for if the faculty member receives evaluative or descriptive feedback about his performance in the classroom, yet is provided none of the resources that are necessary to bring about change in this performance, then he quite justifiably cannot be expected to improve his teaching. Every piece of information that is generated from an evaluative or diagnostic instrument should be coupled with an available training component; otherwise, diagnosis is likely to be more punitive than beneficial.

As an example of a sequencing of components to build credibility and support, we can examine the relationship between "discussions of teaching" and "life planning." While the latter is extremely important in any faculty development program attempting to touch on the personal domain of a faculty member's life, it is often misunderstood and consequently rejected out of hand by faculty. Discussions about teaching, on the other hand, are obviously appropriate to faculty development, and hence should precede, and may lead toward, the life planning component.

The problem of sequencing is particularly important when considering the first steps in a faculty development program. In some instances, these will have already been decided. A president, for example, may decide that faculty should receive training in the use of self-paced instruction, or that faculty should all be evaluated by students, or that incentive grants should be given to faculty who try out new methods in the classroom. The effective faculty development consultant will at this point usually not try to change such decisions unless they violate his ethical or professional standards. Rather, the consultant should work from the institution's own definition of the problem and desired outcome; he may wish, however, to expand the plan and possibly even redirect its definition, while at the same time providing services that directly confront the initially defined problem.

If the consultant is given the opportunity to define a point of entry, he should make this decision on the basis of a systematic assessment of institutional environment and goals[1] and on the basis of institutional acceptance of the services being proposed. One specific entry service (for example, faculty evaluation) may seem right for a particular institution, given its current problems and goals, and may make developmental sense, in terms of the other components of faculty development. However, if faculty find this service to be too threatening, then another entry service should be identified which is not as threatening, like discussions about teaching. This service, in turn, should be designed to lead the participants, and eventually the entire institution, toward a recognition of the importance of more far-reaching activities.

Several of the components identified in this book are particularly appropriate entry points. (1) "Discussions on Teaching," (2) evaluation (especially self and student), and (3) managerial development. The first of these entry points is particularly effective, for it is of low-threat and is directly relevant to teaching and learning. The second entry point may be rather threatening, while the third may be an effective first step only if the faculty is intimately involved with administrative issues.

B. Strategies for Faculty Development

Decisions concerning the sequencing of various faculty development components unfortunately are often made neither on the basis of an assessment of institutional environments or goals nor on the basis of a logical sequence of development. Frequently, these decisions are based on untested and even unstated assumptions about how people and institutions change. These assumptions often form an elaborate construct or "paradigm,"[2] a configuration of particular concepts, materials, methods, technologies, and modes of evaluation through which the process of change is seen. Paradigms vary from individual to individual and institution to institution. To the extent that these paradigms are untested and unarticulated, each individual and institution not only is unaware of holding a particular paradigm but also is unaware that any other paradigm might be equally valuable.

In order to increase awareness about alternate faculty development paradigms,[3] we offer a list of eleven strategies. Each will be briefly described in terms of three issues. (1) assumptions about change, (2) assumptions about teaching and learning, and (3) assumptions about the theory, concepts, or tools of faculty development. Four program designs based on several of these strategies are offered as supplementary documents to this chapter. A forthcoming book by Jerry Gaff, to be published by Jossey-Bass, will describe in some detail the activities of numerous instructional improvement centers throughout this country (see Appendix A) and will hopefully provide a much more sophisticated categorization and description of these various faculty development strategies.

1. Strategy Number One: Training

Faculty development programs that exemplify this strategy tend to be based on the assumption that change occurs primarily by giving people new skills that can be used not only in the performance of specific tasks like teaching but also in the accomplishment of change itself. It is assumed that reward or punishment systems *per se* will not change people; rather individuals must be provided with new skills, attitudes, and behaviors that are appropriate to the desired change. Faculty development practitioners who embrace a training paradigm usually assume that faculty will be more effective teachers if they are provided with new skills in conducting traditional courses and in using new methods or technologies which reflect new attitudes about teaching and learning.

The training paradigm emphasizes the use of both short- and long-term workshops, as well as classroom diagnosis. Personal and instructional development both tend to be emphasized in this paradigm. Organizational development is only partially employed; faculty are trained in the use of such organizational skills as decision-making and conflict-management, but there is usually only indirect concern for organization-wide diagnosis, feedback, or intervention.

Several sequences of faculty development components have been frequently used with some success in training-oriented programs. One sequence, which is more fully described in Planning Document Number Four, involves, first, one or more basic week-long instructional development workshops, usually held during the summer. These workshops focus on teaching methods, training and teaching skills, exploration of assumptions, values, and philosophies associated with teaching, and training in decision-making and problem-solving. Once a certain number of faculty (usually at least ten percent) are involved in the training program, it can begin to expand beyond the workshop level. Faculty may be offered classroom diagnostic services. Contacts may be established between faculty who want to explore certain areas and faculty who have expertise in that area. Departments and divisions may be trained in the use of specific organizational skills.

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[1] For a fuller discussion of this point, see an article by William H Bergquist forthcoming in a collection from Jossey Bass tentatively titled *Elements of Survival*

[2] This term has been used by Thomas Kuhn in his important study *The Structure of Scientific Revolution* (2nd ed., Chicago University of Chicago Press, 1970).

An alternate sequence begins with short-term, on-campus seminars that focus on specific methods or technologies. Usually a rather large number of faculty will participate in these seminars over a two- or three-year period, though these seminars in and of themselves will rarely have a significant impact. Once the credibility of the program is established through these seminars, other types of services may be offered, including more extended workshops, peer assistance programs in which one faculty member works with another in a specific area, and classroom diagnosis. This more cautious sequencing of components is appropriate in a college or university that is not particularly supportive of faculty development or the improvement of teaching from a nondisciplinary perspective.

2. Strategy Number Two: Consultation

The consultation-oriented approach to faculty development, on the surface, seems to be similar to the training strategy. However, there are distinct and important differences between the two The consultation paradigm does not begin with an assumption that training is always an important aspect of change. As a matter of fact, at least one consultative model begins by rejecting the basic assumption concerning the desirability of change itself.[3]

A person using a consultation approach to faculty development will not begin with any well-developed preconception about what the problems are in the teaching and learning process. He will usually make extensive use of information collection, analysis, and feedback after having taken the most critical and often controversial step in the consultative process, the identification of the client: is the client the faculty, the president, the trustees, or the students?

The client, once identified, will define the goals of the program. Given the necessary responsiveness of a consultant to his client, no one sequence of components can be defined as being "typical" of this strategy. Only in the case of the entry point is there a common pattern among consultants. Prior to any consultative intervention, some clarification of the client's problem usually occurs, along with the establishment of a preliminary contract in which the obligation and expectations of both client and consultant are spelled out in some detail. Many consultative processes are basically a recycling between information collection and clarification and contracting between the client and consultant The primary goal of the consultant in this process is to generate valid and useful information for the client, while increasing his options for action. Needless to say, this type of dispassionate, almost detached, process can rarely be achieved by an individual who works within the organization to be served. At an early stage, external consultants can usually do a more effective job than consultants who are based within an organization.

3. Strategy Number Three: Personal and Organizational Development

Personal and organizational development strategies are grouped together because they both emerge from the single paradigm of applied behavioral science. Beginning with the work of Kurt Lewin in the 1930's and early 1940's[4] a steadily accumulating set of theories, models, and techniques have developed around the basic assumption that the process as well as the substance of change must be planned and managed if change is to be successful and productive. Both the personal and organizational aspects of change are emphasized, with attention being given to such issues as (1) sense of ownership for the change process, (2) development of collaborative rather than competitive relationships in the solution of personal and organizational problems, (3) recognition of the personal as well as organizational benefits and costs of a specific policy, and (4) creation of an organizational climate that is characterized by trust, openness, and interdependence.[5] Many of the exercises, handouts, and instruments offered in this handbook reflect this paradigm.

The personal and organizational development strategies differ somewhat from the training or consulting strategy in that their orientation is not primarily toward instruction. Herein lies both the strength and weakness of both the personal and organizational strategy for higher education. In the recognition of personal and organizational dynamics that are common to all human systems, the applied behavioral scientist is able to translate important learnings gained in one setting to a seemingly quite different institutional setting. These practitioners, however, often ignore some of the essential differences between the systems which they serve, and at times neglect the essential problem with which they were initially confronted by the client system. A faculty development consultant, for instance, who indiscriminately uses sensitivity training, team-building, process observation, or life planning will often find that his client grows impatient in waiting for him to directly respond to an entry problem that is likely to be concerned with better teaching.

4. Strategy Number Four: Method-Promotion

The fourth strategy to be considered also initially resembles the training strategy. Method-promotion,

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[3] Chris Argyris, *Intervention Theory and Method A Behavioral Science View* (Reading. Mass. Addison-Wesley, 1970)

[4] Alfred J Marrow. *Practical Theorist. The Life and Work of Kurt Lewin* (New York: Basic Books, 1969).

[5] For further discussions of this issue, see Edgar Schein and Warren Bennis, *Personal and Organizational Change through Group Methods* (New York Wiley. 1965); Warren Bennis, Kenneth D. Berne and Robert Chin *The Planning of Change* (New York: Holt, 1969); Warren Bennis. *Organization Development. Its Nature, Origins, and Prospects* (Reading. Mass., Addison-Wesley, 1969); and Wendell L. French and Cecil H Bell, Jr., *Organization Development* (Englewood Cliffs, New Jersey; Prentice-Hall, 1973)

however, differs from the training strategy in that the primary focus is on a specific method of instruction or a particular educational technology. This strategy has been widely used in recent years for the promotion of criterion-reference instruction, self-paced instruction, the Keller Plan, and personalized self-instruction. These methods enable a student to master specific skills or knowledge in order to pass a course or receive a certain grade. Programs which promote the use of these instructional tools have been widely established in such diverse settings as the United States Air Force (the Community College of the Air Force) and Cleveland State University. Similarly, a dominant emphasis has been placed in some faculty development programs on the use of experience-based methods, instructional simulations, or audio-tutorial devices.

The specific methods or technologies being promoted are, of course, assumed to be at least partial answers to the teaching and learning problems encountered in colleges and universities. The sequence of implementation usually leads from an emphasis on the specific method or technology to either classroom evaluation or diagnosis. Personal and organizational development components are generally only important to the extent that they provide support for the personal and/or institutional acceptance of the instructional tool being promoted

5. Strategy Number Five: Instructional Materials

This strategy is often hard to discriminate from the previous strategy, for in many instances new instructional materials are developed as part of the process of promoting the use of a specific method or technology This strategy, however, can embrace a far more eclectic approach to the development of instruction and will at times much more closely resemble either the training or consulting strategy. The assumptions about change that are usually associated with this strategy center on the availability of resources: people are not more effective, or do not change their mode of operation, because they are neither provided with the necessary resources nor the expertise to generate new resources Specifically, faculty have neither the training nor the time to develop highly sophisticated instructional materials. Change, it is assumed, will take place when these resources become available.

The new instructional resource centers that have been established at several institutions, most notably Syracuse University, either provide faculty members with prepared instructional materials or work closely with the faculty in the design of materials that are specifically tailored to the instructor's goals, knowledge, or pedagogical orientation. This type of faculty development program holds great promise for the future, especially with the increasing emphasis being placed on fiscal accountability. Though many faculty resist the idea that an instructional specialist who is not trained in their discipline may be helpful, this type of service is being used with increasing frequency in many of the instructional resource centers now in existence.

The materials-oriented faculty development program usually begins in a consultative manner, with members of the staff working with a few faculty on the identification of existing materials or on the development of new materials As the program gains credibility, the instructional resource center staff will often offer training programs both to acquaint faculty with the diversity of pedagogical tools that are available and to improve the skills of faculty in the design of their own materials. Workshops on instructional simulations, for instance, can help faculty in designing their own simulations, as well as in selecting existing simulations that are appropriate to their own specific instructional needs At a more advanced stage, the instructional resource consultant may work with an entire department or division on total instructional programs. At this point, the resource consultant may be moving into the much broader area of curriculum development If the resource center staff is aware of and prepares for this expansion of services, it can gain even greater credibility and can produce even more significant change than it may have originally thought possible.

6. Strategy Number Six: Equipment

As mentioned in the introduction to this handbook, many of the major attempts in the past to improve the quality of instruction have focused on the acquisition of new instructional equipment like slide projectors, video tape equipment, and computers Several current programs that are described as "faculty development" continue to be primarily concerned with the acquisition of such equipment. While there are numerous weaknesses inherent in this approach to change, it can be a viable strategy, particularly when used in large, research-oriented institutions, provided it is coupled with an effective training and promotion program.

The equipment paradigm in higher education clearly reflects the more general "technological" paradigm held by our society. It is assumed that many social system problems, like physical system problems, can be solved through technological innovation and dissemination. If we can send a man to the moon, so the argument goes, then we should be able to develop and distribute instructional equipment that will increase the efficiency as well as the quality of the teaching-learning process. The methods and concepts embraced by this paradigm focus on the invention, innovative use, and dissemination of technology. Many of the people who embrace this paradigm are fully aware of the personal and professional problems associated with these three phases of technological change.[6] Thus, the strategies of training, consultation, and organizational development may be ef-

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[6] Donald A. Schon, *Technology and Change The New Heraclitus* (New York Delacorte, 1969)

fectively employed in conjunction with the equipment strategy. Without this expanded conceptualization technological dreams which many hold will never be fulfilled.

7. Strategy Number Seven: Discussion

This strategy reflects the traditions of higher education and is readily embraced by and rarely threatening to many faculty members. Practitioners who employ this strategy usually assume that faculty entering into in-depth discussions about their teaching will gain a more mature perspective on the teaching profession and a more explicitly defined educational philosophy If the discussions are held over an extended period of time with the assistance of a trained leader, they may produce significant personal and/or professional change The work of Nevitt Sanford and his colleagues at the Wright Institute probably best exemplifies this strategy (see Chapter Twelve) The faculty development program now being conducted at California State College in Northridge by Daniel Sedey exemplifies a variation on this strategy A small group of faculty are selected each year to participate in a seminar on college teaching These faculty members are given release time to attend as well as prepare position papers, research projects, and so forth for the seminar group Through the seminar discussions, faculty explore a wide variety of issues related to college teaching In the process of discussing these issues with their colleagues, the participating faculty clarify their own assumptions about teaching and explore alternate modes of learning.

8. Strategy Number Eight: Evaluation

As indicated in Chapter Three evaluation is an essential, though often abused, component of any goal-directed system It often serves as an entry point for faculty development and is among the most widely used tools for the improvement of instruction. The evaluation paradigm is based on the assumption that change takes place when a faculty member is confronted with information about his performance in the classroom, through diagnosis and evaluation.

A faculty evaluation program is based on the assumption that evaluation can serve a constructive and developmental purpose Some evaluation programs, however, are implemented primarily to provide academic administrators with information to be used in making decisions about tenure, promotions, and salaries. This latter use of evaluation is frequently associated with the reward system approach to faculty development to be discussed next.

Since we have already addressed the use of evaluation and its sequencing with other components in some detail in several other chapters of this book (particularly in Chapter Three), it is enough to say at this point that evaluation should not be dismissed as an inappropriate faculty development strategy, for many colleges and universities are eager to begin at this point.

9. Strategy Number Nine: Reward System

Most practitioners in the field of faculty development would agree that support for faculty development must ultimately come through a set of policies and procedures which tangibly reward the improvement of instructional performance. If faculty are not rewarded for the improvement of their teaching skills, then a faculty development program must rely on more subtle, and often fickle, motivators like student acceptance, colleague recognition, self-esteem, or a sense of personal achievement A college or university must embrace a policy which provides (1) an equitable, objective system of performance evaluation, (2) resources to the faculty member for the improvement of his performance, and (3) tangible rewards in terms of salary, promotion, and tenure for the improvement and/or maintenance of a high level of instructional competency.

A number of different approaches have been taken in the use of this strategy. Several state systems have given small grants to individuals who wish to experiment with new methods in the classroom. Other institutions provide release time or sabbaticals to particularly competent instructors. Still other institutions, such as Gordon College, have moved toward "growth contracts" whereby a faculty member and his academic supervisor establish explicit criteria for assessing and rewarding not only performance but also improvement.

The question is often asked: "How do we motivate faculty to improve their teaching?" One answer to this question is a tangible reward system: If faculty are paid to teach better, then they will teach better. This answer should be and usually is followed by a statement that the institution must provide additional services to help the faculty member improve his teaching performance. Unfortunately, on some occasions this latter statement is neglected, which indicates a simple-minded and mechanistic approach to change. An alternate response can be given, however, to the question of motivating faculty: improvement in instructional abilities is itself often rewarding. Like most people, teaching faculty do not enjoy doing an inadequate job in their chosen profession. The experience of repeated failure in the classroom is usually painful and humiliating. Once faculty have acquired and begun to use new instructional methods or have improved their skills in using traditional approaches they begin to experience greater success in the classroom. This experience, in and of itself, often motivates faculty to work even harder on the improvement of their instructional skills.

10. Strategy Number Ten: Career Transitions

This strategy has been used less frequently than any of the others, yet in the near future it may be among those in greatest demand and potentially of great significance. As faculty members critically examine their roles as teachers, some will find that they are not in a profession which they highly value. During the mid-1970's the recognition of this fact may be particularly common and painful, for many faculty who view themselves primarily as researchers or scholars have found that adequate financial resources for these endeavors are no longer forthcoming. As they turn toward teaching, they find themselves in a role they do not prefer. Turning in other directions, however, they find professions which are either over-employed or inaccessible. When this dilemma is compounded by the problem of steady-state financing and faculty retrenchment, the problem of academic career transitions becomes an area of potentially major concern in the very near future.

Faculty development is an appropriate vehicle for assisting faculty members through major career transitions. Several institutions, like the Kansas City Regional Council for Higher Education, have incorporated this type of activity in the initial planning of their faculty development program. In other faculty development programs, this area of concern will gradually emerge as a natural extension of efforts at improving the performance of faculty in their current jobs. Workshops can be conducted, for instance, in which faculty engage in a detailed career and life planning sequence, or in which faculty are trained in various managerial skills.

A faculty development program staff might also help a faculty member assess his current skills and compare these skills with skill profiles from other professional fields in order to identify common areas. The interpersonal, design, and research abilities of many faculty members are very appropriate to certain other professions. This diagnostic process can also be of value in helping the faculty member identify areas for further development. Exchange programs between faculty and administrators can further aid the career transition, as well as provide an institution with potential channels for reemployment of displaced faculty.

11. Strategy Number Eleven: Comprehensive Institutional Development

This final strategy hopefully reflects the future direction of faculty development programming in American higher education. Presently, faculty development is a movement with many disciples, detractors, prophets, and princes. At times it looks like a fad. It certainly is not a panacea, nor will it ever solve all of the problems facing colleges and universities today. If isolated from or even working against other vital issues confronting an institution, it will have little or no impact. Yet if faculty development is systematically and patiently implemented as part of a comprehensive program of institutional renewal, it can have profound and lasting impact on the lives of faculty, their administrators, and their students.

A danger exists, however, in making faculty development part of a larger program of institutional growth and development. Incorporation can lead to diffusion and even elimination. Just as the central function of a college or university—teaching and learning—can become lost or neglected in the press of committee meetings, professional conventions, and research contracts, so, too, can faculty development become lost in institutional goal setting or administrative team-building. Perhaps the one thing held in common by previous approaches to instructional improvement is a failure to reach faculty, particularly faculty in the arts and sciences. Even at this early stage in its growth, faculty development has shown that it can reach these individuals. Faculty development may well become part of a larger process yet, when this happens, care must be taken that it becomes an important component of that process. If this happens, faculty development will find its appropriate place as a major force for improving the quality of learning taking place in the nation's colleges and universities.

The processes of change, as they involve any person or institution, are always subtle and ill-defined. One should be amazed that any significant change ever takes place and should feel gratified if this change has in part been attributable to one's own efforts. The fact that some changes in the performance of faculty in the classroom have taken place is itself justification for a program of faculty development. However, a program that is successful will usually have a broader impact on the campus than may be initially anticipated. As the potential source of a comprehensive institutional development program, faculty development will be confronted with new challenges as well as new insights into the problems of higher education. If such is the case, then our efforts at faculty development may be of greater significance than any of us now hope or imagine.

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APPENDIX C

William H. Bergquist and Steven R. Phillips, "Models for Faculty Development," *A Handbook for Faculty Development*, Volume II (Washington, D.C.: Council for the Advancement of Small Colleges, 1977), Chapter 1.

CHAPTER ONE

MODELS FOR FACULTY DEVELOPMENT

Higher education in the United States has undergone in the last ten years a transition so profound as to be revolutionary. Vietnam, student unrest, declining enrollments and financial retrenchment have all brought at times almost unbearable pressure on educational institutions and structures. Faculty development has been very much both a part of and a response to these rapidly changing conditions. Administrators and students have voiced legitimate concerns over the quality of teaching and learning in higher education. Lack of faculty mobility has forced institutions to look inward for new sources of growth and challenge. The need to survive in the face of increasing financial constraint has led both faculty and administrators to reexamine organizational patterns and structures. These and other forces are clearly behind the emergence of faculty development. Yet it may be that faculty development, broadly conceived as a movement concerned with the entire state of higher education, is considerably more than simply a response to crisis. At this point, as many recently established faculty development programs begin to move toward maturity, some reflection on the state of faculty development seems in order. Consequently in this opening chapter we would like to begin by examining some of the implications of faculty development for higher education. Next we would like to look at some of the competing theoretical approaches to faculty development current today and, finally, we would like to suggest a newer and somewhat broader way of conceptualizing the place of faculty development in an institutional context.

A. Paradigms and Assumptions

In *The Structure of Scientific Revolutions* Thomas Kuhn articulates a theory of intellectual change that has had significant impact not only on the history of science but also on other historically oriented disciplines as well. Although faculty development is not directly concerned with the shift from a Ptolemaic to a Copernican world view or with the change from Newtonian to Einsteinian physics, the process outlined by Kuhn can nevertheless offer a useful way of identifying faculty development's place in higher education.

According to Kuhn, once scientific communities have reached a certain level of maturity they begin to operate on the basis of "some implicit body of intertwined theoretical and methodological belief"[1] that he calls a paradigm. This set of assumptions and beliefs about the way the world—or a part of it—functions identifies for the scientific community the nature and limitation of its research. "The success of a paradigm," Kuhn writes, "—whether Aristotle's analysis of motion, Ptolemy's computations of planetary position, Lavoisier's application of the balance, or Maxwell's mathematization of the electromagnetic field—is at the start largely a promise of success discoverable in selected and still incomplete examples. Normal science consists in the actualization of that promise, an actualization achieved by extending the knowledge of those facts that the paradigm displays as particularly revealing, by increasing the extent of the match between those facts and the paradigm's predictions, and by further articulation of the paradigm itself."[2] Although a single paradigm can never explain all the phenomena with which it may be confronted, such issues are most frequently either excluded from the area of proper research or assumed to be ultimately but not currently explainable.

Occasionally, however, the scientist becomes aware of a significant anomaly, an important fact or event that cannot be explained by the current paradigm or that violates one of its fundamental assumptions. If, over time, scientific activity is unable to solve the puzzle of this particular phenomenon within the terms of the current paradigm, that paradigm itself may be called into serious question. As Kuhn writes, "Because it demands large-scale paradigm destruction and major shifts in the problems and techniques of normal science, the emergence of new theories is generally preceded by a period of pronounced professional insecurity. As one might expect, that insecurity is generated by the persistent failure of the puzzles of normal science to come out as they should. Failure of existing rules is the prelude to a search for new ones."[3] Out of this state of crisis, however, a new paradigm may emerge, one that more fully seems to explain significant phenomena than did the older paradigm. "Almost always," Kuhn very interestingly suggests, "the men who achieve these fundamental inventions of a new paradigm have been either very young or very new to the field whose paradigm they change."[4]

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[1] Thomas S Kuhn. *The Structure of Scientific Revolutions* (Chicago. Univ. of Chicago Press. 1962), p. 16.

[2] Kuhn. pp. 23–24.

[3] Kuhn. pp. 67–68

[4] Kuhn. pp. 89–90.

After some time, and frequently not without significant opposition, the new paradigm becomes accepted as the current tradition.

In summary, the process of scientific revolution proposed by Kuhn may be seen as consisting of five steps. The community begins with (1) a belief in a particular paradigm, which is (2) upset by the discovery of novelty and subsequent confusion, (3) disagreement over solutions follow until (4) the community can begin to coalesce around a new candidate which promises to become (5) a newer and more satisfactory paradigm.[5]

Numerous scholars have applied Kuhn's speculations on the structure of scientific revolutions to a wide range of disciplines, perhaps these ideas may help explain some of the changes that have been taking place in higher education over the past several years. We would suggest that up until the mid-1960's the educational community shared a common, discipline centered paradigm of the teaching/learning enterprise. Primary emphasis was placed on expertise within the discipline, generally as represented by advanced degrees and publications. A close relationship was seen between active research interests and effective teaching, advanced undergraduate and graduate teaching assignments were the most desirable. The teacher was viewed as an expert whose primary responsibilities were to communicate information and to evaluate. "Faculty development" consisted of additional research possibilities, reduced teaching loads, lower student faculty ratios, sabbaticals and leaves of absence.

This traditional paradigm served to organize the activities and interests of higher education until the mid-1960's, when a significant anomaly was discovered or at least acknowledged. college and university teaching was frequently ineffective, at times incompetent. For some this realization came about through student unrest. as the Danforth Foundation's *Annual Report for 1964–65* suggested, "Nearly every discussion of student unrest points out the relation of that problem to the poor teaching that is often found on college and university campuses."[6] For others the realization came through research evidence on the impact of college on students: as one summary of that literature puts it, "the quality of teaching has relatively little effect upon the value outcomes of general education . . . so far as the great mass of students is concerned."[7] For yet others this realization came about through an increased awareness that higher education was primarily serving the research interests of the military industrial complex at the expense of its supposed clients, its students. However this anomaly came to light, it precipitated the period of crisis and confusion Kuhn finds characteristic of the failure of a once firmly held paradigm. Out of this crisis has come faculty development, a potential candidate for a new paradigm.

In the following section of this chapter we will discuss a number of alternate conceptualizations of faculty development, in some cases these are complementary, in others conflicting. Yet for all their differences, each of these theoretical apprаches to faculty development shares the same set of assumptions, the same paradigm of teaching and learning. Those assumptions, summarized from Jerry Gaff's recent study, are as follows:

1. Faculty members are the most important educational resource of a college or university.
2. Teaching is the primary, through by no means the only, professional activity of most faculty members.
3. Scholarship and research—another major professional activity of many faculty members—need not be antithetical to effective teaching.
4. Teaching is much neglected by academic tradition.
5. Although there is little systematic evidence about how good the quality of teaching and learning actually are in most institutions, there is a general feeling, shared by many within and outside academia, that it can be improved.
6. Improving teaching requires working with administrators and students—perhaps even members of the larger community—as well as with faculty members.
7. Just as faculty members receive little preparation for their instructional roles, administrators have little training for the leadership, policy formulation administrative and managerial roles of their work. Department chairpeople, deans, vice presidents, and presidents—no less than faculty members—need to develop and, furthermore, they need to encourage and support the growth of the individuals in their charge.
8. Teaching is a complex set of attitudes, knowledge, skills, motivations and values. The improvement of teaching and learning requires an awareness of the complexities involved in faculty, students and institutions and hence the avoidance of simplistic solutions.
9. Effective teaching involves helping students to attain desired learning objectives.
10. There is no single model of effective teaching or learning.
11. There is great diversity among students. Their various learning styles, which are based on differences in ability, interest, educational background, future aspirations and personality orientations, call for different kinds of learning experiences.
12. Faculty members, too, are a diverse lot.

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[5] This five step sequence is taken from a similar sequence suggested by David A. Hollinger, "T S Kuhn's Theory of Science and Its Implications for History," *American Historical Review*, 78 (1973), 374

[6] Joseph Axelrod, "Teaching Styles in the Humanities," William H Morris, ed., *Effective College Teaching* (Washington, D C American Council on Education, 1970), p 39

[7] Jerry G Gaff, "Making a Difference: The Impacts of Faculty," *The Journal of Higher Education*, 44 (1973), 606

13. An indivdiual's professional work is intimately connected with his personal life.
14. Intrinsic interest rather than extrinsic demand is what leads individuals to seek improvement.
15. The willing involvement of faculty members and others in the various programs typically is seen as a necessity if enduring improvement is to be obtained.
16. Every institution contains many persons with expertise and experience which may be included in instructional-improvement programs.
17. Teaching and learning are individual but not solitary activities; they occur within a social context. The climate of the institution, the relationships between faculty, administrators, and students, and the policies and practices of the school affect the character of teaching and learning.[8]

These assumptions underlie and structure the faculty development paradigm. It is important to point out, however, that in Kuhn's terms a significant paradigm shift has not yet taken place in higher education gene[illegible]; faculty development is at best only a candidate for a new paradigm. Many still cling to the traditional paradigm, many hope that the events of the past several years were only a minor eruption in the otherwise tranquil flow of academic life. Whether or not the paradigm offered by faculty development will become the new tradition is largely up to all of us.

B. Three Models for Faculty Development

Although the assumptions contained in the paradigm identified above will be shared to some extent by all of us concerned with faculty development, there are perhaps as many approaches to faculty development as there are individual programs. Three general models, however, can be identified; hopefully, aspects of one or more of these can help all of us clarify our thinking about the nature of the enterprise in which we are engaged.

Even though, as we shall see, each of the models discussed below has certain areas of disagreement, all three are nevertheless based on Goodwin Watson's belief that change can be seen as taking place in the areas of *structure*—organization, use of space, authority—*process*—human interaction, communication—and *attitude*—values, assumptions, philosophies.[9] Although Watson, as a social psychologist, insists fairly heavily on the modification of structure as the genesis of significant change—changed structures cause changed processes which in turn cause changed attitudes—the three models of faculty development discussed below all suggest that a program may theoretically begin at any of these three levels. Emphasis on a particular level will be determined more by timing, the needs of the program and the needs of the institution than by Watson's assumption about the sequence of change.

The first model of faculty development was presented by the authors in a 1975 article in *The Journal of Higher Education*; this model sees faculty development as composed of the related activities of personal development (attitude), instructional development (process) and organization development (structure). In our original article we stressed our belief, which we continue to maintain, that instructional development is the most logical entry point for most emerging faculty development programs and that, while personal and organizational development are necessary elements of a comprehensive program, they are nevertheless usually secondary. It is important to emphasize, however, that a comprehensive program of faculty development will be able to operate at all three levels of attitude, structure and process.

A second and related model of faculty development has been presented by Jerry Gaff in his recent study of the entire field. Gaff identifies three alternate conceptions of instructional improvement: faculty development (attitude)—apparently for him "Faculty Renewal" as used in the title of his book is the more broadly encompassing term—instructional development (process) and organizational development (structure). Although the latter approach is the same in the two models, a glance at the accompanying diagrams will indicate that there is considerable difference in the first two categories, for Gaff's concept of "faculty development" contains elements of both what we define as personal and instructional development, while his idea of "instructional development" focuses much more closely on course and curriculum design. A perhaps more important difference between the two models is that while the first suggests that all three elements should be present in a mature faculty development program, the second seems to imply that any one of the three alternatives may be implemented without necessary reference to the other two. Hopefully when examined together these two models will do more to clarify than obfuscate efforts in this area.

A third model of faculty development has been more recently developed, which extends some of the ideas contained in the first two. While maintaining a concern with attitude, structure and process, this model broadens the definition of such terms as instructional and organizational development, adds the concept of community development, a concern with the entire environment of an institution, to the vocabulary of faculty development and extends the area of faculty development to issues beyond the level of individual institutions. Perhaps the most serious weakness of the first two models is that instructional development is limited to the process level and that organizational development is limited to the structural level. This third model indicates, however, how an intervention like instructional development can have im-

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[8] Jerry G Gaff, *Toward Faculty Renewal* (San Francisco Jossey-Bass, 1975), pp. 5-7

[9] Goodwin Watson and David Johnson, *Social Psychology. Issues and Insights* (Philadelphia. Lippincott, 1972), pp 196-221

pact at not only the level of process but at the level of structure and attitude as well. Finally, the third model clarifies the focus of various kinds of efforts in this area by suggesting alternate approaches to the individual, the group, the institution and the meta-institutional.

C. Faculty Development in an Institutional Context

Each of the three models discussed in the previous paragraphs attempts to isolate and define particular faculty development activities in a way that hopefully helps clarify their particular orientations and assumptions. Yet as anyone who has actually worked in faculty development knows, no particular activity retains in practice the precision of theoretical definition. Hence it may be better to visualize faculty development as a set of overlapping and concentric circles as presented in Figure One. Instructional development, for instance, can be considered a subset of professional development which, in turn, is partially, though not exclusively, an aspect of faculty development. Organizational and community development can be considered overlapping, yet distinctive, components of a faculty development program, yet both areas of activity also exist independently of faculty development. Organizational development can be distinguished from community development in that its ultimate aim is increase in productivity through improvement in the working conditions and climate of the institution. Thus, the focus is on the product and the way in which people work together in the accomplishment of institutional goals. By contrast, the focus in a community development program is on the individuals in the institution; how, if at all, are their personal needs being served in the context of the institution (community) to which they belong? Organizational and community development, on the other hand, do overlap in that both focus on the institutional setting—the way in which it operates and the way in which people relate to it.

By contrast, personal development focuses on the growth and development of the individual, with only secondary reference to the institutional setting or responsibilities of the individual. Personal and organizational development are interrelated, however, since both place an emphasis on interpersonal processes and the creation of supportive settings that are conducive to the development and expression of professional competencies. Personal and community development are interrelated in their concern for the welfare of the individual.

Since faculty development is a rapidly expanding field, this somewhat broader model is offered as only a tentative and temporary structure to describe the current and possible emphases in faculty development programming. Faculty development is more than merely a response to crisis and retrenchment, for it fundamentally offers a new and considerably more complex paradigm of higher education than that held in the past. This new model, in spite of its tentativeness, hopefully reflects both the order and complexity of this new vision. In many of the following chapters of this handbook, we will attempt to fill out several important aspects of the new paradigm through discussions of personal, instructional and organizational development and some speculations concerning the possible implications for faculty development of a new area, community development. Perhaps these efforts can play some part in continuing to establish faculty development as the new and dominant paradigm for contemporary higher education.

Model Number One*

	ATTITUDE	PROCESS	STRUCTURE
	Personal Development	Instructional development	Organizational development
Focus	Individual Faculty	Individual faculty Individual courses Curricula	Academic and administrative programs, departments and divisions
Purpose	Clarify values, attitudes and philosophies Improve intrapersonal and interpersonal functioning	Improve instructional effectiveness	Improve organizational effectiveness
Activities	Life planning Faculty interviews Interpersonal skills training Personal growth workshops Supportive and therapeutic counseling	Classroom observation and diagnosis Microteaching Instructional evaluation Instructional methodology and technology Course design Curriculum development	Team-building Conflict-management Decision-making Management training

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* Source William H Bergquist and Steven R Phillips, "Components of an Effective Faculty Development Program," *The Journal of Higher Education*, 46 (1975), 183

Model Number Two*

	ATTITUDE	PROCESS	STRUCTURE
	Faculty Development	Instructional Development	Organizational Development
Focus	Faculty members	Individual courses Curricula	Organizations
Purpose	Promote faculty growth Help faculty acquire needed knowledge, skills, sensitivities and techniques	Improve student learning	Create an environment which promotes effective teaching
Activities	Seminars Workshops Evaluations	New learning materials Redesign courses and/or curricula Workshops on setting objectives Evaluating students	Workshops for group leaders or team members Action research Revise organizational policies

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* Source: Jerry G Gaff, *Toward Faculty Renewal* (San Francisco. Jossey-Bass, 1975), p. 9.

Model Number Three*

		STRUCTURE	PROCESS	ATTITUDE
FOCUS OF INTERVENTION	Individual	*Instructional Development* Consultation and training on course design, curriculum reform and educational technology *Organizational Development* Evaluation of faculty Faculty reward system	*Instructional Development* Classroom observation, diagnosis and training Training in interpersonal and small group skills Training in out of class skills associated with faculty roles	*Instructional Development* Promotion of alternate instructional methods Discussions about teaching Values Clarification *Personal Development* Life and career planning Counseling
	Group	*Instructional Development* Curricular and course design consultation Interdisciplinary and team teaching *Organizational Development* Departmental reorganization Use of space and time	*Instructional Development* Discipline or department centered instructional training programs Peer observation and feedback *Organizational Development* Group process observation	*Instructional Development* Knowledge utilization Departmental/divisional retreats *Organizational Development* Team-building Support groups
	Institutional	*Community Development* Communication and support networks *Institutional Development* Research and development center *Faculty Development* Program governance	*Community Development* Intergroup negotiation *Institutional Development* Implementing development programs *Faculty Development* Program planning and implementation	*Community Development* Community building *Institutional Development* Development of support for change *Faculty Development* Generating program support
	Meta-Institutional	*Meta-Development* Funding Establishment of formal networks and consortia	*Meta-Development* Define and clarify new change oriented professions Continuing education for educational change agents	*Meta Development* Publication of books, periodicals, etc. Demonstration projects Cooperative research projects

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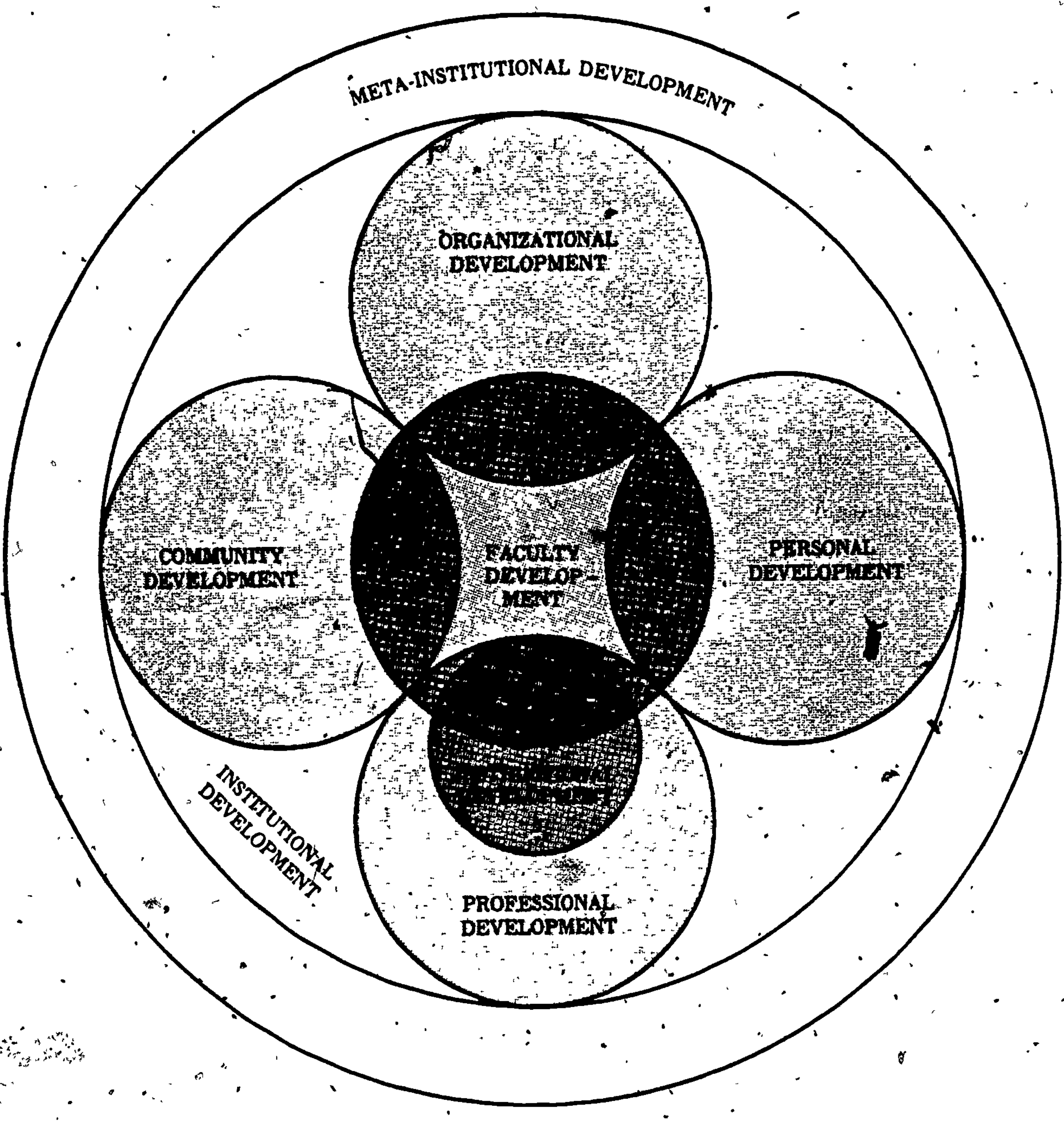
* Source. Prepared by William Bergquist for the Association for Innovation in Higher Education in conjunction with a presentation at the 1976 National Conference on Higher Education sponsored by the American Association for Higher Education.

Figure One.—A Graphic Representation of Faculty Development Activities



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APPENDIX D

William H. Bergquist and Steven R. Phillips, "A Community Development Approach to Faculty Development," *Handbook for Faculty Development*, Volume II (Washington, D.C.: Council for the Advancement of Small Colleges, 1977), Chapter 13.

CHAPTER THIRTEEN

A COMMUNITY DEVELOPMENT APPROACH TO FACULTY DEVELOPMENT

During the past decade, the field of community development has emerged as an area rich in new insights about change and action in complex social settings. As social institutions which act in many ways like small towns or municipalities, American colleges and universities can benefit by an examination of the learnings from this new field. Though community development is ridden with conflicting philosophies, goals and images concerning the ideal society—as are other fields of social and behavioral science—it is a field which has produced a number of provocative approaches to social change.

Central to the field of community development is the distinction between lower-order (or first-order) and higher-order (or second-order) change. Lower-order change can be defined as an action which alters social outcomes but does not alter the way in which these outcomes are derived. A lower-order change might, for instance, influence the policy of a social system but will change neither the way that decision was made nor the way related decisions will be made in the future. A higher-order change, on the other hand, influences not only social outcomes but also the actual social process as well.

The concept of higher-order change is emphasized by Michael Lauderdale and James Peterson in *Community Development*. Major community changes, according to the authors, bring about new modes of thinking, behaving and interacting. These changes "alter the total frame of reference and produce revolutionary Gestalts, which in turn modify interrelationships among all elements."[1] In Thomas Kuhn's terms (see Chapter One), major community changes involve the destruction of existing social paradigms and the creation of new ones.

Lauderdale and Peterson present an excellent example of higher-order change when they describe the effects of technological breakthroughs in transportation on our concepts of space and time:

> We do not become more efficient in traveling by horse but rather we change the *mode* of travel, first through mechanized means on the ground and then through the air. This change of mode then redefines the psychological concepts of time and distance. . . .
>
> In the villages of the 1800's a man's neighbors were usually little beyond his vision or the sound of his voice. Community was a spatial concept clearly defined by the boundaries of the village and reaffirmed every day by person-to-person contacts. Concepts of larger community, such as the city or the nation state, were still quite new and fragile in the nineteenth century, yet were rapidly being reinforced by the technologies of the railroad and the telegraph.[2]

Higher-order change is usually very difficult to bring about, whether one is seeking change in a community or in a college faculty; in many cases successful execution of lower-order change may be all that is reasonably possible. To clarify, therefore, the various approaches that may be taken to community—and academic—change, Lauderdale and Peterson outline five different approaches to social development. The first three of these—capital infusion, leadership and group dynamics and service coordination—are usually lower-order change efforts; the last two—pressure groups and natural groups—offer the potential at least for more profound, higher-order change. An examination of each of these five approaches will not only provide a systematic overview of alternate approaches to change but will also suggest a range of activities and options for faculty development.

A. Capital Infusion

This is probably the most dominant mode of community development. It is represented in most foreign aid programs, the Peace Corps and domestic and foreign agricultural assistance efforts. Capital infusion programs are resource oriented; they "deal with the dysfunctional aspects of a community's organizational patterns by inputing massive amounts of resources."[3] Since existing governments and institutional structures become the vehicles for implementation of the program, capital infusion can be carried out with relatively little resistance from sources of power. It is often, however, a disjointed and insensitive response to complex social problems. The existing structures are reinforced, when in fact they might be contributors to current problems.

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[1] Michael Lauderdale and James Peterson, *Community Development* (Washington, D.C., Education, Training and Research Sciences Corp., 1971), p. 2.

[2] Lauderdale and Peterson

[3] Lauderdale and Peterson, p. 13.

Faculty development programs often operate on this model. Typically, there is an infusion of such new resources as time (release time or sabbaticals), money (salary increases), transportation (support for travel to a national convention), communication (subscriptions to major journals or newsletters in a discipline or in higher education) or machinery (purchase of a new computer terminal). As with other capital infusion projects, this type of program is usually administered through existing organizations and campus governance structures and hence tends to reinforce their existence. Faculty development efforts of this type are quite common precisely because they are subject to minimal resistance by the faculty who receive the resources or by the administrators who make the decisions concerning their disbursement.

The infusion of major new resources into institutions of higher education will not be a common occurrence in a period of financial retrenchment Yet even though large amounts of money are not generally available, funds for certain priority areas—like faculty development—may be. In designing a program based on the addition of significant new resources to an institution, it is worthwhile to keep in mind the strengths and limitations of capital infusion. Faculty have a legitimate and pressing need for the resources required to remain current in their disciplines, to conduct research, to obtain subscriptions to professional journals and to attend professional meetings; it is crucial that these resources be made available, either through institutional budgets or external funding. Yet it must be emphasized that capital infusion primarily reinforces existing structures and attitudes; to the extent that faculty development is an effort to alter patterns of operation and behavior capital infusion will be unproductive. Greater command of and commitment to a discipline can result from increased resources for research and professional travel; changed attitudes toward interdisciplinary studies, toward colleagues and toward the process of teaching and learning is not likely to result. While protecting and supporting traditional faculty needs, faculty development must look elsewhere for more significant change strategies.

B. Leadership-Group Dynamics

This approach to change, which frequently emerges in response to disillusionment concerning capital infusion models, focuses on improving the quality of leadership and of small group functioning in the community. Leadership-group dynamics is used widely by social workers and psychologists as well as by church and civic groups. It makes use of insights and expertise concerning human relations training developed in the last twenty or thirty years, largely in industrial settings. Faculty development practitioners have also made extensive use of this approach, conducting leadership training workshops and conferences on small group dynamics for both faculty and administrators.

An emphasis on change based in leadership and group dynamics faces two major problems. First of all, many people resist this type of training, labeling it "sensitivity training" or "touchy-feely." Although this is frequently the response of ignorance, some resistance may be justified, for the human relations movement has often lacked precision concerning training goals; the experience itself, and not the learnings generated by the experience, at times seem to be the major objective. Second, leadership and small group training experiences are primarily focused on individuals, not on their social systems. Unless all influential members of a community are exposed to this training within a short period of time, and unless all major structures and procedures of the community are operated in accordance with the procedures and styles being promoted in the training program, the participants will return to an alien community which is not supportive of significant change in behavior

On the other hand, it is essential to recognize that this approach can be an important element in a change effort, for a fuller understanding of leadership skills and an increased sensitivity to the dynamics of small groups cannot only improve the current functioning of existing structures but can also over time change the very process by which those groups operate; manipulation and power plays can give way to consensus. Although an emphasis on leadership and group dynamics has not proven to be the panacea some had expected, it remains for many social systems a viable approach to change.

C. Service Coordination

Efforts at community development based on this approach involve "an identification of community needs, process and programmatic efforts to resolve these needs through utilizing existing resources and the development of supplemental resources."[4] Typical of this approach to community development are community councils, united funds and social welfare coordination, while in recent years the role of "ombudsman" has gained increased credence in a service coordination function. The ombudsman assists a member of the community in working through existing structures and procedures to address grievances or obtain services.

In college communities, the service-coordination function has been provided for students through student unions, student counseling services and the office of Dean of Students. Even the role of student "ombudsman" was given serious consideration by some colleges and universities—and adopted by a few—during the late 1960's and early 1970's. On most campuses, however, there is no comparable service for either faculty or administrators. Certainly this is one of the new directions in which faculty (and administrative) development might wish to proceed. A faculty development program might, for instance, provide faculty with information about

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[4] Lauderdale and Peterson, p. 15.

mental health, financial counseling, day care or recreation services, since each of these can be shown to have an impact on the performance of faculty in their professional lives. A faculty development might also provide faculty with valuable research assistance. One California college, for instance, is now exploring a consultation project in which several members of the computer service staff, who are also trained in statistics and research design, work closely with faculty from the beginning of their research, so that at the point when programming and computational services are needed, the data will be fully compatible with the available computer programs. The faculty development director on this campus will coordinate these research-consultation services.

Service-coordination helps make currently available resources more accessible and useful and hence tends to establish the credibility of a program which provides this coordination. At a relatively low cost, a faculty development practitioner can incorporate this type of coordination into his program. The practitioner in either community or faculty development, however, should recognize that this model, like most capital infusion efforts, involves only first-order change; the existing structure is helped to function more effectively. The two remaining community development models, however, both speak to at least the possibility of structural change, the first by bringing about profound change in current formal structures, the other by creating or reinforcing the emergence of an alternate, naturally-based structure.

D. Pressure-Group Model

Closely associated with the work of labor unions, civil rights groups and other protest groups, this approach has been described by Lauderdale and Peterson as the "organization of individuals into a cohesive, action-oriented group" with a focus primarily on "changing organizational characteristics of the community that have made the solution of human needs impossible."[5] The work of both Saul Alinsky and Ralph Nader, in quite different ways, illustrate the use of this approach in the achievement of significant community change.

The pressure group model may incorporate a variety of approaches to social change, including boycotts, demonstrations, political bloc voting, civil-disobedience, investigatory reporting and dissemination of privileged information. Lauderdale and Peterson identify seven basic assumptions that are central to this model:

(1) local people want to solve their problems,
(2) local organizations can be utilized to carry out action plans;
(3) planning for action encompasses all needs of the community;
(4) democratic societies respond to pressure;
(5) development of indigenous leadership is an effective form of change;
(6) local people desire to be self-directing and
(7) action plans can be self-supporting once they are initiated.[6]

In addition to the localization of effort which Lauderdale and Peterson emphasize, several other themes tend to dominate this approach. First, although the pressure-group model emphasizes the destructive quality of current social structures and policies, it requires of the effective practitioner an extensive knowledge of this very structure—both of its weaknesses and its strengths. An effective organizer of pressure groups will use those resources of the current social system which have been designed to prevent change from within the system as a vehicle for blocking effective response to change that has been generated from outside the system by the pressure group. In a college or university, for instance, the very fact that a new policy or action will take two to three years to pass through the complex committee structure of the institution can be used to advantage by a change agent, for this same encumbering structure may prevent one's adversaries from effectively blocking a program that has been started outside the formal structure.

Second, this approach requires the composition and maintenance of a support group which can sustain activities through periods of personal doubt, failure and even punishment. Charismatic leadership in this support group may not be essential, though it certainly can be helpful. The support group certainly needs its own safe, isolated setting, where the ideologies and aspirations of the group can be reviewed and reinforced.

Third, the effective pressure group requires a diversity of roles and functions. There is a need for both the dreamer who has constructed an alternate future and the revolutionary who is effective in bringing about the overthrow of the current system.

The frequently confrontational tactics employed by pressure groups in community development are not necessarily antithetical to the more collegial norms (or ideals) of higher education. Physical confrontation, of course, is not likely to be productive but the intellectual confrontation of a well prepared pressure group can be effective. Like the change teams described in *Renewing Higher Education from Within*,[7] a committed group of individuals can have significant impact on the structure of academic institutions. A faculty union need not be the only—or best—way of exerting pressure for change; other efforts, working at least tacitly within institutional norms, can have significant and lasting success and may form an important part of a faculty development effort.

E. Natural-Group Model

This approach to community development seeks to

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[5] Lauderdale and Peterson, p. 16.

[6] Lauderdale and Peterson..

[7] Walter Sikes, Lawrence Schlesinger and Charles Seashore, *Renewing Higher Education from Within* (San Francisco: Jossey-Bass, 1974).

focus upon the organizational patterns of communities and nations which inhibit human need resolvement through broadening decisionmaking roles."[8] Natural relationships which exist among people with unresolved needs are systematically blended to form a functional, action-oriented organization. This relatively new approach to community development usually is based on a systematic assessment of a community's needs, the identification of natural helping networks and relationships in the community and the establishment of efforts to work with the networks to increase their capacity to meet these needs.

Several community development agencies in the United States, like Jim Kent's Foundation for Urban and Neighborhood Development in Denver, Colorado, have worked with communities in the identification and development of their own internal resources. In the area of health care, for instance, developers have extensively interviewed members of the community to determine their needs and the informal ways they go about meeting them by asking such questions as "Who do you talk to if your baby is sick?" and "Who do you go to when you are feeling sick?" The community developer will then work with the "natural helpers" thus identified to improve their services rather than set up an alternate and competing health care delivery system.

A faculty development practitioner can make effective use of both an assessment of community needs in her institution and an assessment of the natural helping network among faculty. Community needs can be identified in a variety of ways, through in-depth interviews of faculty and other members of the institution, through questionnaires, through psychometric devices and through sessions which bring together a small group of individuals to assess and discuss systematically various aspects of institutional life. Similarly, the natural helping network of a college or university can be assessed through the use of in-depth interviews, questionnaires, observations and small group discussions. This procedure can be extremely valuable not only as a source of information for the faculty development program about potential sources of assistance but also as a vehicle for establishing the program among those people who have been contacted.

The information which is collected about the natural helping network can be used in several ways. First, if no informal network is found to exist at the institution, that is, if faculty indicate that they do not consistently go to any other person for help in solving a specific type of problem, then the faculty development practitioner has access to valuable information concerning one or more vital needs of the campus. Second, if the interviews, questionnaire, observations and/or small group discussions do reveal a helping network, then this information can be used to assist the institution in deciding where to distribute most effectively various resources such as money, time and materials (thus blending the capital infusion and natural helping group models of community development). Finally, a faculty development program can become a source of information to faculty about those people on campus who might be of help in solving a specific problem.[9]

F. Conclusion

In this survey of several models of community development, we have touched lightly on a few of the many ways in which this new field might be applied to faculty development. The problems and promises associated with work in a collegiate institution might be more effectively addressed by the faculty development practitioner if he has examined a wide variety of strategies and techniques for change in complex social systems. The themes and models just described should provide not only several specific suggestions concerning faculty development, but also a conceptual context within which programs might creatively generate new approaches to social change and professional growth.

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[8] Lauderdale and Peterson, p 17

[9] A program based on internal linkages such as these may extend that strategy by providing faculty with information on resources outside the institution through linkages to NEXUS (the national clearinghouse on information about human resources in higher education, 800/424-9775), ERIC (Educational Resources Information Clearinghouse—a national network on information about printed resources in higher education), the Yellow Pages on Innovation in Undergraduate Education (*change* Magazine), the CASC Consulting Network (clearinghouse for information on human resources in the small, liberal arts college: CASC, Washington, D.C) and Resources for Planned Change (clearinghouse for information on human resources in state colleges and universities, Association of State Colleges and Universities, Washington, D C) Many of these clearinghouses were established to provide, on a national level, the type of linkage services that are being described here for the individual campus. Such a linkage service can effectively combine the natural group and service-coordination models of community development

APPENDIX E

Charles P. Friedman and others, "The Rise and Fall of PSI in Physics at MIT," *American Journal of Physics*, 1976, 44.

THE RISE AND FALL OF PSI IN PHYSICS AT MIT[a]

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Abstract

Small-scale trials of the Personalized System of Instruction (PSI) in Physics at MIT under the sponsorship of the Education Research Center were followed by adoption of large-scale introductory PSI courses in the Department of Physics. After four semesters, all introductory physics PSI courses were suspended. This study investigates what happened. We point out organizational difficulties in going from small-scale to large-scale use of the PSI method. We also identify certain conflicting perceptions among participants and observers that contributed to the suspension. The study, we hope, is an example of an informative "post-mortem" of a type much needed in higher education.

REASON FOR THE STUDY

This paper reports, and seeks to understand, the rapid growth and sudden decline of a major innovation in undergraduate physics instruction at the Massachusetts Institute of Technology (MIT). The Personalized System of Instruction[1] (PSI, sometimes known as the Keller Plan or self-paced study) was first tried out at MIT by Ben Green of the MIT Education Research Center in the spring of 1969, when the second-semester freshman physics course was offered to twenty undergraduate volunteers. Five years and over 3500 students later, a PSI course—in substantially altered form—was given to 650 physics students for the fourth time under the auspices of the Physics Department. Immediately following the last course the Physics Department decided to offer no more major introductory courses in this mode during the following academic year; the return to a standard lecture-recitation structure was announced.

The questions we posed ourselves were "What happened?" and "Why did it happen?". What were the combined factors that led to adopting the scheme in the first place, its rapid expansion, its evolution over time, and its final suspension?

We have two audiences in mind. *First* are those already acquainted with PSI. Green's 1971 paper "Physics Teaching by the Keller Plan at MIT"[2] was one of the most popular and widely reprinted papers ever published by the *American Journal of Physics*. During 1971–1973 MIT was one of the leading centers for dissemination of PSI. Many hundred college teachers visited or wrote to the (then) Education Research Center[3] for an introduction to college teaching in this format. There is thus a considerable constituency who legitimately might want to know why physics teaching by PSI has been discontinued in the large introductory courses at MIT.

Second, we hope the paper will encourage others to attempt historical appraisal and review of educational innovations. Educational experience and wisdom is seldom codified, distilled, and transmitted: traditional education research—for whatever reasons—is of scant relevance or use in this respect. If even 10 percent of the time and other resources spent in innovating were reallocated to discovering what went wrong with past schemes, it might pay handsome dividends. We seek here to document the evolution of one particular innovation at a major university, and at the same time to illuminate conditions and circumstances associated with pedagogic experiments more generally. We explore a significant single instance but one that is representative of others.

There is nothing terribly sophisticated, esoteric, or expensive in the way we went about this study. Faced with

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[1] J Gilmour Sherman, Ed., *Personalized System of Instruction, 41 Germinal Papers*, W. A. Benjamin, Menlo Park, CA, 1974.

[2] Ben A. Green, Jr., Am. J. Phys *39*, 764 (1971).

[3] Set up in 1960 as the Science Teaching Center, the Education Research Center (ERC) developed a university physics course to follow the PSSC high school physics course and later undertook a variety of other curriculum developments. The Center died in the summer of 1973, partly as a result of the recent general reduction of federal funding. A major project during its last three years was to act as a national center for the dissemination of the PSI method. The ERC staff gave talks about PSI country-wide, ran workshops at MIT and elsewhere, responded to inquiries about existing PSI courses, and held the first national conference on PSI (October, 1971).

the questions we sought to answer, we pursued common-sense lines of inquiry We talked at length with most of the principal actors, the various instructors in charge of the PSI courses and those with more general responsibility for undergraduate teaching in the Physics Department. We pieced together, retrospectively, a narrative of what had happened—a more difficult procedure than anticipated because of incomplete records and uncertain memories. We read student evaluations solicited at the time. We discussed sequential drafts of this paper with an ever-increasing group of those who had been involved and a late draft with the Physics faculty as a whole. Obviously there is much else we could have done, e.g., sent detailed questionnaires to every instructor, interviewed and tested PSI students two years later, and so forth. But these would have turned our relatively informal study into a major piece of social science research We are brash enough to assert that the additional insights generated by this more ambitious effort would not have justified the increased expenditures of time, effort, and money.

This is not to say that we did not exercise caution and care in how we went about the study Interviews were conducted with two of the authors present and detailed notes compared to insure accuracy In compiling the record of successive events and procedures, we cross-checked with other sources. We sampled student evaluations randomly. The general methodology derives from "illuminative evaluation,"[4] a style of research into educational practices and phenomena that emphasizes the close interaction among "content," "method," and "context," among the intellectual substance of the curriculum, the instructional means of delivery, and the wider institutional circumstances Students and faculty respond to all of these factors concurrently, separating them to reduce complexity is often arbitrary and artificial, and divorces the study from educational reality as experienced.

NARRATIVE

The evolution of PSI in physics at MIT falls into three phases: (1) the growth phase (centered on the Education Research Center); (2) the initial large-scale trial (carried out by the Department of Physics), and (3) subsequent large-scale trials (lasting for three more semesters) In order to understand this narrative, the reader needs to know that the "mainstream" sequence of physics courses for an MIT physics major consists of five one-semester courses, of which the first three deal with Newtonian mechanics and electricity and magnetism, and the last two deal with quantum physics. All MIT freshmen, not just physics majors, are required to take a year of introductory physics Most of them satisfy this requirement by taking the two courses described under "large-scale trials" in items (2) and (3) of the narrative below. Freshmen are graded "pass" or "fail," while upperclassmen are generally graded A through F

A final introductory point, to simplify the account we have dispensed with names of all participants except for Ben Green, Robert Hulsizer and the authors of this article This may tend to overemphasize the roles of these players in a production that had, in fact, a cast of hundreds.

(1) The Growth Phase (centered on the Education Research Center)

New initiatives in college instruction are often traceable to single individuals—in the case of PSI at MIT, to Ben A Green, Jr Newly arrived in the fall of 1968 as a staff physicist in the Education Research Center (ERC), he was asked "to work out what he was going to do." Green, a long time enthusiast of programmed learning and Skinnerian psychology, had been impressed by Keller's original paper about PSI called "Good-bye, Teacher . . .,"[5] seeing in it a way of applying Skinner's principles in a generally acceptable manner. After some discussion within the ERC, permission was sought from and granted by the Department of Physics for a second-semester physics course to be given to a limited number of volunteers using the PSI method.

We will not describe PSI here, but as first tried by Green it had the customary characteristics.[6] Students worked through a progression of self-study guides at their own pace, taking unit tests—if necessary, repeatedly—in order to qualify to move from one unit to the next. Student proctors (or tutors) handled the testing and Green, as instructor, pursued managerial and tutorial functions, supervising the proctors and dealing with unusual student difficulties. Occasional lectures had a strictly "motivational" function. Green himself prepared the fifteen study guides covering the customary MIT second-term freshman syllabus in physics More than 100 students volunteered; twenty were chosen by an informal method intended to include students with a variety of reasons for taking the course.

Green's first PSI course was widely considered to be a success It led, in the following four semesters, to a startling rate of growth of PSI courses. Several others on the ERC staff (including Taylor, Friedman, and Hirschi) and faculty in other departments at MIT joined Green in offering a range of PSI courses,[7] which most often were given in parallel with regular sections of the same subject

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[4] Malcolm Parlett and David Hamilton, "Evaluation as Illumination a New Approach to the Study of Innovatory Programs", Occasional Paper 9, Centre for Research in the Educational Sciences, University of Edinburgh, 1972

[5] F S Keller, J Appl Behavior Anal, 1, 78 (1968).

[6] See, for example, references 1, 2, and 5

[7] For example, by the fall of 1971 (in addition to the large-scale physics trial described below) there were five other PSI courses in physics, and five other departments were offering PSI courses

taught by the conventional methods In the Education Research Center study guides were developed, tried out, rewritten, tried out again, an initial enrollment of twenty to thirty in each new course was allowed to increase toward 100 as confidence in the effectiveness of the materials and procedures increased, a number of "pedagogical management" and administrative problems were slowly ironed out This growth phase was marked by (a) students volunteering in large numbers for the PSI courses and asking for more subjects to be offered in this mode; (b) step-by-step adjustment of procedures in the light of experience; (c) increasing expertise, a continuity of key staff members, and sharing of accumulated know-how with newcomers, (d) an expanding level of interest, with numerous inquiries from within MIT and from many other institutions, and (e) a concentration of PSI activities in the Education Research Center The Physics Department approved the offering of each physics PSI course, and several faculty members participated, but most of the initiative came from ERC physicists

(2). First Large-Scale Trial (under the MIT Department of Physics)

With consistently good reports emanating from the ERC, it is perhaps not surprising that the Physics Department decided to apply PSI to its own large course offerings, especially the two semesters of introductory physics required of all freshmen. Again, the response, when it came, was due to individual initiative, that of Professor Robert I. Hulsizer, a senior Physics faculty member and former director of the Education Research Center Hulsizer had two previous experiences teaching in relatively small PSI classes and was strongly enthusiastic on account of the greater amount of personal contact PSI afforded between students and teachers, and also because the method "accommodated well to both the slowest and the fastest students " Assuming responsibility for the large first-semester physics course in the fall of 1971, Hulsizer sought and received approval to have it taught on PSI lines He realized that such a course could not be organized on the same pattern as the earlier ERC-sponsored trials Instead of a small company of approximately 100 volunteers, it was to be a battalion of approximately 600 students, most of them conscripts taking a required course

During the summer preceding this new PSI course, Hulsizer began drafting study guides for twenty-seven units per semester, a number he understood Keller to have recommended in a personal conversation The course was to have three regular lectures per week, given jointly by a junior faculty member and by the (then) Associate Head of the Department (Regular lectures are not part of the standard PSI format, but were included both "to set a standard pace" and to provide a verbal presentation of the material for ear-oriented students) Aside from lectures, groups of 40 students were assigned to sections each supervised by a faculty member with one or two paid graduate teaching assistants and two or three undergraduate tutors who received academic credit for participation. The staff of each section was to be available six hours per week, during which time students would come in to ask questions and take unit tests. With 27 units in the semester, students would have to complete two units per week on the average to keep abreast of material covered in lectures, but they could run somewhat slower or faster than this pace without serious consequences. In addition to unit tests, final examinations were to be offered at three different times. Although Hulsizer had had considerable earlier contact with the ERC staff, the Department's specific plans for the large-scale trial were developed independently of the ERC

The seventeen faculty section leaders were those routinely assigned to the introductory course and were not volunteers (although one or two asked for reassignment when they learned that the PSI method was going to be used). These section leaders were introduced to the new teaching method at two initial staff meetings, and during the term staff meetings were held to discuss the method and the progress in the course

Despite the extensive planning, the initial operation of the new course was described by more than one observer as "chaotic " There were initial problems in getting multiple copies of study guides and unit tests into the hands of students and section leaders, two unit tests per week per student proved to be more than the staff could handle, students had to wait in lines to ask questions and have their tests graded, and grew restive, the recruitment of undergraduate tutors was delayed and, when appointed, tutors often could not come for all six of the meeting hours of their section—and so would appear for an hour or two only to disappear again, faculty instructors found themselves shouldering a large part of the test-grading burden and were free neither to supervise the operation of the system nor to talk in a leisurely manner with students who had special questions.

Initial difficulties often accompany major changes in pedagogic format, and emergency steps are sometimes called for as they were here. After three weeks, the number of remaining units was cut to one per week as the average rate; the flow of study guides and unit tests became more dependable, and more undergraduate tutors were recruited With these changes the course settled into a more placid state, though still characterized by some complaints. For instance, the unit tests were much easier than the assigned exercises so that students soon stopped working the exercises, even though they were repeatedly encouraged to do them. Students also tended to put off the physics work, since classes in other subjects still employed regular quizzes, problem assignments, and other deadlines.

To counter this "procrastination," the organizers established several target deadlines and urged students to finish certain units by these dates But this created fresh problems: students came in large numbers just before these deadlines, swamping the attention of staff and giving students the impression that the staff could not give them adequate individual attention. During the time between deadlines the section staff now had little to do. Instructors thus got a double impression: that they were under-utilized as teachers during the slack periods and overworked as test-graders during the busy periods.

As the end of the term approached, it became apparent that a significant fraction of the students were not going to complete the course "on time." The organizers had allowed for this by planning three similar final examinations: the first three weeks before the end of the term, the second at the end of the term, and the third six weeks after the end of the term at the conclusion of the MIT January Independent Activities Period. Students could take one or more "finals" until they passed one of them. In order to be able to compare student performance in the PSI course with that of students in earlier lecture-recitation versions, final examinations were designed to be similar to final examinations given in previous years. The level of mastery required by this test was higher than that of the unit tests and was more nearly equal to that of the problem sets, which students had stopped doing early in the term. As a result, 27 percent of the students had not completed the examination satisfactorily by the end of the term and 15 percent had still not completed the course six weeks later. Hulsizer went to considerable lengths to assist these students, even to the extent of organizing a fourth final examination six weeks into the second term. (This resulted in some perplexity and even resentment in other departments: they did not like to have some of their students still working on first-semester physics so far into the second term.)

Despite these difficulties, there is considerable evidence (presented below) that students in the first large-scale trial of PSI learned an acceptable amount of physics, and that the majority was not unhappy with the PSI method. But it is clear that the method obtained a bad name in several important constituencies. The narrative below traces the gradual improvement in the operation of three later large-scale trials (one per semester), yet the consciousness of the MIT "academic public" never caught up with later improvements, and the awareness of the initial difficulties dominated the general reputation of PSI in physics thereafter.

(3) Subsequent Large-Scale Trials

After the first large-scale trial, the PSI method was used with various modifications for three more semesters by the Department of Physics before discontinuance. The second semester of introductory physics was taught for two years running by two young faculty members acting as coordinators and the (then) Chairman of the Department as lecturer. No department official suggested that they try the PSI method, but late in their preparation for the course they decided "to give PSI another trial." This decision was based not on any personal commitment to PSI but rather on the conviction that they could run a satisfactory PSI course by learning from the experience of the preceding semester. While maintaining the general organization used in the first large-scale trial, they carried further some of the modifications already begun in the first semester: the number of units was further cut to eight per semester; new attempts were made to combat procrastination by imposing "hard deadlines" such as two one-hour exams and "moving windows" that specified an earliest date and latest date on which credit could be obtained for passing a given unit; and in order to encourage students to work the assigned exercises, unit tests were carefully matched to some of these exercises.

Students who had taken the first two semesters of the PSI course felt, by and large, that there had been an immense improvement in the operation of the second trial compared with the first. A few new grumbles appeared, such as the complaint by some faculty and students that the exercises were of highly variable difficulty and that dividing the subject into only eight units made each unit too long and too difficult to examine with one or a few test questions, but these difficulties were relatively minor.

We will not give a detailed description of the two large-scale PSI courses which followed in the academic year 1972–1973. Overall, the modified PSI courses of these semesters saw steady improvements in study materials, administrative procedures, and level of satisfaction reflected in student comments. Many of the faculty section leaders who participated in the first trial were not, however, involved in the course thereafter, and so were not aware of the improvements that did take place. The drift of the changes was clearly away from "classical" PSI, away from self-pacing and toward deadlines. Indeed, by the end of the large-scale trials, the PSI features of the course essentially were being added on to a conventional lecture format, with only the section meeting serving a function different from the conventional recitation.

In the spring of 1973 the Associate Department Head assembled a committee to discuss the overall problems of the introductory courses. The informal discussions of this group provided some of the information used by a more formal departmental committee appointed to study the entire undergraduate physics program during the summer of 1973. One of us (EFT) was a member of this summer committee, which examined, among many other subjects, the PSI introductory courses. A near-unanimous dissatisfaction with these courses was expressed by faculty members on the committee. As far as we can tell this dissatisfaction was not based on any evidence of widespread lowering of standards or other academic grounds, nor on evidence of organizational difficulties, these having been largely overcome. However, the committee voted to recommend a "cooling off period": that the large introductory courses should not be taught by this method during the following academic year. The

Department, realizing that so many faculty were dissatisfied, acted on this recommendation, returning these courses to the lecture-recitation format.

DISCUSSION

In thinking about the rise and fall of PSI in physics at MIT, we have come to recognize two layers of analysis. The outer layer consists of some relatively straightforward conclusions about what seem now to have been organizational errors made in going from small- to large-scale use of the PSI method. Hulsizer, who initiated the first large trial, has identified, in retrospect, two initial policies that had serious consequences. the first was to compose and use new study guides with the full 600 students without first trying them out with a small class; the second was to have 27 units per semester rather than 15 or fewer units as used in previous MIT trials.

More than one organizer of the large-scale PSI trials has said that since the courses involved were required subjects, PSI should have been offered as an alternative option rather than as a total displacement of the standard lecture-recitation method. Had this been done and had faculty members teaching by the PSI method also been volunteers, this alternative method might well have attracted participants who found it compatible to their learning and teaching styles, and the number of students taught by PSI could have reached some equilibrium level.

These are straightforward conclusions, reflecting a consensus among those close to the experiment

The response of the Department to PSI was consistent with the way it had handled innovations in the past. The customary practice is to grant to faculty who request it permission to try innovative materials, to provide supporting facilities and staff as needed, and otherwise to give them freedom to teach the course in their own way This pattern has resulted in a series of well-known textbooks that have contributed substantially to MIT's reputation in physics education Slater and Frank, Frank alone, Morse and Feshbach, Sears and Zemansky, Ingard and Kraushaar, and more recently Kleppner and Kolenkow, Benedek and Villars. The new introductory course developed in the late sixties in the Education Research Center was introduced in the same way. Although it included films, background publications, and "corridor experiments," as well as texts (authored principally by A. P. French), the course *format* was the usual lecture-recitation one.

Hulsizer's request to teach the introductory course by PSI was handled in the customary way that had been so successful in the past Only after the large-scale trial was underway did it become apparent that the changed *format* of PSI involved more fundamental dislocations than had been experienced in the earlier innovations. With the widom of hindsight, several observers agree that it would have been helpful to have organized at the beginning an *ad hoc* departmental committee that could have performed one or more of the following tasks: collected from a variety of sources (including the ERC staff) suggestions and recommendations for how the first large course should be organized, solicited personnel to run the offerings subsequent to the first trial while providing them with continuity of experience, information, and advice; provided a neutral forum in which faculty feeling about the course could have been vented and examined; acted as a buffer between course managers and other departments; and organized an independent evaluation of the results

We feel that useful insights may be drawn from the foregoing discussion by innovators in other circumstances. But if we stopped with these straightforward conclusions we should have failed to grapple with a whole set of more basic and puzzling questions that lead to a second layer of analysis, questions such as:

> Did the large-scale PSI trial truly succeed or fail?
>
> What conclusions follow about the PSI method itself?
>
> Do students want what PSI has to offer?
>
> Whose opinion was finally of consequence in suspending the PSI trial?
>
> How useful is education research to those making educational changes?

Since the original actors in the drama are still available, one might expect to be able to obtain direct answers to these questions. However. in attempting to do so we soon found that reactions of different participans'to the same events differed markedly from one another. Moreover, the evolution of PSI in physics at MIT seems to have been determined not by the *answers* to these questions but by the conflicting *perceptions* of different participants and observers concerning the issues that underlie these questions. To move, as we do now, to a discussion of these perceptions and conflicts of view is to enter a more complex and inevitably more subjective realm. It is difficult to treat such issues in a systematic manner, but we cannot avoid them if our account is to reflect more than a superficial analysis. What were the central underlying disagreements and other factors that we have identified? We discuss the principal ones below.

Points of view on failure

We have already noted that the "academic public" at MIT began to perceive the large-scale use of PSI in physics as a failure as soon as the first trial ran into trouble. The "failure" label was pinned on PSI at that point and stayed put through four semesters despite success in overcoming various management difficulties and pedagogic problems. The label was read relatively uniformly across other departments and certainly by the large group of physics faculty members not directly involved in the course. Among those physics staff who actually taught the sections there seemed to be three groups: small minorities who were strong advocates or opponents, and a large middle group holding views that could be described as mildly negative First impressions are often lasting, in academic communities as in others, and it takes a long time for general opinion to catch up with any gradual improvement in a situation initially perceived as unsatisfactory.

Those actually in charge of the large-scale PSI courses felt that after the first semester their courses went quite well. In describing the second of the four trials, one of these innovators recalled.

> "The feeling was that it certainly was no worse than before. the faculty were not terribly unhappy. student ratings and grade reports were typical It was just ordinary—we were relatively satisfied"

Student reaction to the course can be determined somewhat more precisely. As part of the freshman pass fail system at MIT. students are asked to fill out two forms describing their progress in each course. one in the middle and one at the end of each semester We have transcribed. on an anonymous basis. a random sample of more than one third of the student comments on the courses we are studying[1] After reading through these comments. we were inclined to ask. "What failure?" Aside from a very small number of vituperative broadsides and a larger number of mild suggestions directed at one or another administrative procedure. the vast majority of students seemed satisfied

This conclusion has been questioned by some readers of early drafts of this paper on the following grounds although all students in a course are supposed to fill out forms on the course, in fact students who drop it or fail it often do not fill out the forms. Therefore. so this reasoning goes, the opinions expressed on the forms are dominated by those who have profited from the course. and the comments will be more favorable than a balanced picture warrants. It is difficult to evaluate this criticism. but we feel that a contrary effect is present also. of those who do fill out forms. dissatisfied students tend to express their "gripes" more often than satisfied students extend praise.

One other source reflects student opinion about the course The student-published course evaluation for the first large-scale trial was negative but was principally concerned with the fact that the unit tests were thought to be too easy The published evaluations for subsequent trials showed gradual improvement in virtually all areas. but especially in course organization

We have already mentioned that the final examination in the first PSI trial was made very similar to those administered in previous years. Hulsizer's interpretation of the relatively new pass-fail grading system for freshmen courses led him to raise the dividing line between pass and fail in the course he administered by some 20 percentage points over what it had been in previous years. He felt this higher level of achievement could be demanded without undue penalties by allowing each student to take as many as three similar versions of the final examination. Consequently. it is clear that in terms of conventional test-passing criteria. the students on the dividing line between pass and fail were "learning more physics" under the conditions of the large-scale trial (with its repeatable testing feature) than similar students had under the former lecture-recitation format (with its non-repeatable final). We have not been able to assemble comparable information for the subsequent three semesters of large-scale PSI physics.

The mystique of physics teaching

In our discussions with faculty participants in the large-scale PSI trials. we encountered a widespread opinion that the PSI method itself lacked some essential ingredient necessary to the teaching of physics This opinion was variously expressed: PSI failed to display the "richness" of physics or its "interconnectedness," or to provide the "extra something" conveyed by lectures, or to train students to solve exercises, a skill sometimes "taught in the elaborate recitations" of a regular course. Still others felt that the large number of units focussed attention on the paperwork. allowing students to move from test to test "in a closed way" that accentuated the all-too-common student inclination to "go for the right answer" rather than to understand the power of the subject in a larger context Somehow or other, according to this set of opinions. what is important in physics teaching is *ineffable*. it cannot be compressed into objectives. carried out by means of study guides. or justified by performance on unit exams aimed directly at these objectives Although there is no specific agreement among those holding this general view of physics teaching. the following paraphrase of a statement by one faculty member who taught a PSI course demonstrates this objection to PSI:

> PSI units are rather restricted. the method lends itself to material that can be taught in a mechanical fashion. not the subtle stuff. The physics presented in the units must be transparent and as elementary as possible, but physics is not really transparent. The PSI units I have seen do not contain satisfactory physics. They reduce physics to simplicities and set a low standard. The problems have to be straightforward. yet the fundamental ideas are really subtle In self-paced courses a difficult problem really floors the students These units concentrate on one idea and you cannot build in that way the more powerful style that physics requires.

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[1] Files of student comments are maintained by the MIT Freshman Advisory Council The Council insisted that the anonymity of student comments be strictly preserved They made the files available to a "Skill Bureau" typist whom we employed to transcribe the comments without names No one at MIT connected with this study has seen the names of students who made the comments or of staff members mentioned in the comments We are grateful to the Freshman Advisory Council for their cooperation in this procedure

Over this question there was marked disagreement. For example, the reaction of another faculty member to the paraphrased opinion above (and others like it) was as follows:

> ". . . . Baloney . . . I think there is nothing incompatible about PSI and physics. Every possible level of skill and complexity and conceptualization can be achieved in a PSI context. And I would say that on the whole the ability of working on a one-to-one basis with students allows you to *encourage* them and help them work problems and think about things at a much more sophisticated level than you can when you just toss them a bunch of problems and leave them in their dormitories to wrestle with it with whatever help they can get from their colleagues. My feelings is that a well-run PSI operation can do a *much* better job of teaching physics than a standard lecture and section format."

These two opposing statements reveal underlying fundamental disagreements about the teaching of physics. Is something lost by breaking down complex ideas into simpler ones? Are lectures the best way to communicate "the subtle stuff"? What goes into helping students to think at a "more sophisticated level"? We cannot resolve such questions here What is clear, however, is that individual teachers have their own private views on such questions, often strongly held, and that these were not publicly debated at the time. College faculty rarely discuss their fundamental convictions concerning teaching, much as they avoid discussing religious beliefs · Yet these convictions influence judgments and policy positions despite their subterranean nature. Genuine consensus demands that disagreements and dissatisfactions be traced to their roots and acknowledged

What Students Really Want

Although PSI gives students some freedom in the scheduling and style of their work on a course, many faculty feel that this freedom runs counter to what students—MIT students at least—are trained for and expect Listen to the organizer of one of the large-scale PSI trials in physics

> "One thing that we were all trying to get away from, is the thing that it was very easy to get back to, namely, it is well known that MIT students love to be driven. And if you set them difficult goals with tough schedules and hard examinations and very difficult situations, they will rise to those demands . . If they hadn't beat their heads against the tough schedules and competitive examinations, they wouldn't have gotten into MIT. They're all primed for that kind of approach and it is guaranteed to work"

At the time we interviewed another of the organizers, he was teaching the same subject again, but this time by the regular lecture-recitation format He had added to this regular method very stringent scheduling and detailed instructions to students and section leaders. Here is the paraphrased description of this lecture-recitation course and its results:

> This term the morale of the faculty is extremely high. The student evaluations are excellent, though we don't have the final rating. They know what they will be taught in class on a particular day, they know what they've got to do. There is a quiz in class every week, they know the dates from the beginning . . . . Not only students are told what to do, but instructors are told what to teach in each section meeting. They love it; even [one of the section leaders most enthusiastic about the PSI version] is happy.

Some evidence confirming this perception of what students want can be found in the midterm and end-of-term freshman evaluations. One student wrote at the end of the first large-scale trial:

> "The idea of a self-paced course is great for students WHO WANT IT, BUT IT *SHOULD BE OPTIONAL*. With students coming in from all different backgrounds, it is ABSURD to think they are all qualified to pace themselves."

The number making this complaint was balanced by an almost equal number of students who apparently felt stimulated by the added freedom of PSI. Halfway through the second semester course, one student remarked:

> "I prefer it this way, i e., self-paced—no tension and, perhaps most of all, lots of room for personal innovations."

For some students procrastination was a by-product of having only one of four or five courses per semester in the self-paced format:

> "I can't quite decide whether I think self-paced courses are good or not. I don't really think they are a good idea for a pass/fail course, that is, when all a student's courses are pass/fail. There is a tendency to let yourself get behind in the self-paced courses, and concentrate more on the courses that have stringent deadlines on their assignments."

Apparently at least some freshmen require relatively unambiguous direction about how to manage their time. These students find the greater freedom of PSI to be a hurdle in itself.

The Role of the Faculty Section Leaders

The faculty section leaders in the large-scale trials occupied a central position in the execution of the course. Yet they often did not feel that they were themselves innovators. By and large their role in the large-scale PSI course was more passive than the one they were accustomed to play in the conventional lecture-recitation format, and also different from the role played by instructors in the earlier small-scale trials of the PSI method in physics. In a regular lecture-recitation course, faculty recitation instructors have a good deal of autonomy; although they are expected to reinforce the presentation carried out in the lectures, they have considerable independence in running their sections, both in the style of teaching and in the coverage of subject matter. And in the trials of the PSI method in the Education Research Center, instructors themselves prepared study guides and unit tests (and therefore controlled the presentation in detail) and also supervised the tutors (rather than themselves grading unit tests); their "teaching time" was spent supervising the system and answering student and tutor questions about the subject.

The position of faculty section leaders in the large-scale trial of PSI in physics was altogether different. Typically they had not volunteered to teach by PSI, received only a brief introduction to the method, were not involved in writing study guides or unit tests, and had little control over the way their sections were run. When they were not overloaded as test graders, they were underutilized as teachers, a difficult position for MIT faculty. As a result they typically did not identify with the new scheme: it was someone else's innovation.

When we asked Hulsizer how much of the negative reaction by some section leaders could be attributed to general resistance to *any* teaching innovation, he replied in part,

> "I don't think that the resistance, the negative reaction by some section leaders, is necessarily attributed to resistance to *any* teaching innovation. I just think that some people prefer the section situation in which they play a more dominant role in the teaching process."

If the large-scale PSI trials changed the role of the section leader in the manner we have described, it is understandable that a powerful faculty constituency should have finally weighed in against continued use of the method.

The Usefulness of Education Research

We wondered about the hesitancy of some physics faculty to draw upon the experience of the ERC staff during the planning stages of the large-scale trials. Local politics and personality factors may have been partially responsible and need not be aired here. However, during our interviews we became aware of a widespread and very recognizable attitude—more often implied than expressed—that there is little profit to be gained from taking the time to study carefully the non-curricular aspects of the educational process and environment. It is not quite correct to say that most physics professors feel that "anyone competent in physics can teach it," but there was certainly a strong undercurrent of skepticism about the usefulness of most educational research and a corresponding disinclination to involve in the design of new courses individuals whose main professional activity is education research and innovation. When we interviewed one of the principal supervisors of MIT undergraduate physics teaching, he remarked, "I don't follow the education business."

Skepticism about education research is not uncommon, and we have a good deal of sympathy with it. One of us (EFT) has assembled a bibliography in physics education and has been forced to acknowledge that while articles treating the *subject matter* of physics are often helpful, good articles about how to improve the *format* of courses or how to analyze the *context* adequately to insure that an improved format survives, are in short supply. The literature in this area could charitably be described as "dilute."

Yet the present study has reinforced our opinion that anyone who undertakes an academic innovation must take into account far more than the course content and the technicalities of running the course. The wider context also has to be considered: how to ensure that all involved are informed about what is happening; that divergences of basic viewpoints are brought to the surface; that attention is drawn to the good points as well as to the bad; that difficulties are quickly rectified; that there are compensations to counterbalance the reluctance to undergo the upheavals attendant to innovation.

The general lack of confidence in the value of education research was strengthened in the present case by a specific distaste for "motivational" and "reinforcement" techniques associated with the name of Harvard psychologist B. F. Skinner. The PSI method grew out of the behaviorist school of psychology identified with Skinner, and both Keller and Green were influenced by him. Some MIT faculty (in departments other than physics) have been the most vocal public critics of Skinner, and Green intentionally did not emphasize Skinner's connection with PSI. Nevertheless, several managers of the large-scale PSI physics courses have acknowledged that they hoped to make use of the "obviously desirable" aspects of PSI without the "Skinnerian overtones" and "extreme measures" such as "lecture as reward" and other "contingency-management" techniques used by Green in his ERC courses.[8] At least some of these managers avoided asking for advice because they expected not to be able to accept it.

CONCLUDING REMARKS

Some readers will be disappointed that we have not provided a definitive single answer to the question "Why was the large-scale trial of PSI in the MIT Department of Physics discontinued?" We are ourselves convinced that

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[8] After reading a draft of this paper, Green has commented that, in his view, the faculty attitude toward contingency management is doubly ironic. The first large-scale trial suffered from "student procrastination," i.e., inadequate contingency management; the changes made in later semesters to remedy this situation involved the use of deadlines, which are contingencies in their most direct form and in fact harsher contingencies than Green himself used in his own co[illegible]

there is no such single answer, but that a variety of events, circumstances and reactions combined to produce a widespread impression of failure. Indeed, a case can be made that the large-scale trial of PSI did *not* "fail" in its central function of teaching physics to students. Instead it seems to us the large-scale trials were discontinued because of the *perceptions* of both participants and non-participants.

The "failure" label derived particularly from the days of initial difficulties with the trials. But if many faculty had enjoyed teaching this way; if there had been a vocal group within the physics faculty strongly and persistently advocating PSI; if PSI had been offered simply as an option for teachers and students who found this style compatible; if the critique of the standard age-long teaching methods implied in PSI had been made explicit repeatedly; if there had been continuity or organization from small-scale to large-scale trials, then these initial difficulties might have been rapidly forgotten, being designated as "teething troubles." As it was, the moderate success of the later trials was not sufficiently publicized or acknowledged. Moreover, with successive modifications of PSI the scheme became more conservative, so that even the attractions of the "radical alternative" were eroded. At the same time the undergraduates became less critical of established forms.

What characterized the first phase and rendered it different from what came later was that it was organized by a group who made PSI a major professional commitment, who acted as an anchor group (with steadily accumulating experience) from semester to semester; who were in touch with (as well as further promoting) a national PSI movement. They also worked with volunteers—i.e., students who purposefully opted out of the conventional course format to try the PSI version. This pattern contrasts with the large-scale trial, which was modified in form, imposed with minimum consultation on an educationally conservative, highly research-oriented and extraordinarily busy faculty group, and required of incoming students.

In retrospect it appears straightforward to point to the need for appreciation of "scale" changes, for extensive communication and consultation in the early stages of a major new venture, and for understanding of changing roles that follow in the wake of a newly imposed course structure. But we realize—as well as our readers—that these lessons are the hardest to learn except through personal experience. If, as a result of this post-mortem, some intending innovators revise their plans to take more account of their own particular circumstances and build in extra supports for their fledgling ideas, then our study will have been worthwhile.

APPENDIX F

Summary Report of the CASC Advanced In-Service Faculty Development Program.

THE CASC ADVANCED IN-SERVICE FACULTY DEVELOPMENT PROGRAM

The Council for the Advancement of Small Colleges (CASC) is a national association which was founded more than twenty years ago to meet the unique needs of the small liberal arts colleges. In recent years, CASC has devoted considerable attention to the emerging needs for faculty development in these colleges.

The first stage of the CASC faculty development program was made possible with a grant for $150,000 from the Lilly Endowment CASC provided expert consultation to CASC college teams that wished to plan for institutionally based faculty development programs during the annual CASC Summer Institute in August of 1974. Forty teams consisting of three faculty members, the president, and the academic dean, met to expand on a tentative plan for faculty development which they had each prepared before participating in the national institute With assistance provided during the week by ten nationally known consultants, each campus team reviewed, studied and refined its plan through group discussion, personal reflection and negotiation. This planning process continued in the fall of 1974 at a series of regional CASC conferences

The second stage of the faculty development program began in the spring of 1975, when faculty from forty-five CASC colleges were selected to receive training and consultation in the implementation of faculty development projects Approximately one-half of these colleges were among those involved in stage one The second stage of the program was supported by a generous grant of $190,000 from the W K Kellogg Foundation.

The forty-five faculty trainees—called "on-campus consultants" (OCCs)—attended four national institutes: (a) a seven-day basic training institute which was conducted in August, 1975, at Lake Forest College, (b) an advanced six-day training institute which was conducted in January, 1976, at the College of Mount Saint Joseph, (c) an advanced nine-day training institute, involving two three-day specialized modules and one three-day core module which was conducted in June, 1976, at the Snow Mountain Ranch near Denver, Colorado, and (d) an advanced five-day training institute involving two three-day specialized modules and a one-day core module, which was conducted in November, 1976, at Bethany College.

These institutes served several important functions First, the OCCs were exposed to a wide variety of faculty development services, and provided with sufficient information and skill[illegible] offer many of these services on their own campuses. Some of the areas to which the OCCs were exposed in depth are: instructional diagnosis and improvement, student evaluations of instruction, course design consultation, leadership training and curricular design and reform. During the core modules, all of the OCCs were also trained in the use of consulting skills, and were provided with information to assist them in grantsmanship, planning futuristic curricula and evaluating faculty development programs. Second, the institutes provided an opportunity for the OCCs to establish a close and enriching learning community. As faculty development practitioners who come from similar institutions, the OCCs were able to share successes and failures, and to provide important interpersonal support at times of difficult personal and professional challenge and change Third, the institutes enabled regional groups to be established which reflect natural patterns of help and communication among CASC colleges. Finally, the institutes proved to be occasions for each OCC to temporarily leave her busy and pressurized existence at a CASC college in order to spend several days reflecting on her current and future professional life.

The OCCs received six other services: (a) copies of two volumes of *A Handbook for Faculty Development*, which were written by William Bergquist and Steven Phillips for this program, (b) a series of three to four on-campus consultations by seven nationally known experts in the field of faculty development, each epert serving as a mentor to four to eight of the OCCs; (c) meetings of four to eight OCCs from colleges in a specific geographic region of the country with the mentor assigned to each region, (d) provision of monies to each region so that the region as a totality, or individual OCCs in the region, could plan, implement or attend training workshops, conferences, or other activities associated with professional growth, (e) a four-day training program for ten of the OCCs in the use of illuminative evaluation, and (f) visits by the ten trained OCCs to thirty-five of the participating CASC colleges, where an illuminative evaluation of the faculty development program at each institution was conducted.

Participation in each of these activities was gratifying. At least forty OCCs attended the first three institutes, thirty-four attending the fourth (which was held at a time when classes were in session). The regional meetings were attended by most OCCs, and the mentorship program has been actively used by virtually all OCCs. At least forty-two of the original forty-five OCCs can be said to have actively participated in this program.

Several important benefits have clearly emerged for the OCCs who have participated in this program. First, the OCCs have gained information and skills that they can and have used on their campuses. Second, because of their participation in the program, the OCCs have gained increased credibility at home. Third, the OCCs have often moved into positions of academic leadership (or were already in a leadership position prior to entering the program). They are able to work in this position with greater insight into the nature and development of faculty, and more knowledge of current and future trends in American higher education. Fourth, the OCCs have acquired new friends, a continuing mentorship relationship, and a functioning regional network, which allows them to continue their own professional development after the program has terminated. Fifth, in many instances, the OCC has worked closely with a faculty development committee or team, conveying important learnings from the CASC program to other faculty and administrators. In this way the impact of the CASC program has been extended, and probably will be sustained

This program has also had a significant impact on CASC. For the first time, CASC is working with faculty rather than administrators over an extended period of time. The CASC staff has learned about faculty in these colleges, and the faculty have learned about CASC. For many faculty at the participating colleges, this is the first CASC activity that has been felt at the ''grass roots'' of the college. Furthermore, this program has allowed CASC staff members to better understand how they can most effectively facilitate this renewal. In general, the traning institutes (especially those with focused themes), the mentorships, the handbooks and the regional networks have proven to be successful devices for the provision of services by CASC to its participating colleges. One of the indirect—and perhaps most important—benefits of the CASC faculty development program has been the insights provided by the participants concerning how faculty development can be effectively implemented in the small, liberal arts college.

APPENDIX G

Sample Design of A One-Week Intensive Faculty Development Workshop.

SAMPLE WORKSHOP DESIGN

Duration: One Week
Focus: Instructional Development (Secondary emphasis on personal and organizational development)

Day & Time	Activity	Brief Description
WEDNESDAY Evening	Orientation to Workshop Informal Social Period	Review Workshop Design Review Rationale for Workshop
THURSDAY Morning	Discussion Session: Roles as a Teacher Short Theory Session: Teaching Styles Discussion Session: Teaching Styles Micro-College Planning	Respond to question: "Who Am I As A Teacher?" Presentation of a taxonomy of six different teaching styles Small group discussion on implication of ideas from theory session
Afternoon	Micro-College	Concurrent presentations by staff and interested participants on topics chosen by entire group
Evening	Skill Training Session: Helping	Theory and practice in establishing a helping relationship
FRIDAY Morning	Discussion Session: Roles as a Learner Role Play: Student Learning Styles Short Theory Session: Student Learning Styles Micro-College Planning	Participants reflect on their own learning processes in a variety of settings Presentation of six different learning styles
Afternoon	Micro-College Teaching Laboratory	Actual teaching in a video-taped laboratory
Evening	Skill Training: Problem-Solving	Presentation and practice in using a variety of problem solving techniques
SATURDAY Morning	Discussion Session: The Influence of the Institution on the Classroom Micro-College Planning	Use of problem-analysis to assess nature of institutional influence; individual assessment, plus small group discussion
Afternoon	The Dilemma of Power	A simulation on power and systems

Evening	Free	
SUNDAY Morning	Exercise: Small Group Decision-Making and Conflict-Management Micro-College Planning	Consultation and brief theory session
Afternoon	Micro-College Teaching Laboratory	
Evening	Skill Training Session. Decision-Making	Use of Decision-Making games, plus theory
MONDAY Morning	Discussion Session: Reflecting on Planning for the Future	Use of Life Planning Exercises modified to specifically focus on teaching
Afternoon	Teaching Laboratory Preparing for Return Classroom	Participants provided with opportunity to try out new teaching methods
Evening	Discussion Session: Preparing for Return to Significant Other People	Reflection on personal learnings from workshop, how to convey these to spouse, children, friends, and so forth
TUESDAY ~~morning~~	Workshop Evaluation Interviews Workshop Evaluation Questionnaire	Participants interview each other regarding significant learnings from workshop; particularly, what did each participant learn about the way he learns, how to continue the type of development begun at this workshop Evaluation form given out to participants

SUMMARY, CURRENTLY-USED MECHANISMS AND DELIVERY MODES FOR NONACADEMIC PERSONNEL

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FOREWORD

The following report is a very brief overview of the use of multi-media techniques in continuing education for engineers and scientists. In the time allotted this is all that can be done. This subject could very easily lend itself to an extended study and require one man year of effort.

In the report are illustrative examples of uses of media in continuing education for engineers and scientists. The author is aware that many more examples could be given, but they serve to show the scope. The Appendix contains some lists of people, materials, and sources of producers/users of media based programs to serve as a starting point for future documentation. Although the use of these techniques are not insignificant, they represent only a small fraction of the continuing education effort of industry, professional societies, and universities in this emerging area of education.

The potential for increased use of these techniques for bringing more continuing education to the practicing engineer/scientist are many, if certain problems can be overcome. The National Science Foundation has the capability of providing the leadership in getting this initiated if they would exhibit the interest to become actively involved.

The author is deeply indebted to Lenore Biedenbach, Donna Ford, and Linda Maynard for their help in compiling this report. Without their help and advice it would not have become a reality.

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PROPOSED COURSES OF ACTION FOR NSF

Introduction

Most continuing education programs in universities have to be self-supporting and therefore, the continuing education director is under pressure to make sure his time and effort are spent on doing those things that will make his programs successful. As a result he does not have much time, nor is he willing to make the effort to prepare in detail proposals to NSF or other agencies (with little chance of success for funding), to undertake research projects for disseminating information on continuing engineering education. Although there has been much written on the continuing engineering education field, it is of a general nature and very little hard research has been done. This is a tragedy because people are making decisions on programing with insufficient hard data to make the best decisions. Because of this, the author would like to propose that NSF use a different approach in asking for proposals.

Rather than using the "scattershot" approach, and requesting individuals to submit proposals on their ideas, the NSF should ask for specific proposals on topics where they perceive a need for research. This would give some direction to the field of continuing education and would enable some solid research to be done which would help all those concerned. This is especially true in the engineer need assessment area, individual motivation, evaluation of programs, and other such areas of general interest to people involved in the continuing education field. In addition, one of the serious problems facing continuing engineering education personnel is the requirement for upfront funds to do some basic research in getting information out to their colleagues. Even though the funds required to do the job are approximately $10,000.00 to $30,000.00, organizations just cannot take that risk in the hope that they can recoup these funds from selling the monographs or booklets in the various research areas. If NSF could develop a strategy to overcome this problem, there are a great number of people in the field who could participate in the development of many studies.

I've listed below some specific items that NSF should consider in trying to develop a progressive looking program over the next three years.

1. Support four regional workshops around the country to determine "grass roots" perceived needs from engineers, industry, and universities.
2. Support study on the Current Status of Television/Video Tape Programs for CEE.
3. Support study of the Current Status of Professional Society CEE Programs.
4. Study on Current Status of CEE Programs in the Academic Environment.
5. Study on Current Status of CEE Programs in Industry.
6. Study on How Engineers/Scientists Learn as Adults.
7. NSF Actively Participate in an International Continuing Engineering Education Conference.
8. Support the Development and Production of a Compendium of CEE Program Monographs.
9. Make a Need Assessment study of CEE for the Practicing Engineer.
10. Support a study on the motivation of engineers, industry and universities to participate in CEE.
11. Support and encourage proposals such as the AMCEE and GENESYS Systems already under consideration. (Consortia looks very productive in the future and the Carnegie Commission reports seem to bear this out.)
12. Make a study of the effective evaluation instruments that should be used in CEE programs.
13. Support and study investigations designed to bring continuing education programs to engineers in small and medium size companies.
14. Support the development of an annual university and private proprietary institutions catalog of continuing education programs available to industry. (Take the place of Learning Resources catalog which has become defunct. With a different format, it could be self supporting in two to three years.)
15. NSF personnel should actively participate in FIE Conference and CIEC each year, and have a session devoted to NSF (give and take) each year.
16. Make a study of the criteria referenced continuing education programs being developed in the nation today. This shows good promise for the future.
17. Support several workshops around the country on the techniques of offering and marketing CEE programs.
18. Support monograph on how to use industrial advisory committees for CEE program development.
19. Support and study the effect which mandatory registration, re-registration, certification etc. would have on the CEE programs around the country.
20. Support and study the status and future of the Professional Development Degree (or equivalent) as a reward system for continuing education. (Not to include CEU's. This is what everybody is worried about.)

INTRODUCTION

Before one begins to discuss the use of media-based instruction as a technique to bring continuing education to the engineering and scientific professions, he must have a thorough well thought out philosophy of continuing education. Over the past decade continuing education has become vitally important for anyone in an engineering or scientific field. It is obvious that the technological explosion, the competitive environment for consumer products which prevails in our society because of recent economic conditions, and the necessity for greater productivity for all people in our working society makes it mandatory that the engineering departments of industry become much more productive. This places a great strain on the individual engineer's personal time if he is working in industry, and on the engineering manager's budget who must be concerned with a short term profit goal for his department

In any context, education is hard work One cannot learn a new technology, remain abreast of the existing technology or relearn things forgotten without great effort. If one considers the forgetting curve, it becomes readily apparent that although one may have learned a particular technology in the past the natural forgetting phenomena rapidly lessens one's expertise in a scientific area.

The responsibility for continuing education of the engineer must be shared by the individual, industry, colleges and universities, and the professional societies. It is important to realize, however, that the individual cannot abdicate his responsibility for maintaining his own professional development. The other organizations mentioned can assist, but individuals are accountable for their expertise in any particular technology at any given point in their career.

THE ENGINEER'S/SCIENTIST'S PROBLEM

If we look at the engineer's problems, we find that he is motivated to do certain things, utilizing Maslow's Hierarchy of Needs. Figure 1 is a simple graphic illustrating this theory.

Self-Actualization
Self-Esteem Needs
Social Needs
Safety Needs
Physiological Needs

Figure 1:—Maslow's Hierarchy of Needs

Under the influences of our present society, most engineers are working at the self-esteem and self-actualization level. Physiological, safety, and social needs have largely been met in our affluent society; therefore, continuing education programs must put special emphasis on the self-esteem and self-actualization level. Many of our current programs for utilizing multi-media techniques or live instruction do fail to emphasize this fact.

In addition, the engineer, because of the pressures of his job, family, and society has set some very specific priorities in his life style. Figure 2 lists the typical priorities of a modern adult.

Figure 2:—Typical Priority Listing of an Employed Engineer

Activity	*Priority Level*
The Full Time Job	Top
The Emergency Job	Top-Top
Wife and Children	Top
Community Affairs	High
Hobby, Personal Fitness	Irresistible
Family Emergencies	Top-Top
The Other	Unavoidable
Education	If Possible

Obviously an engineer's full time job and family come first in his priority listing. It is important that all educators and managers realize that the engineer will participate in educational programs only if he has the time and if there is a "payoff" for his participation in learning activities. This is especially true if he must participate in learning activity after his working day. Although most continuing educational programs throughout the country are termed successful, when one looks at the number of participants in these programs one is hard pressed to determine whether or not the majority of the educational needs of the greatest number of professional people working in this industry are really being met.

An engineer develops life long learning patterns and styles from the time he is in elementary and secondary schools. Figure 3 gives us some indication of how an engineer currently keeps up to date.

Figure 3:—Engineer Life Long Learning Patterns

Reading the Literature
Discussion with colleagues
Attending the Conferences
On the job learning
Formal courses

It is this author's observation that although most people say that they learn best on the job and from reading the literature, this is not really the case. Very often we can say that a man with twenty years of experience really has one year's experience repeated nineteen times. One often wonders if other people can read and digest all the literature better than he, himself, can. I, for one, never test myself on whether or not I got 90% of the knowledge from the material in the literature that I read, and it raises a question on how much I really learned. If one examines the forgetting curve again and the ability to remember things that are read, he realizes the truth of what educational psychologists tell us: the maximum, under ideal conditions, that the learner could possibly absorb is 50% of the material read the first time through. Very few of us have the time to read over articles three or four times to get the maximum benefit from any particular program unless the job requires emergency procedures immediately.

The problems of the adult learner include personal time, finances, individual motivation to learn, and his inability to determine always what his actual needs are In many respects, time and motivation are the two most important aspects of this problem. The use of multi-media programing techniques in most programs could help solve these two major reasons for not participating in a life long learning environment Because of the problem solving and problem definition ability most engineers and scientists possess, they are asked to serve on many community committees. Therefore, their motivation and time available to participate in other educational programs of any length is lessened.

Most engineers and scientists, if they have a problem, consult their peers, supervisors, and peruse the literature. It is interesting to note that anyone who works with continuing education programs for any length of time begins to realize that the academic level of information which engineers need most on the job is not on the graduate or post graduate academic level Most of the problems confronting those working in manufacturing or industrial environments are people problems, and the skills which are needed to solve many of these problems could be classified on an academic scale of elementary, high school or the bachelor of science degree level. This fact sometimes is a very rude awakening to young engineers in the field and they feel that their skills are not being fully utilized within industry.

Cyril Houle, University of Chicago, stratifies professional people in four classifications. innovators, pace-setters, majority adoptors and laggards. In many respects this is very accurate. Although many of us would like to think we are innovators, we really aren't. The majority of us are pace-setters or majority adoptors, and in our profession we have approximately 10% laggards. Innovators are those persons who come up with the new ideas which set the pace for our profession, our professional life, and are definitely in the minority. The pace-setters take what innovators have designed and thought out and put it into practical terms so that the rest of us can benefit from these ideas. This is the ideal person, then, to be used to develop the multi-media packages for the majority adoptor. This model gives us a very good perspective on how we should develop continuing education programs, which should be designed for majority adoptors and for pace-setters; primarily the former. Continuing education programs as we envision them in industry and the university will not help the innovators or the laggards. The innovators do not have the time to attend meetings from which they will probably glean little. They learn from their colleagues who are also working on the frontiers of their particular technology. Laggards lack the motivation to keep up to date. No matter what, they will find an excuse for not participating, and nothing will increase their individual motivation substantially to benefit from programs, whether they be multi-media or live instruction. Therefore, continuing education programs should be designed for the middle two classifications.

The continuing education director or manager interested in the professional career development of his constituencies must look at the entire spectrum of an engineer's life and realize that he learns in different ways and at different speeds. Each individual is different; one multi-media program will not work for all kinds of material. As you look at the educational career-life of an engineer or scientist, you would come up with something similar to figure 4, which Bill O'Brien from Princeton University has called "The Continual Learning Diagram". (See fig. 4.)

It is obvious that the engineer and scientist at minimum opts for the bachelor's degree and moves up in various stages through his entire career span. He enters the work life at different stages and retires at approximately age 65.

With this brief background of the problems encountered by an engineer in maintaining his life long learning competence, we will attempt to show how multi-media has been utilized by the engineer, university, professional societies and industry to help solve these problems.

WHY USE MULTI-MEDIA MATERIALS IN CONTINUING EDUCATION?

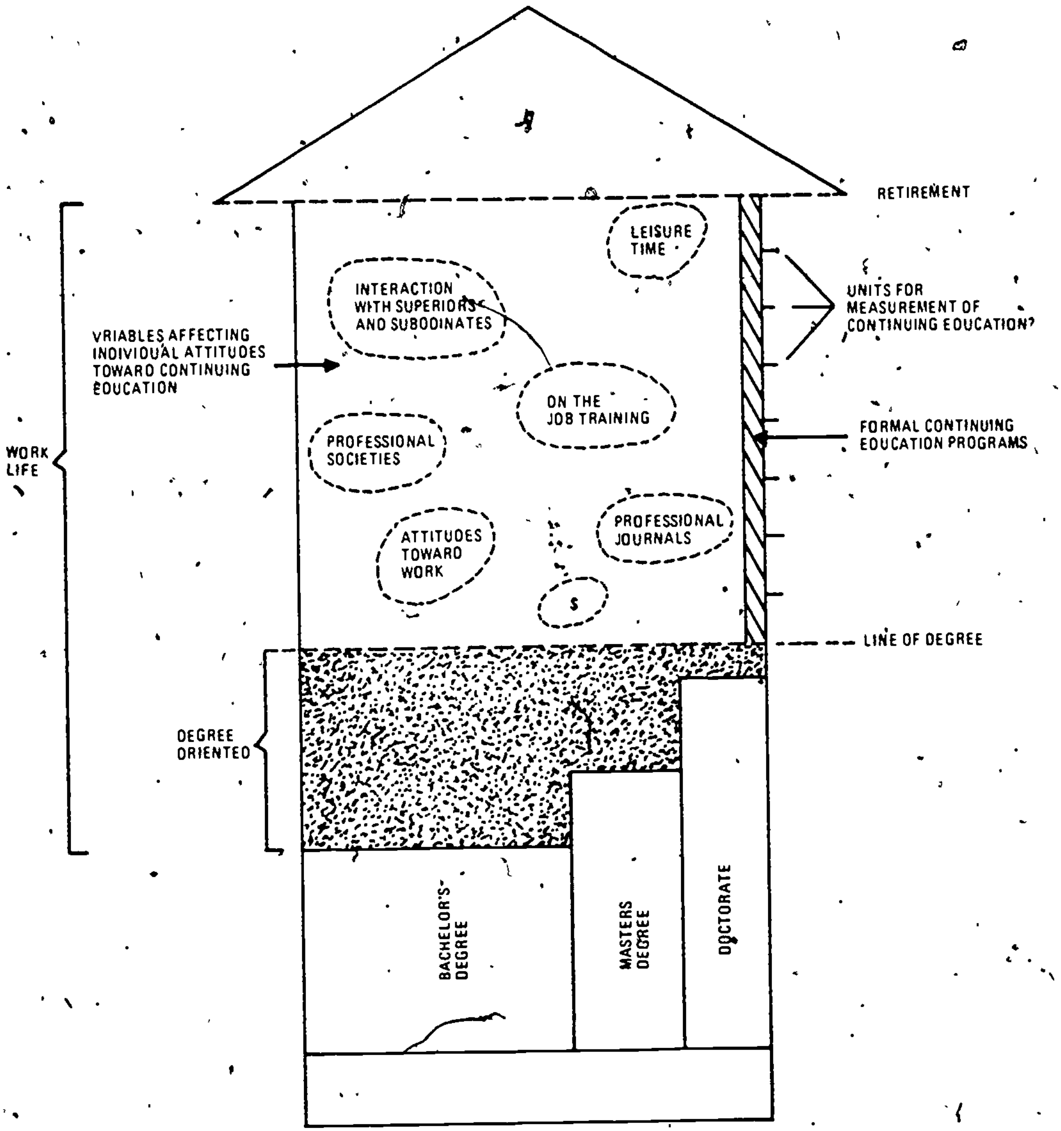
The use of multi-media techniques to bring continuing education to practicing engineers/scientists is becoming exponentially more popular each day.

Some of these are behavioral in origin: the individual needs mental refreshment; some are the result of good merchandising by both academic and proprietary institution, more efficient equipment more innovatively used. There are several very good reasons for this:

1. A large number of people can be reached over a widely scattered geographic area.
2. Working in small groups is a more effective way to communicate technical skill educational material.
3. It is more cost effective if we consider large masses of people
4. It is space and time independent.

The development of self instructional material which can be used easily by an individual, or groups of three

Figure 4:—Continual Learning Diagram



and four enables an industry to have open enrollment in programs without requiring prerequisites; allows flexible scheduling of the individuals' time. There is tremendous savings of learning time, and individuals can proceed at their own pace. And last, but not least, a more effective program can be developed over a period of time because it can be evaluated for the results very efficiently. When one considers the personnel required to provide a multi-media package, five different categories come to mind. The producer, director, educator disseminating the information, instructional technologist, and the participant who will eventually take this program. These five categories of people have different characteristics, and unless a team is organized efficiently the participant will not get the program needed. In too many instances the participant's needs are not well understood and the multi-media programs that have been developed have been very inefficient and ineffective. This is one of the reasons that some of these materials have not been readily accepted by many practicing professionals.

Multi-media programs are very convenient for the participant, requiring no travel on his part and allowing for a minimal interruption of the work schedule. Most important probably is their suitability for small groups and classes which normally would require twenty registrants to render them cost effective. A program can be developed for four or five people if there are sufficient groups throughout the nation that need the material. Probably the most important facet of such programs is that they are portable in terms of time and place. These programs however, to be successful, must be attractive to the participants and meet their perceived needs, be challenging and up to date, and give the participant a sense of gratification upon completion. Hopefully, they will be habit forming if they are convenient to his place of business. In the previous section it was noted that one of the problems associated with continuing education was the motivation of the engineering manager and the engineers themselves to participate. Only those multimedia programs which can overcome some of these problems will succeed.

What is a multi-media program? Some people would consider a text book a media based instructional tool which is very inexpensive. However, the 1970's has upgraded the electronic modes, and most people learn a great deal by being able to see as well as hear the information. Among educational psychologists it has been known for some time that people learn better by using more than one sense for any particular learning experience. A multi-media package properly designed can expedite this result very cost effectively.

What is a good multi-media package? One that is efficient and attractive to an adult has several characteristics. They must of course include the three I's: Information, Instruction and Inspiration as part of their development. They also must be designed properly to be accepted as fulfilling the adult learning process. Facets of the learning process are shown below.

1. They must have the willingness and desire to learn.
2. Adults learn only when they feel a need to learn as proved by Houle and Knowles.
3. Adults learn by doing.
4. Adults learn by solving realistic problems.
5. Adults have had previous experience which affects their learning.
6. Adults learn best in an informal environment.
7. Adults respond to a variety of teaching methods and not just a single media technique.
8. Adults want guidance and not grades.
9. Adults want to be treated as adults.

Thus, anyone who is attempting to put together a multi-media course or program must take these characteristics into consideration if the program is to be successful. Many current multi-media presentations do not.

When one looks at the work day of a typical scientist or engineer, he finds that it can be broken down into the following:

Activity	*Time (Hrs.)*
Sleeping	8
Bathing and Grooming	1
Eating	3
Traveling to Work	1
Working	8
Personal Time	3
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The above table is important in analyzing multi-media techniques because, unless the employer is willing to use some of the eight hours of the working day an individual has only three hours to do everything he would like to do (including continuing his education). This is a minimum time each day for this important activity.

When designing a multi-media program the director-producer must continually worry about the educational pedagogy requirements of adult learning which include visual contact, flexibility with visual aid projection and object presentation, and also provide an opportunity to recall the information that theoretically was learned.

The most commonly used multi-media techniques in programs for engineers and scientists today include the following:

Media Used	Knowledgeable Contact Person with Practical Experience
Electrowriter	William O'Brien Princeton University (also Stanford, Wisconsin)
Video Tape	Lionel Baldwin Colorado State
Close Circuit TV	David Waugh University of South Carolina
ITFS	Albert Morris Genesys Systems
	Kenneth S. Down Stanford University
Computer Assisted Instruction	Donald Bitzer University of Illinois
Satellites	Lawrence P. Grayson National Institute of Education
Dial-A-Tape	Medical School University of Wisconsin
Self-Paced Instruction	James Stice University of Texas, Austin

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Telephone	John Klus University of Wisconsin
Audio Cassettes	William Ledgerwood Exxon Corp., Houston. Texas
Cable TV	Henry Cauthen South Carolina ETV, Columbia, S. C.
Radio	University of Wisconsin

The people listed above are known by this author, and whose judgment about the pros and cons of the techniques he trusts. There are other "experts" in each area, however. As can be seen by the list of programs that are available for using multi-media techniques in the appendix, a variety of these formats are used. You will also notice that some of these programs contain different kinds of media to convey the cognitives It is important in developing any media based package of learning that different techniques be used throughout the program to assure maximum retention by the participant.

The most important problems associated with the development of multi-media programs are:

1. The needs assessment for the proposed participant.
2. The programming.
3. Evaluative techniques.

It is wise for the developer of any multi-media package to remember the old adage "better equipment does not necessarily mean better programing", and that content of the program is what most professional engineers and scientists are interested in learning We must not lose sight of the learner's objectives, and must utilize his available minimum time efficiently.

Present variables of most programs utilizing live instruction could be summarized as follows

Teacher Centered—Formal

Degree Oriented—Primary emphasis
Evenings or weekend formats

Some non-degree—time and location vary
travel involved for participant.

Established curriculum—repeated each year

Classroom Setting—some Audio Visual Aid
Use (Usually Poor)

University Developed Courses

University Faculty as Teachers usually
programs intermittent

The above characteristics are in conflict with many of the adult learning characteristics mentioned earlier.

The characteristics of a good multi-media program that could be used many times at locations throughout the nation would include:

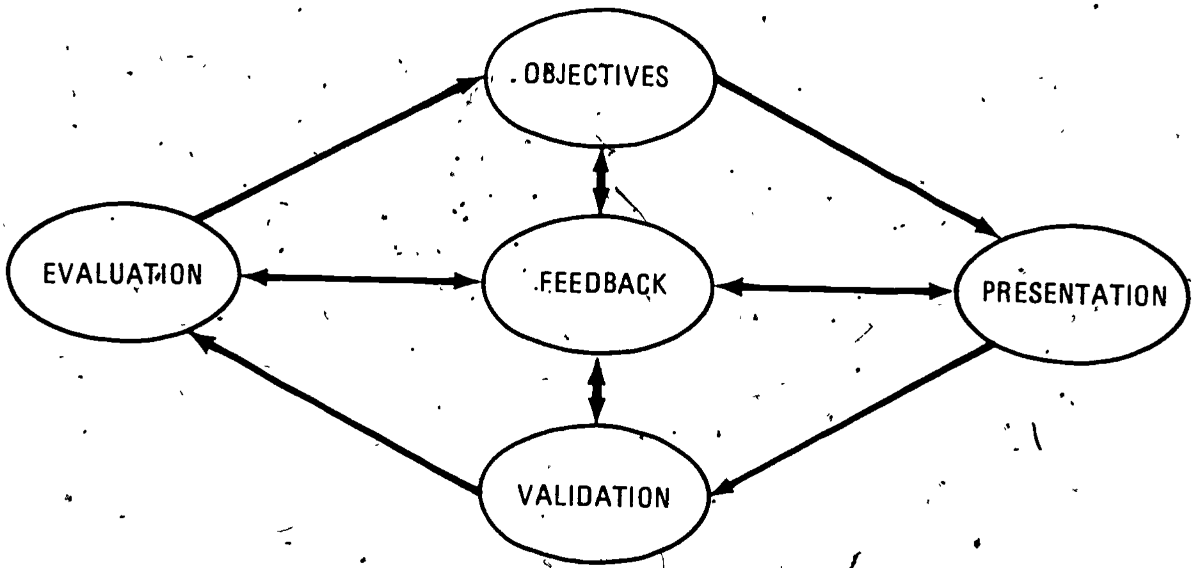
1. Individual Oriented—learner centered information
2. Degree or non-degree orientation—the time and location of presentation at convenience of the learner
3. Although they may use the present curriculum of colleges or universities, the modules developed can be based on the education and skill needed by the participant
4. The learning packages are flexible and have a variety of delivery modes and supplementary teaching aids
5. They are usually a joint university-industry program, jointly developed because they can or must be sold to industry
6. They are developed strictly for the working professional engineer or scientist
7. They can be used continually at any location for the professional development throughout the life time career of the engineer or scientist
8. The programs can be reviewed by the individual as often as needed to get the information required by the participant at any given time, and for varying purposes.

CONSIDERATIONS REQUIRED IN PLANNING AN EDUCATION DELIVERY SYSTEM

In designing a multi-media educational delivery system, several items must be considered. They include:

1. A very detailed consideration of the market and how to dichotomize it geographically.
2. The delivery system must be comfortable to the participants, those who developed the program, and the sponsors.
3. The texts should not be overlooked and should play a part in the program. This author has found that supplementary workbook materials containing all the visuals and supplementary material enhance a good multi-media program immensely.
4. The capitol and investment cost to start a particular program are paramount. This probably is the biggest problem facing the development of more multi-media packages today.
5. Logistics of delivering materials are tremendous, and the cost of using telephone lines and mailing of materials are factors that are often overlooked in the development of efficient systems.
6. Whatever system is decided on must be responsive to changing needs. Video tapes could be replaced by video disk, although this author does not believe this will happen except in rare situations for the engineering and scientific continuing education programs required in the next decade. The market is only rarely large enough to warrant the expense of making the original disk.
7. The effectiveness of the delivery system from a learning point of view must not be overlooked.

Educational Systems Viewpoint Required for Multi Media Programs



Because video tape is involved does not mean that one should use it as the primary delivery system. Audio tapes may be better, or perhaps a well-designed self-paced individualized instruction workbook would do the job better.

8. The reliability and timeliness of the delivery system must be considered. As an example, it is well known among educators that in most instances black and white video tape is just as effective from a learning point of view as color. However, most people are accustomed to color TV for entertainment programs in their homes and a black and white tape seems inferior.

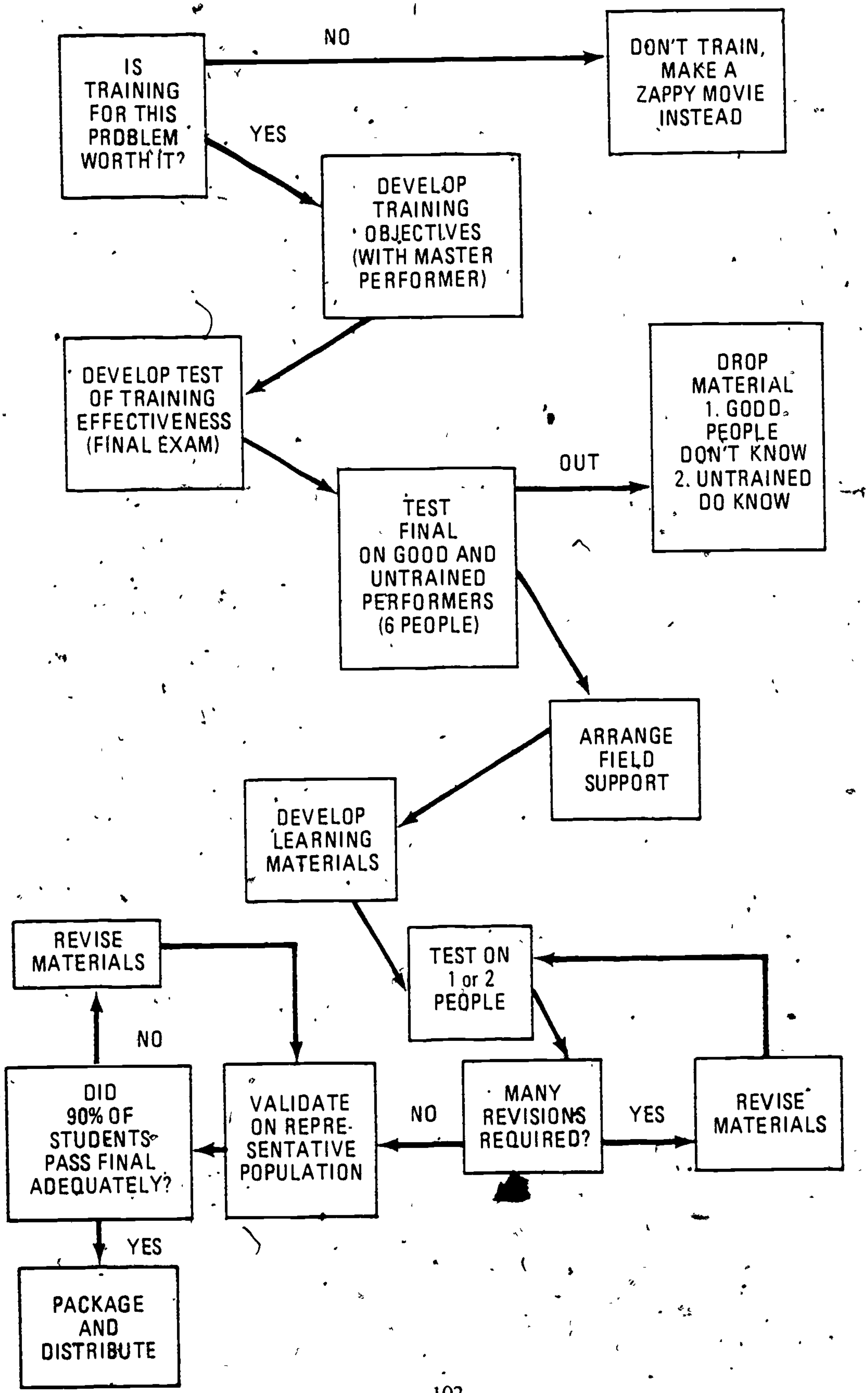
The system must be designed to work. Below are diagrams showing graphically how the system must be implemented if it is to be effective. It should be noted here that if our "live lecture techniques" used in most undergraduate and graduate programs were analyzed in this fashion, the time required for a student to receive an advanced degree in engineering or science might be readily reduced. However, most faculty are comfortable with the present system, and it is well entrenched even though it may be somewhat inefficient. There is a tremendous resistance to change in the academic community because these individuals are somewhat conservative, as pointed out by Mary McCauley in her article published in the College Industry Education Conference Proceedings in 1976. (See bibliography).

Any instructional materials that are developed in a multi-media program must clearly state the instructional objectives, have practice exercises, have the capability of providing feedback to the student, have a pre and post test capability, and somewhere have an attitudinal measure of the participants' real reactions. This is very difficult to achieve and the costs are often prohibitive. This is one of the reasons many of the professionally developed materials are not being readily accepted by adults. It is worth noting here however, that Ollie Holt with the Bell Laboratories in Piscataway, New Jersey, who has a group working on the evaluation of prepackaged learning materials, feels very strongly that it is much more economical to buy a somewhat less expensive multi-media program package and improve it than to start from scratch and develop your own. The cost factor is about a 10 to 1 ratio. Developing multi-media packages is expensive and the market must exist or the program will not be saleable.

It would again be wise here to reiterate the adult learning characteristics which must be acknowledged if the multi-media packages and delivery systems are to be effective. They include:

1. The adult time perception is different than during youth. We do not teach adult engineers and scientists the same way we do undergraduate and graduate students. The techniques of androgogy must be used rather than pedagogy.
2. Convenience needs of adults are very important and must be adhered to; time is important.
3. There are greater differences in adults than youth in learning and motivation.
4. Adults have developed many predispositions, preconceptions and sets concerning learning, and they must be taken into account in the development of the programs.

Steps to Good Training



5. Adults have a much higher self-perception than do young people.
6. The persistence of an adult is different and is generally much longer than youth because they want to learn more rapidly the particular topic they have enrolled in.

In developing the educational delivery system ~~the~~ adult learner (engineer/scientists) must be taken into consideration in developing the educational process. It is important for the producer-developer to realize that:

1. The adult is anxious and wants to make sure he gets the information he needs as quickly as possible.
2. The adult is usually a much better goal setter than is the younger student.
3. The adults also want to know what their goals should be; therefore, the behavioral objectives and results of the program must be spelled out in some detail.
4. The adult begins to learn immediately because he is highly motivated to get the job done.
5. Again, it is wise to remember that the adult persists longer than the young student.
6. An adult is usually well aware of whether or not he is reaching his own individual goals, and will not tolerate inefficient, time consuming learning techniques. As every continuing education director knows adults vote with their "feet". As a result multi-media programs must be planned to have active participation.
7. Allow for individualization of instruction, be problem centered, be relevant to life and meaningful to the participant's present employment, and as he grows older he will want to be responsible for his own learning because of his mature self-assessment capabilities.

Delivery System Factors to be Considered

Primary	Comparative Costs to Other Systems Convenience for the Participant Existing Learner Motivation
Secondary	Convenience for the Instructor Flexibility for Changing Instruction Content Course Program Content

When all costs of an educational system are considered (i.e.: travel, time away from work, tuition, etc.) multi-media programs become highly cost effective, especially if the teaching expertise is not readily available locally.

Certainly the advantages of multi-media materials are somewhat obvious, but probably should be stated briefly again. Most media presentations allow for short sessions and the participant can select the time in which he can participate in the educational program. And last but not least, participants can set their own pace. Additionally, the materials can be reviewed four or five times to increase comprehension and to take into consideration the individualized differences in learning rates.

WHAT SYSTEMS ARE IN COMMON USE?

Introduction

There are currently a variety of multi-media systems being used at all levels of education. It is obvious that many of these techniques have had successes and failures, but one characteristic of all of them is that they are growing in use. It is true that some of them are progressing slower than others, but it is important for the reader to realize that a generation of Americans is growing up in the electronics age and will accept new methods of instruction much more readily than the older generations who are in the power structure today. It is very difficult, if not impossible, for a detailed discussion of each of these techniques to be comprehensive in such a short time frame, but it is hoped that each technique can be highlighted.

Video Tape/Cassettes/Videodisks

Video Tape, Cassettes, and Videodisks provide an independent and flexible time table for the program participant to receive further education. Not only is it time flexible, but it allows the participant to have such possibilities as motion, synchronized rewind without losing the audio and visual portion of the learning experience, but also the capability of using the original tape repeatedly for other kinds of programs, reducing library storage costs and large inventories of tapes for the individual user. Each can be shipped throughout the country in a relatively short time span and is easy to obtain. One need only recall the acceptance level of this type of format, as it progressed from reel-to-reel to tape cassette, to realize the potential it has for common everyday usage. The recent announcement by RCA and others of the 2-hour and 4-hour video tape cassette machines will enhance their use even further. The versatility of this type of material will be very evident. The author has, himself, purchased a recording unit for his own personal use at home so that movies, news programs, and other programming of personal interest can be taped while not in the confines of his home, and the tape stock used again later. As time goes on, this will become more prevalent and will cause all kinds of enforcement problems, such as copyright and reproducing of material for local distribution. These social and legal problems, however, may be worked out progressively if educators can learn how to develop supplementary systems enabling interactive communication between instructor and participant. Additionally, this author has found that in small groups it is a very effective teaching tool. It is important for all educators to realize that the practicing engineer/scientist does not need to know everything about a particular subject, but is only interested in specific aspects of the problem. Therefore, it can be used as a facilitative device.

Closed Circuit TV/ITFS/Cable TV

Many closed circuit TV and ITF Systems have been developed in industry and universities throughout the country. Great promise was held for such approaches, but the major interest at the university level has been for credit and degrees; developing goal-oriented programs. Cable TV probably has a great opportunity for the dissemination of formally structured continuing education programs for those whose time is unstructured enough to allow their participation as part of a rather large group. Although cable TV has the possibilities of providing continuing education programs, it has not been as successful as closed circuit TV and ITFS Systems This should change, however, as enrollments decrease and universities try to increase their enrollments with housewives and retirees, and if they begin to see their role as knowledge disseminators rather than strictly entertainment This will require a great deal of re-evaluation by the managers of cable TV networks and the universities

Satellites

The satellite is a futuristic type disseminator of information which can cut across state lines and not only enables regional televised educational programs to be delivered, but has the possibility for a national impact. Hopefully, it can be operated 24 hours a day and act as a delivery system, utilizing video tape cassette playback units scattered around the country to deliver educational programs on a non-real time basis. It is conceivable that the large companies, in conjunction with consortia of universities, will form a viable combination to disseminate technical information to "pockets of engineers" scattered throughout the country where the need to know a particular subject is evident The author visualizes a satellite as having the capability of disseminating information about a "new technological breakthrough" in a short time frame to all of industry and universities throughout the country. One good example of this would have been the proliferation of the need-to-know about micro-processors and mini-computers which has been thrust upon us in the last 18 months. With the proper satellite system, the latest information about micro-processors could be developed by a national scientific educational center and distributed in all parts of the country within a 30-day time period, facilitating instruction in the theory and use of these important electronic devices. Currently, I believe the most popular electrical engineering continuing education programs in the country are one-, two-, and three-day micro-processor courses. Satellites would enable this job to be done on an international scale at much less cost.

Computers

The computer will serve as an even greater educational tool in the near future. Not only will it be an effective means to interact with participants to enable them to interact with different industry and university branches in a self-paced instructional mode, but it will also enable us to control the learning system for any particular learner. The Plato system and the Mitre system seem to be the best examples of this to date, with the former becoming the more recognized success. By controlling learning speed, the teacher will be better able to determine what the needs are and the progress being made by the learner as he goes through a particular program. This is becoming more and more a necessity, as the technology changes at such a rate that we must keep up with where the individual stands at any point in his career.

Electrowriter

The electrowriter is a device which enables the teacher not only to be seen but heard at a distance from the source of instruction, using telephone connections. This technique is being used in many auto plants to keep track of production scheduling at several locations, assuring that proper stock is available as needed. Success has been effected using this technique at Stanford, Princeton, and the University of Wisconsin, but has not had as much impact in other areas because of its cost. The utilization of commercial telephone lines, video tape and closed circuit TV has replaced this mode of instruction because of the "jerky motion" that usually accompanies the technique.

Telephone

The telephone has not had the impact that it probably should have in education over the past decade, although several networks have been very successful, in particular at the University of Wisconsin which offers various forms of programs for both credit and non-credit recognition. It has the advantage of being real time and allows feedback from the participants with the instructor very quickly, although the major disadvantage is the inability to transmit any photographs and other visual aids that the instructor may deem pertinent. From this standpoint the electrowriter previously mentioned has good potential to transmit graphs and charts to be drawn by the instructor as he works through the formal instruction.

Audio Tape Cassettes

Audio Tape Cassettes have proven successful for various kinds of media where only the sense of sound was important to the learning process. People are able to listen to audio tape cassettes as they drive in a car, or while doing other rote tasks. When used in conjunction with slides, it is a very effective learning technique, as it allows one more of the senses to be used. Many businesses develop many kinds of machines which synchronize audio tapes to slide presentations. The one major fault with these approaches however, is that when one attempts to synchronize the slides with the audio tape there is an initial capital cost, since compatible standardization has not as yet taken place.

Audio tape/slide programs have been used extensively and effectively in the oil industry. Training directors have found them very useful because of the worldwide distribution of their engineers and scientists and their need to know information about specific operations. It is quite effective for individual instruction because tape recorders and 35mm projectors are common place and the programs are very cost effective to produce.

Radio

Radio never achieved its potential because it was preempted by TV. However, radio probably is the most economical method for transmitting current educational information to remote areas, and has found wide applicability in medical continuing education instruction in New York State, North Carolina, Utah, California, Wisconsin, and Ohio, where the best educational radio operations exist today.

THE FUTURE OF SUCH SYSTEMS

I believe it is safe to say that technology disseminated by electronic media can and is making significant contributions to the future of continuing education. Over the past decade we have witnessed many isolated examples of how TV, computers, electrowriter, and other systems have been used effectively to solve problems confronting producers and users of instruction. This trend will continue and will enable higher education to better meet its goals and objectives for a technically based society. I personally feel that a recent article by Martin N. McCartney entitled "The Future Revised" in the Wall Street Journal of April 8, 1976 sums it up best. He indicated the educational trends as follows:

1. Increasing the demand for continuing education.
2. Flexibility in the content and structure of education.
3. More uses of the computer in education.
4. The use of video disks
5. More use of communication techniques and multi-media programs.
6. The need for productivity is increasing
7. More use of low cost open modes in education.
8. The growth of learning centers.
9. Weekend colleges patterned after Mid-America University, sponsored by NIE.
10. More emphasis on the development of values.
11. More use of video packaged instruction.
12. Increased use of testing and a trend toward criterion referenced testing based on specific objectives.
13. Increased student expertise in computers and personal portable calculators.
14. The price of mini-computers dropping from $10,000.00 to $1,000.00 over the next 15 years.

How soon these trends will become fact will be determined by the ingenuity and innovation of the people in the power structure in our educational establishment.

I believe it will come about in the near future whether through government support, or from the civilian operated economy. The speed will be determined by the demand, and the need-to-know.

PROBLEMS ASSOCIATED WITH MULTIMEDIA PACKAGE DEVELOPMENT

The problems associated with multi-media packaged learning are many, especially for engineers and scientific personnel because of the rapidly changing technology. Anyone who has attempted to put together a program realizes that the number of potential participants is small and their geographical distribution is relatively large compared to other participants in education. The heterogeneity of the participant population is obvious and a greater number of packages must be made available than would be necessary if one used the more traditional modes. In addition, the support personnel needed for proper instructional feedback and course management is great and must be taken into consideration. The rate of change of technological information is so rapid that care must be exercised in putting only those programs into media-based instructional modes that have a payoff life expectancy.

A. Development of Materials

The development of instructional materials that go into the proposed media package is probably the most critical problem facing an institution once it decides to develop some media based programming. The problem basically is making the necessary need assessments of industry and the individual engineer on what they would like to purchase and view for their professional development. Many programs are put together without this needs assessment resulting in programs that do not have a sufficient market appeal to sell. This is critical because most of these programs have to pay for themselves and the life of the materials may be too short to recoup the initial capital investment.

When developing a program for a field such as electronics, one is faced with a tremendous diversity of needs even within a given specialty of electronics. For example, if one decided to put together a program on micro-processors, it becomes important to know whether or not you are going to make just a survey program or whether you are going to go into the deep technical details of the Intell 80-80 or the Motorola 6800 system. This requires a great deal of judgment on what equipment is currently available in industry and being used The university then is in a dilemma since their goals and objectives are much broader than any individual entrepreneur and they are open to criticism if they develop materials which "sells" one particular product over another. This doesn't bother the engineer since he is just interested in learning more about the materials he is working with, but it causes a great deal of difficulty within the academic community on what the goals and objectives of the institution should be.

Another important problem in the development of materials is the selection of the instructor who will put the materials on the media based package. Most college professors are not familiar with developing programs in this format. They have been very successful at the typical stand up lecture format with a group of students in front of them. The instructional material people required to put together a multi-media package have much different characteristics This author has found that approximately one out of seven faculty members can easily make the transition to change their teaching style in developing media based programs. It's not an easy task. Many multi-media packages have been put together utilizing professional actors or speakers once it has been developed. The RCA experience has shown, however, that engineers and scientists would much rather listen to "real live working engineer/scientist types" than they would hearing a professional speaker/actor reading from a script. Therefore, instructor selection is very important.

When any multi-media package is put together, the evaluation of that package becomes paramount. This is a criteria, which although used in typical graduate and undergraduate programming done in universities by tests and exams, is much more critical with media based instruction. Tapes can be viewed several times and people not familiar with the subject matter will be in the evaluation process to determine whether they should be purchased or leased. The present curriculum is evaluated not necessarily by each individual course but rather a combination of courses which last over a period of four years and then the students evaluated on what they can do upon graduation. The multi-media package, however, must stand alone and must evidence a change in behavior immediately. This is a very difficult task to achieve and subjects the multi-media package to close scrutiny by many individuals. Much more research is required in this area.

B. Marketing of Materials

The marketing of multi-media packages is very important and is critical for the survival of any multi-media development program at a university or by a business venture. Such questions as What is the market?, How do we find the person in a particular industry to speak for that industry to determine program content?, and What are their needs? need to be answered This is a problem which needs much more research and techniques must be developed to successfully resolve this problem

The "up-front" costs in developing a multi-media package are quite large If one does not know the market, this can be lost very rapidly. Continuing education directors who utilize short courses, institutes and workshops have found that they, too, must develop some marketing skills, but they need not be as sophisticated as the ones required for the development of multi-media packages. This probably is one of the biggest deterrents to universities to develop more video tape programming. They just do not have the $15,000 00 to $20,000 00 to put into programs, hoping for a return on the investment over a period of three to five years The idea of consortia, as suggested by AMCEE, is one possible solution to this problem. Together the consortia may be able to develop programs to cover these initial costs and still allow the program to be given at a price that can be afforded by small and medium size companies.

In the marketing of materials on a national scale, many colleges and universities find themselves in conflict with the goals and objectives of the university. Many universities are committed to serving local clientele in a particular region. Multi-media package development, however, assumes that a great number of people can use the same materials, and the universities begin to cross into other peoples "turf" This means that many problems have to be worked out with various institutions to get their cooperation AMCEE is probably the one organization that has been able to accomplish this on a national scale to date.

[illegible]. Overcoming Opposition to New Techniques

Overcoming opposition to using new techniques of teaching is also very critical. The "not invented here" syndrome, our faculty is better than your faculty, and we can do it better, are some of the most important problems that must be overcome. With the proper selection of teaching materials as well as subject matter, this can be minimized if the faculty involved do not have the skills which exist in other groups. With the diversified industry in this country, it becomes apparent that all universities cannot be all things to all people. Therefore, with the exchange of multi-media packages, a service can be rendered to local industry by institutions that do not have particular expertise. Not only do the faculty express opposition to trying new techniques which are unusual to them, the potential participants, and the people who are in the power structure who can sign off for purchase requisitions for lease or purchase of the materials have a problem. They have come up through an educational system which has not used these new techniques and they are leary of whether or not anyone can learn in this fashion. Everyone knows this is contrary to the published research but it still probably is the biggest single factor against their wide spread use.

Another problem which opposes the use of these techniques is in the whole area of copyright, who owns the tape, and who receives the payment for their use. This author believes that these problems are superficial, are really of an administrative nature, and can be solved rather easily. The best way to do this is to offer royalties to people who have put them together and, as many industry people already know, a fair and equitable share of the cost and profits can be gotten by all parties concerned.

Of even more concern to faculty members, however, is how long can these various educational programs be used before new techniques in the field make the tape somewhat obsolete. It requires someone to make a judgment however. The administrator is trying to get his return on his investment back as quickly as possible and the professor certainly does not want to be shown on the tape as not knowing the latest techniques. This problem is being worked on by various organizations and should be solved in most people's minds in the next two to three years.

Discussion of problems associated with multi-media packaged development would not be complete, however, if a comment was not made about the reward structure in most institutions. The rewards in most educational institutions are for research and publishing, and to date most of the multi-media package development has not been one of the criteria used by most universities for the faculty in their quest to secure tenure and promotion. Until this is worked out in the whole field of a reward structure, little will be done from the educational institution viewpoint.

SUMMARY

In the appendix of this report can be found a long list of programs that have been developed by various organizations over the past few years, and which are currently available from proprietary vendors as well as university organizations. In a later part of this report some of the more important techniques that are being used both in industry and universities will be discussed. The reader is encouraged to look at the bibliography to better understand the scope.

INDUSTRY

A. Growth of In-House Programs

The growth of in-house programs in industry over the past decade has been quite substantial, particularly in the large industries. There are many [illegible]ns for this but most large industries are beginning to realize the need for constant updating of technical people in their organization and to help lower their resistance to change in an ever changing technological society.

The industry in-house programs are very well defined because it has become obvious to the people within the industry what their educational problems really are, if people are not working efficiently and with increased productivity Education will not solve all of the problems that industry faces with the new technology but it is a place to start. The in-house education programs are usually highly successful for a variety of reasons.

1. The needs of the employees are very well defined from an educational point of view, and the industry does not have to worry about the overall education of the person. They just zero in on the educational needs for the moment and develop a program that will meet these objectives rather quickly.

2 There are no prerequsites for any courses that the industry develops. They give the programs to people who have a need to know and do not worry about upgrading those people who perhaps could do the job if some prerequisites were taken first.

3. Industry does not differentiate between employees. If the technologist needs to know something about differential equations, they are in the same classes as the engineers who need to know something about differential equations. It is sometimes hard for academic personnel to realize that industry is interested in solving the problem and are not worried about degrees, accreditation of their programs or worry about the validity of their graduates. If the graduates can do the job upon completion of the course it is good enough. They do not worry about many of the other details that they hope the universities do to maintain their accreditation.

4. Industry is interested in training the largest number of people for the lowest possible cost in those areas of expertise that are needed in their own organization. They can educate a larger number of people with the same dollars it costs them to send a few people to special short courses and other programs within the university. Once these people return to the work environment they often cannot communicate effectively with the people who did not attend the educational program. Thus in-house programs have a great deal of appeal to them.

5. Participation in in-house programs solves one of the major stumbling blocks to university programs: personal motivation. If the chief engineer and plant manager give an impression of being interested in people participating in education employees participate. It is as simple as that. By

presenting programs in-house after hours, lunch hours, or even during some part of the workday, people are motivated to participate because they do not have any travel time, it does not cost them anything, and it does not infringe upon their free time as much as the university program does.

6. The programs that are developed in most in-house situations are centered around real life problems within that industry. The instructors are well qualified and are the participants' peers who work with them. They respect each others' judgment, and this author has found that instructors from industry seem to talk up to the students rather than down to them and this is not always true of academic personnel.
7. Most industry instructors for in-house programs have little hangup on techniques that are used for educating people. They will use anything that works and thus reduce some of the problems that are associated with university education
8. Although industry in-house programs cost a lot more than they are willing to admit, these costs can be hidden in all kinds of budgets within an industrial organization. A good case could be made that it is cheaper to send the individual than it is to train him within the plant, if one looks at all of the costs. This is very difficult to do because of existing accounting systems

B. Payoff for Participation in CEE

The payoff for participation in continuing education is still the biggest stumbling block to motivating people to participate. Industry does not promote or give pay raises to individuals just because they participate in continuing engineering education programs. The payoff is on job performance during any given year. If this begins to slip, the individual does not receive a merit increase nor is he promoted. Job performance is the key to all industrial promotions on the average. There are exceptions to this but people who get promoted for other reasons usually do not remain with an organization very long once they are "found out"

A great deal of additional research must be done on determining the payoff for participation in continuing engineering education. There has to be some intangible benefit for participation in continuing education which is at least evident to through self evaluation. NSF may find this a fertile field for future research projects.

C. Industry Use of Multi-Media Programs

Industry and government have probably made the most efficient use of multi-media programs of any of the major institutions in our society. The reason is that they have specific requirements which are very well defined, indicating which employees need a particular educational experience. The military has probably led the way in the development of multi-media materials to train their personnel. The major reason, of course, is that they encompass large numbers of people who need the same kind of educational or training experience and also are widely dispersed, therefore, it behooves them to develop a program which they know will work and then distribute it widely to all personnel who require that particular skill.

Industry has a unique problem in that they are profit oriented and the training dollar must come from that source, therefore, they are very careful to insure that the educational experience is the best possible cost-effective method of getting the information across. This leads to difficulties at times, however, since training directors can develop tunnel vision and overlook the difference between cognitive and affective learning. They are chiefly interested in short-run objectives, and one wonders why they are surprised when employees do not grow and do not maintain their professional vitality as planned. I believe it might be inappropriate here to discuss what is the engineer's job. Alden Jones has deftly defined it by stating, "The job of the engineer is to design a product to meet a customer's need and which could be manufactured at a profit." I believe this is an important concept to which the universities must address themselves in the near future if they hope to maintain their viability in the continuing education market and to develop the multi-media programs required to do the job.

Dr. Lindon Saline from General Electric has done a study within the company and determined the factors leading to improved engineering and scientific performance in the following manner:

80% Work Assignment
10% Coaching and Supervision
2% Career Planning
5% Education
2% Others.

Although these figures are in the nature of educated guesses based on wide experience, they indicate to most engineers in what priority their efforts should be placed in order to progress and to improve their performance. This means that the 5% of the effort that the engineer or scientist should spend on his education must be very efficiently scheduled. Multi-media techniques can expedite this, therefore, the "Not invented here" syndrome has less effect on their planning.

Below are listed, with a brief description, some of the better types of programs utilizing multi-media techniques currently being used in industry. The reader should realize that this is not an exhaustive list, but is a representative sample of the programs which have been used successfully in companies throughout the United States.

RCA

RCA was one of the first companies to utilize very extensively videotaped programs for training engineers.

Their unique problem required updating and maintaining professional technical knowledge for approximately six thousand engineers deployed throughout the world. Specifically their need was to develop those programs that would maintain basic skills so that engineers could be transferred from one related technology to another as it developed from research laboratories

They decided on video tape as the best method since it was easily transportable and relatively easy to make. With a modest investment of less than $75,000.00 for a three-camera, black and white TV Studio, they were able to produce a series of courses for less than $10,000 00 each. In addition, they were the first organization to pioneer the concept of a systems approach to the educational process. Not only did they make video tapes, but a text book was assigned for each course. A workbook was given to each student which contained replications of all the slides that were on the video tape cassettes The tape stopped every ten minutes, and active participation on the part of the viewer was required in solving a problem which answered questions that were on the tape. Written assignments were given for each period to be returned to a central location for grading and comments by a knowledgeable expert in the field Letter grades were not given, but rather encouragement was indicated in the remarks to motivate the participant. Quizzes and examinations were periodically placed in each of the programs. Although no grades were recorded nor entered in the personnel file, the learning experience served as a motivating factor and enabled the participant to assess his own achievements.

It might be noted here that this particular system has served as a model in many of the programs that have been developed since, and along with the SURGE program at Colorado State, probably has set the pattern for video taped instruction as we know it today.

Union Carbide

Union Carbide is another company which has utilized the video tape media to get information disseminated to all of their plant sites. They have developed a high quality series of video cassettes concerning energy conservation in industry and the various machines which they use in their own facilities. This has been accomplished at very low cost compared to university type operations and is quite effective. Both the RCA and Union Carbide programs are examples of what can be done inexpensively, with an eye on the "bottom line" of a budget sheet, and still be educationally effective.

Sandia Laboratories

Sandia Laboratories probably has the best technician training/education program of any industry in the United States. They utilize study carrels, individualized instruction video-tape, and 35mm slide and filmstrips for their program. They probably have pioneered in industry the whole concept of criterion-referenced educational endeavor, clearly indicating the necessity of defining the problem and all of its constituent steps so that the training effort can be maximized Evaluation of their programing indicates that they achieve very close to 100% competence after the training. It is important to note here that the industry makes no distinction between the engineer, technologist or the technician, if those individuals "have a need to know".

Bell System Training Center

The Bell System Training Center in Lisle, Illinois has probably the best system for simulation of technological problems of any training school in the country. They are able to simulate technical failures in a typical telephone system Engineers must be able to determine from remote locations the cause and effect of such a breakdown and repair it as quickly as possible to preclude the loss of revenue during down time. The educational staff at the Bell System uses a very sophisticated technique to determine the needs and assess the program once it has been implemented Much could be learned from study of this system at this training center on the use of simulation of problems. This author has seen no other location where more cost effective education is being performed.

Texas Instruments

Texas Instruments is very deeply involved in video tape instruction, especially for training in electronic programs. They have a very active development of video tape programs for their employees, and have become so successful that a spinoff of their business enables them to merchandise the material for sale in other industries.

Hewlett Packard

Hewlett Packard has a series of electronic media programs on circuitry that probably makes the best use of visual aids this author has seen for illustrating circuit diagrams and what is happening in an electronic circuit at any given time. Their overall use of visual aids is unsurpassed.

Xerox Training Center

The Xerox Training Center in Leesburg, Virginia is probably the most up to date and modern training center in the country using multi-media techniques. A wide gamut of programs has been developed using audio tapes, slides, individualized instruction and other techniques. Their video tape in-house distribution system at the training center is the finest in the world. In addition, the Xerox Corporation in Rochester has a group working on individualized instruction, using 35mm slides, audio tapes and program materials that are second to none in quality and versatility.

The one characteristic of all the programs listed above is that the goals and objectives of all the programs developed by industry are very well defined before they start to put the program together. They do not simply take "another lecture" and put it on video tape. They are fortunate in that they know their "Audience" quite well, have defined the problems, and are not interested in training large numbers of people outside their organization, who may have diversified interests. This makes the job much easier and allows multi-media presentations to be used quite effectively.

It should be noted here that industry has many non-degree people employed as engineers, although it would appear that only baccalaureate level engineers are hired for such job classifications. Again, media-based training programs are used to update and fill in necessary technological information as needed. Since this has proved to be a practical and economical solution for industry, many of the present "on paper" requirements will be inevitably phased out. Additionally, many individuals are not aware that present government regulations covering Equal Opportunity Employment and Affirmative Action hiring will ultimately force industries which have not already done so to drop some of the "paper" requirements, regardless of opinion and convictions to the contrary.

WHAT THE UNIVERSITIES ARE DOING

Over the past decade, many engineering schools throughout the country have made a real effort to try to bring continuing education programs to the industries in their region. This has been primarily focus on the providing of some mechanism by which engineers in that region can acquire a master of science degree. Although most of this has been provided through off-campus programs taught in the traditional mode, several institutions have instituted multi-media approaches to help solve the problem. The major emphasis has been using ITFS systems or video tape methods of instruction. The GENESYS system in Florida, the TAGER system in Texas, the ACE system at Stanford, and the SURGE system at Colorado State University have been the most predominant. These are examples with which the reader is most familiar.

It is important to note that the most successful multi-media systems utilizing video tape or ITFS are those that have been versatile and that have fitted into the existing structure found in those regions. Thus when the GENESYS system in Florida was designed only for NASA, it was found that the engineering population could not support such a system once the Aerospace Industry declined in that area.

Below are examples of successful university systems which serve as examples only of what has been done. Many other universities have made similar efforts, but these are highlighted to illustrate the scope of endeavors.

EXAMPLES OF SUCCESSFUL SYSTEMS

A. Stanford/ACE System

The Stanford system, which began as a television system designed to bring a masters degree capability to people off-campus, expanded into a format in which noncredit continuing education programs became highly successful and made the entire system economically feasible. Utilizing a TV system with a very directional antenna system, they were able to meet the educational needs of an industrial community on the west coast.

The interesting aspect of this system (although the credit courses continue to be successful) is the continuing education aspect of the non-credit programming. Industry has supported this aspect of the system quite well, and it continues to grow. Not only are Stanford professors used as instructors, but the participants also receive instruction from some of their colleagues who are more expert in areas of industrial interest. The whole concept of allowing people to take courses, even though they do not have the "educational prerequisites" required by a university of the stature of Stanford, has developed industrial relationships with the university which are basically sound.

Below is a list of the enrollments and gives one a picture of how it continues to grow. The use of adjunct professors has been documented recently in several journals and verifies the experiments made by RCA in the early 70's utilizing a non-instructor oriented system at the site where the education is received. I personally believe this trend will continue in other areas as time goes on.

Below are some statistics that the reader may find of interest on the Stanford TV system.

Stanford Televised Engineering Instruction Participation Data

	1969–70	1970–71	1971–72	1972–73	1973–74	1974–75	1975–76
Honors Coop Program (Degree Seekers)	762	836	546	562	577	685	666
Non-Registered Option	37	106	66	95	185	374	350
Television Auditors	102	97	746	1372	1246	1475	1296
Total Registrations	901	1038	1358	2029	2008	2534	2312
Number of TV Courses	116	148	143	145	150	148	154
Average Per Course	7.8	7.0	9.5	14.0	13.4	17.1	15.0
Number of Member Companies	23	24	26	30	36	38	42

Questionnaire Distribution and Response

Student Category	Distributed	Returned
Honors Coop Program	100	70
Non-Registered Option	87	41
Television Auditor	463	201
Totals	650	312

Motivation for Enrolling in a Televised Course

Student Category	Degree Seeking	Convenience	Professional Development
Honors Coop Program	33	34	11
Non-Registered Option	20	15	18
Television Auditor	2	31	189

Ages of Participants

Student Category	Mean	Median	Range
Honors Coop Program	27 9	27 0	20–47
Non-Registered Option	27 1	27 5	22–46
Television Auditor	38 1	36.5	22–64

The Association for Continuing Education (ACE) also uses the system for its after hours programs and their statistics of enrollments are listed below for 1975–76.

1975–76	Courses	Enrollments
Stanford	154	2312
ACE	78	2483
	232	4795
1976–77		
ACE		3366

B. Colorado State System

The Coloado State System, which was funded some time ago by NSF, continues to set an example of what can be done with video tape. The SURGE system, as envisioned by Lionel Baldwin, has been highly successful for Colorado State University. Please note below the current enrollment figures on how they are serving that area.

In addition, the Colorado State faculty has become familiar with the capabilities of such a system and has developed several video tape programs that are well received by industry is a very cost effective format. This kind of innovation is much needed in higher education and this author believes it will be one of the models that will be followed for the decade ahead with some modifications. The concept of enabling an engineer to accomplish his entire program utilizing video tape at a site remote from campus is intriguing not only to the employer but to the participant who values the small amount of time he has available for educational and recreational efforts.

A typical year of statistics using the SURGE system would result in the following statistics:

40 courses/semester
35 participating locations
SURGE adds average of 12 enrollments to average class of 16
Delivery cost per credit hour less than basic cost
100 MS Degrees—20 MBA awarded

C. University of South Carolina System

The University of South Carolina system uses a closed circuit system along with video tape, and periodic visits to the campus by the student (approximately 3 times per semester). This hybrid system was initiated because the closed circuit TV system already existed in the region in which the University serves. The College of Engineering was able to piggyback on a system during the late hours of the day and evening and not have to make the capital expense of putting a system together by utilizing live instruction over the closed circuit system once a week and mailing out video tapes to the individual sites around the state twice a week. The instruction is equally as good as on the campus. In fact, live lectures are sent out over the air by an instructor who is teaching a class on campus. Both the Colorado State system and South Carolina's system utilize the concept of increasing class size enrollment to make graduate programming in engineering available not only to their full time students but to the industry serving the state. Without both of these two components of the class, it is doubtful that graduate programs would be as extensive in both institutions.

In addition to the brief descriptions of the three programs that are in the forefront in the use of video in the universities in the country, for engineering another phenomena is beginning to take place which has tremendous impact for media-based instruction and especially video. This is the formation of a consortia of the major schools providing video material in the country as described in Part D.

Some statistics from the South Carolina APOGEE program should give the reader some insight into the growth of the effort over the past few years at 24 sites.

APOGEE Enrollments

Academic Year	Enrollments
69–70	30
70–71	101
71–72	144
72–73	215
73–74	258
74–75	400
75–76	486
76–77	470

D. AMCEE

The Association for Media-based Continuing Education for Engineers is a consortia formed by twelve charter member universities to increase the national effectiveness of continuing education for engineers utilizing media-based instruction. These twelve institutions probably produce the largest substantial percentage of all video based off-campus instruction in engineering With these programs as a base, the member institutions hope to coordinate their efforts in an expanding national program of media-based continuing education for engineers

AMCEE was formed to try to solve some of the problems listed below:

1. What use of the concept of consortia among universities and colleges of engineering can be made that will more effectively meet the needs of the widely dispersed small engineering and technical firms around the country?
2. What types of programs are the most successful for the practicing engineer?
3. What formats are most efficient in teaching an adult originally trained in a technical field?
4. How can engineering schools improve the programs that currently exist and are in the planning stage?
5. What rules should individualized instructions systems use to bring continuing education programs to the geographically dispersed engineers?
6. What role should media-based instruction play in the continuing education efforts of the fully employed engineer?
7. What is the most effective way to market continuing education programs to engineers in the field; off campus?
8. How cost effective are programs compared to on-the-job training and job rotation?
9. What is industry doing to promote continuing education programs for their professional employees, as has been done at RCA and other multi-national industries?
10. How can a clearinghouse be formed for a "one stop shopping place" for industrial personnel people who are seeking for programs that are currently available?

The members of AMCEE include the following universities: Case Western Reserve University, Colorado State University, Georgia Institute of Technology, Illinois Institute of Technology, Massachusetts Institute of Technology, Southern Methodist University, Stanford University, University of Michigan, University of Minnesota, University of South Carolina, University of Southern California, University of California at Davis. It is a non-profit organization and has added several members to its rolls since its inception.

The whole concept is intriguing to this author because it is the first time that a large number of prestigious universities has attempted to solve their differences and meet the needs of their graduates in a coordinated fashion. Hopefully it will continue to grow and expand and help answer some of the problems that are facing the dissemination of media-based instruction in engineering. This is probably the first start of its kind in the history of engineering schools and will serve as a model for the future. No one university has the manpower nor the resources to undertake such a wide distribution of programming, but together they may be able to solve some of the problems that are plaguing multi-media program development at the universities.

CONTINUING EDUCATION IN PROFESSIONAL SOCIETIES

In the last few years the professional societies have initiated many activities in the continuing education field for their membership. The members of the various professional societies have been very vocal over the past three years asking serious questions from the various professional society staffs on what they are getting for their dues.

In order to help to overcome this criticism they have begun to offer more member services. The continuing education programs of the various societies have thus increased as they perceive a problem in this area. They are primarily of the live lecture variety and are given throughout the country. Their biggest problem is that they have a large membership scattered over a wide geographic area. They are prime candidates for continuing education utilizing multi-media techniques and in particular video-tape cassette programs. The American Chemical Society is already putting together video tapes in conjunction with MIT through an NSF grant. The Institute of Electrical and Electronic Engineers is beginning to put together a series of video tapes dealing with microprocessors and they should be completed by early fall of 1977.

The professional societies have had some experience with audio tape cassette programs. Societies such as the American Society for Training and Development, IEEE, American Chemical Society and others, have put together audio tapes of some of the main speakers at their various conferences. In addition, several of them have tried to package and market audio tape cassette programs dealing with specific subject areas in their field of speciality. The problem becomes the cost to the membership. Although the membership is large, the interest in any one particular scientific segment is very fragmented and thus the cost per tape is high. In most cases the individual engineer or scientists must individually purchase these items. Several companies have subscribed to this kind of service and have put it in their library, thus making it available to their employees. This has been a somewhat discouraging adventure for several of the societies however, and they are constantly looking for ways of reducing costs to the individual member.

The latest technique that is being used by professional societies with some success is in trying to develop some rapport with the various contining education divisions of the engineering schools around the country. By forming consortia they have a marketing arm which they do not have to pay for in their overhead cost. In this author's opinion this will increase over the next decade and these professional societies will become co-partners with the universities to serve the engineers and scientists throughout the country. At the present time there is a certain amount of friction between the two groups, as they feel that each is trying to take over the entire market. This is an impossibility. There is more continuing education necessary than there are resources and manpower by any one single organization to accomplish this objective.

Probably one of the strong points for the professional societies is their ability to evaluate any program. Among their various technical groups and organizations within the Society they have experts that could tell the universities whether or not the information that is being presented is the latest up to date material. This is a plus factor and the universities should be utilizing the professional society more for this evaluation procedure. The Institute of Electrical Electronic Engineers is trying to work with the Continuing Engineering Studies Division of the ASEE to accomplish this task.

Multi-media package education programs have the potential of providing quality programs for the various local sections of any society around the country. Hardware costs for each individual section seems to be the biggest stumbling block. However, a close working relationship between the professional society and the university or industry in the local area could help reduce this problem. The NSF could support experiments in this area and help determine if it is feasible.

An interesting development in continuing education that effects the professional societies is the increasing emphasis placed on professionals by the various states to continue their education. This is being accomplished by state legislative action and the professional groups themselves. A chart, published in a recent issue of the Chronicle of Higher Education, is attached to indicate the current status of such efforts. If these groups are moving in this direction the engineering and scientific societies must ask themselves "Can we be very far behind?". If it comes to pass that the scientific and engineering community moves in this direction the professional societies will play a key role. This will require extensive use of all multi-media techniques to disseminate the information. The number of instructors required to do the job over a widely dispersed constituency, along with the cost and individual time constraints make the typical approaches of workshops, seminars, etc. ineffective.

The professional societies will not be able to finance such an effort alone. Consortia will have to be formed between societies, between the professional society and universities, and between industrial employers and the societies. A new organizational model for continuing education activities will be needed because of the lack of resources, manpower, and time by any one of the groups mentioned alone.

EVALUATION OF MULTIMEDIA PACKAGES

Introduction

The evaluation of multi-media packages is one of the most important aspects of all before the purchase of a multi-media program by any university or industry. This is critical because of the cost and the need to satisfy the specific needs of the adult learner in industry. How does one go about it?

Whereas most of the evaluation of live instruction is somewhat objective (tests, quizzes, etc.) by the participant, those who attend a multi-media package program can be viewed by many people of various disciplines and expertise in a subject area. The universities have had a long history of success in training people for industry utilizing the live lecture technique and as a result people who have graduated from such a system know it works and accept the rather hazardous judgmental evaluation (letter grades and tests on small numbers) that most instructors place on people who attend their programs. Multi-media package programming, however, is quite diffent since it can be viewed at any time at any place by anyone. Therefore, the evaluation instruments must be designed from an objective viewpoint. This author has not seen an evaluation instrument that meets this criteria perfectly for multi-media packages, and doesn't believe there is one which covers all programs.

It is becoming apparent that the evaluation cannot be subjectively viewed for evaluation, because most of these programs are prejudged by people who may or may not be qualified to understand the learning characteristics of engineers and scientists.

Instrument Becoming Available

The one company that has accomplished the most in evaluating multi-media packages before purchase is Bell Laboratories of AT in Piscataway, New Jersey. They have developed an evaluation instrument and field tested it for several years to meet their specific needs. Although it is not perfect, Ms. Barbara Bauer and her colleagues have designed an instrument which enables the laboratories to mix the packaged programs it purchases with those they themselves devise. This document will be made available to the public through the American Society for Engineering Education in the Fall, 1977. In discussing the instrument with colleagues in the Continuing Engineering Studies Division, there seems to be lukewarm support to such an instrument; however, it is a good starting point for one who develops his own instrument to meet specific goals, objectives, and needs.

States that Require Professionals To Continue Education

States	Certified Public Accountants	Dentists	Lawyers	Nurses	Nursing-home Administrators	Optometrists	Pharmacists	Physicians	Real-estate Personnel	Social Workers	Veterinarians
Alabama	x				x						
Alaska	x					x	x	y			x
Arkansas					x	x		x			x
Arizona					x			x	x		
California	x	x	x	x	x	x	x	x	x		
Colorado	x			y	x	x		x	x	x	x
Connecticut				x		x					
Delaware						x				x	
Florida	x		x	x	x	x	x	y			x
Georgia	x		x	x	x	x					
Hawaii	x				x	x					
Idaho						x			x		
Illinois						x		x			x
Indiana					x	x	x				
Iowa	x		x		x	x					
Kansas	x	x		x	x	x	x	x		x	x
Kentucky		x			x	x	x	x	x	x	x
Louisiana					x	x			x		
Maine					x	x	x	y			
Maryland	x				x	x		x		x	
Massachusetts					x	x		y			
Michigan	x					x		x			
Minnesota	x	x	x	x	x	x	x	x	x		
Mississippi					x	x					x
Missouri						x					x
Montana					x	x		y			x
Nebraska	x			x	x	x		x	x		x
Nevada	x				x	x	x				x
New Hampshire	x			x	x	x					
New Jersey					x	x	x	y			
New Mexico	x	x			x	x		x			
New York								y			
North Carolina					x	x		y			x
North Dakota	x	x			x	x					x
Ohio	x				x	x	x	x			

States that Require Professionals To Continue Education (continued)

States	Certified Public Accountants	Dentists	Lawyers	Nurses	Nursing-home Administrators	Optometrists	Pharmacists	Physicians	Real-estate Personnel	Social Workers	Veterinarians
Oklahoma		x			x	x	x				
Oregon	x			y	x	x	x	y	x		
Pennsylvania	x							y			x
Rhode Island						x		x			
South Carolina	x					x					
South Dakota	x	x		y	x	x				x	
Tennessee						x					
Texas			x		x	x			x		
Utah								x			
Vermont	x			x				y			
Virginia						x					
Washington	x		x		x	x	x	x	x		x
West Virginia					x	x					
Wisconsin			x		x	x		x			
Wyoming	x				x	x					

"The Catalog" edited by Prof. Lauer at the University of Colorado, has also made an attempt to evaluate programs that are listed in The Catalog. They are rather subjective, and in many respects place the decision responsibility on the viewer. Thus the "eyes of the beholder" syndrome again takes place. However, it is valuable to the reader to look at these evaluations to help him to decide on what to purchase or preview. Much time can be saved using even these beginning techniques.

In summary, it is obvious that much more effort and time must be placed on the evaluation of prepackaged multi-media programs. It is hoped that the National Science Foundation might lead the way in developing instruments to enable the judgments to be made more objectively. In any event, such an instrument helps the producer-director develop criteria for future productions to be made available for the market place.

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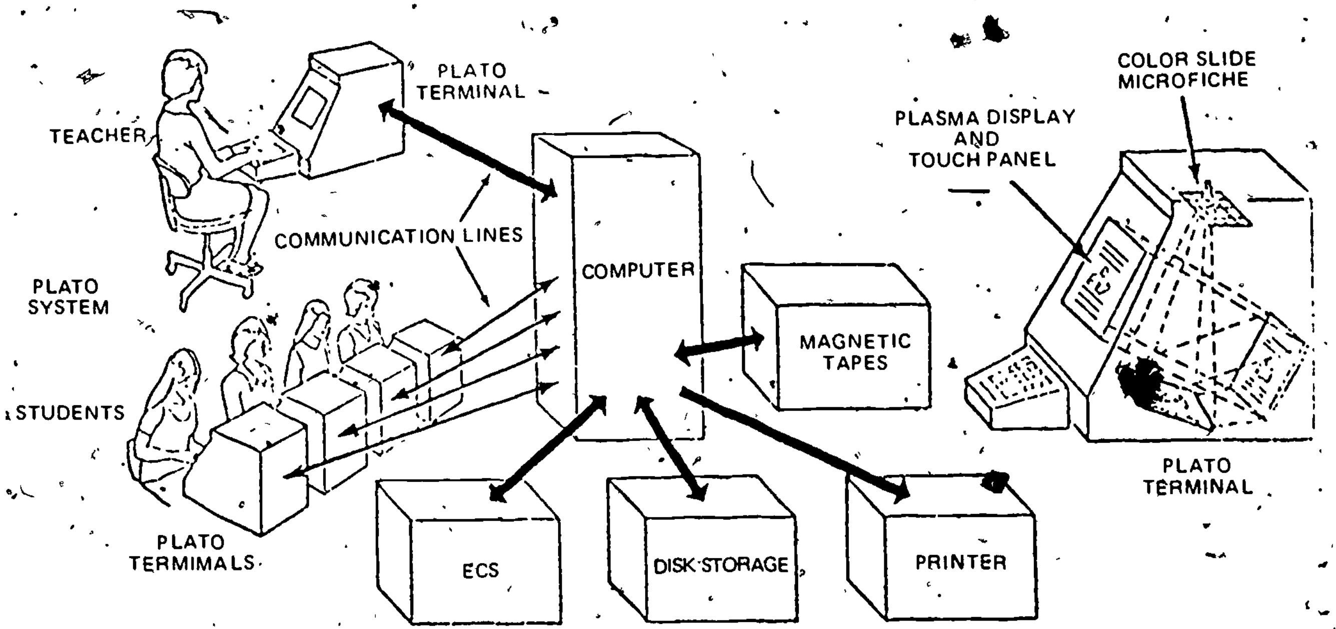
Below is a list of the continuing education articles utilizing various aspects of *multi-media* packages that would be of interest to readers of this report. It is important to note that engineering and scientific programs have not been widely put on video tape or other media, although there are very isolated examples of good programs. Much can be gained from what has been learned in other disciplines however, especially the elementary and secondary school levels where some multi-media programs have been used very effectively in educating large numbers of students. One of the most promising experiments is the computer based Plato program with which everyone is familiar. This has great potential if one considers the use of the stationary earth satellite as a distribution system for Plato terminals in the major population areas of the United States. (See Bibliography: p70).

The entire field of multi-media education is so diverse and so widespread that a coherent thesis on the subject will, of necessity, be dichotemized.



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LIST OF PERIODICALS AND PAPERS CONTAINING INFORMATION ON MULTI-MEDIA TECHNIQUES FOR INDUSTRIAL PERSONNEL

When one looks through the literature, he finds that there is no single journal that makes all this information readily available. In fact, it is this author's opinion that most of the good descriptions of the use of multi-media packages usually come from the trade journals and not always the academic-educational types of journals. The trade associations are more current and write more articles in a style which is more informative for those who are looking for solutions to specific training problems rather than cognitive theory. The reader is encouraged to become familiar with these periodicals.

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LIST OF PEOPLE INTIMATELY ASSOCIATED WITH CONTINUING EDUCATION

Below is a list of those who are intimately associated with continuing engineering education programs in the United States. This is placed in the report so that anyone interested in this rapidly emerging area has an initial point to start with respect to obtaining more information about current practices. The individuals listed are members of the Continuing Engineering Studies Division of the American Society for Engineering Education, the only professional society which has a group solely devoted to the continuing education aspects of life long learning for engineers and scientists. They participate in the College Industry Education Conference each year which is the one place where knowledgeable people in all areas of continuing education for engineers and scientists can be found. I hasten to add that there may be unintentional omissions. However, it is the most concise list that is currently available anywhere. It is readily apparent when one attends an American Society for Training and Development meeting, where personnel directors meet, there is a noticeable lack of knowledge known concerning how scientists and engineers learn and continue their career development. The interest of most people in continuing education in industry, if they are personnel directors, seem to be in the professional development of managers. This limits the knowledge of the learning characteristics of engineers/scientists and the need for specific kinds of programs for their continuing development.

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Associate Dean College Engr.
Georgia Institute Tech.
Atlanta, Ga. 30332

M. E. VanValkenburg
Dept. Elec. Engr.
University of Illinois
Urbana, Illinois 61801

Leonard A. Vanden Boom
Asst. to Academic V.P.
Milwaukee School Engr.
Milwaukee, Wisconsin 53201

John R. Van Horn
Westinghouse Electric Corp.
Gateway Center
Pittsbgh, Pa. 15222

Robert W. Van Houten
Pres. Emeritus Newark College
Engr. 34 Addison Dr.
Short Hills, N. J. 07078

C. H. Vervalin
Hydrocarbon Processing
Houston, Texas 77001

Ray M. Wainwright
Stearns-Roger, Inc
P. O. Box 5888
Denver, Colorado 80217

Augustus C. Walker, President
Effective Research
141 Westland Dr.
Pittsburgh, Pa. 15217

Raymond C. Watson, Jr. Pres.
Southeastern Inst. of Tech.
P. O. Box 1485
Huntsville, Alabama 35807

Bruce D. Wedlock, Director
Lowell Institute School
Mass. Institute of Tech.
Cambridge, Mass. 02139

Joseph Weil
Special Asst. to President
Florida Institute of Tech.
Melbourne, Florida 32901

Bob E. White
Dir. Off Campus Engr. & Tech.
Programs, Western Mich. Univ.
Kalamazoo, Michigan 49001

Lester E. White
Cont. Ed. Dir. Ohio Univ.
Belmont Co. Campus
St. Clairsville, Ohio 43950

Richard Wiegand
Dir. Cont. Ed.
Georgia Institute of Tech.
Atlanta, Ga. 30332

C. Allen Wortley
Asst. Prof. Univ. Wisconsin-
Extension, 432 N. Lake St.
Madison, Wis. 53706

William W. Wuerger
Assoc. Chairman Dept. Engr.
Univ. Wisconsin-Extension
432 N. Lake St.
Madison, Wis. 53706

VIDEO PUBLISHERS

The following list of companies are producers of video software for a quick reference by the reader. It is duplicated from the Television Digest, Video Expo Show Supplement, and was taken from the new Knowledge Industry Publications, Inc. report, "Video In Libraries". The overwhelming majority of these producers of software develop materials in the soft sciences because that is where the large market exists. As the need for more engineering and scientific material becomes evident, it will also become available.

ABC Merchandising Inc.
(Subsidiary of ABC)
1330 Avenue of the Americas
New York, NY 10019

Admaster Inc.
425 Park Avenue, South
New York, NY 10016

Advanced Systems Inc.
1601 Tonne Road
Elk Grove, IL 60007

Agape Productions
138 East 93rd Street
New York, NY 10028

Agency for Instructional Television
(subsidiary of National Instructional
Television)
Box A, 1111 West 17th Street
Bloomington, IN 47401

Alternate Visions, Inc.
130 West 86th Street
New York, NY 10024

American Cable Network Educators'
Video Cassette Service
701 S. Airport Road, Box 936
Traverse City, MI 49684

American Educational Films
132 Lasky Dr.
Beverly Hills, CA 90212

American Enterprise Institute for
Public Policy Research
1150 17th Street, N.W.
Washington, DC 20036

American Journal of Nursing
Company
Educational Services Division
10 Columbus Circle
New York, NY 10019

American Occupational Therapy
Association
6000 Executive Boulevard, Suite 200
Rockville, MD 20852

American Physical Therapy
Association
1156 15th Street, N.W.
Washington, DC 20009

American Video Network
660 South Bonnie Brae
Los Angeles, CA 90057

Ken Anderson Films
Box 618, 152 East Winona Street
Winona Lake, IN 46590

April Video Cooperative
Box 77, Route 375
Woodstock, NY 12498

Artcom
(division of LaRue Inc.)
708 North Dearborn Avenue
Chicago, IL 60610

Associated Educational Materials
Company
14 Glenwood Avenue, Box 2087
Raleigh, NC 27602

The Athletic Institute
200 Castlewood Drive
North Palm Beach, FL 33408

Audio Visual Productions
1233 North Ashland Avenue
Chicago, IL 60622

Audiovisual Education in
Neurosurgery
15 Columbus Circle
New York, NY 10023

August Films Inc.
321 West 44th Street
New York, NY 10036

BNA Communications Inc.
(subsidiary of Bureau of
National Affairs)
9401 Decoverly Hall Road
Rockville, MD 20850

Biomedical Communications
Univ. of Nebraska Medical Center
42 and Dewey
Omaha, NE 68105

Blue Sky Productions
Box 548
Santa Fe, NM 87501

Borden Productions
Great Meadows Road, P.O. Box 520
Concord, MA 01742

Brigham Young University
Green House
Provo, UT 84602

Broadman Films
127 Ninth Avenue
Nashville, TN 37234

C K Communications
551 Fifth Avenue
New York, NY 10036

CRM/McGraw-Hill Films
Del Mar, CA 92014

Career Information Center
1944 Herbert Avenue
Salt Lake City, UT 84108

Cambridge Book Company
488 Madison Avenue
New York, NY 10022

Center for Effective
Negotiating, Inc.
10686 Somma Way
West Los Angeles, CA 90024

Chamber of Commerce of the
U.S.
1615 H Street, N.W.
Washington, DC 20062

Chelsea House
70 West 40th Street
New York, NY 10018

Coe Film Associates
70 East 96th Street
New York, NY 10028

Columbia Pictures Cassettes
711 Fifth Avenue
New York, NY 10018

Classroom World Productions
22 Glenwood Avenue, Box 2090
Raleigh, NC 27602

Command Performance
Video Network
(division of Educating
Systems, Inc.)
320 Interstate North
Atlanta, GA 30328

Communications Group West
6335 Homewood Avenue
Suite 200
Hollywood, CA 90028

Community Development
Foundation
48 Wilton Road
Westport, CT 06880

Contempo Communications Inc.
1841 Broadway
New York, NY 10023

Control Data Corporation
Individualized Education
Services
8100 34th Avenue, South
Minneapolis, MN 55440

Cornerstone Productions
6087 Sunset Boulevard
Suite 408
Hollywood, CA 90028

Cornell University ETV
Center
Van Rensselaer Hall
Ithaca, NY 14850

Counselor Films, Inc.
2100 Locust Street
Philadelphia, PA 19103

Creative Media
820 Keosauqua Way
Des Moines, IA 50309

Custom Films, Inc.
11 Cob Drive
Westport, CT 06880

Deltak
9950 W. Lawrence Avenue
Schiller Park, IL 60176

Do It Now Foundation
Box 5115
Phoenix, AZ 85010

Lee Dubois Company
Box G
Hyannis, MA 02601

Education Development Center
55 Chapel Street
Newton, MA 02160

Educational Communication
Association
822 National Press Building
Washington, DC 20045

Edutronics Systems
International Inc.
3435 Broadway
Kansas City, MO 64111

Electronic Arts Intermix, Inc.
84 Fifth Avenue
New York, NY 10011

Electronic University
Box 361
Mill Valley, CA 94941

Emcom, Inc.
4000 West 76th Street
Minneapolis, MN 55435

Encyclopaedia Britannica
Educational Corporation
425 North Michigan Avenue
Chicago, IL 60611

ETL, Inc.
1170 Commonwealth Avenue
Boston, MA 02134

Exec-U-Service Associates
P. O. Box 2214
Princeton, NJ 08540

Executive Videoforum, Inc.
200 Park Avenue
Suite 303 East
New York, NY 10017

Family Theater Productions
7201 Sunset Boulevard
Hollywood, CA 90046

Films, Inc.
1144 Wilmette Avenue
Wilmette, IL 60091

Films for the Humanities, Inc.
Box 2053
Princeton, NJ 08540

Flagg Films Inc./Bandera Enterprises
Box 1107
Studio City, CA 91604

Furman Films
3466 21st Street
San Francisco, CA 94110

Genesys Systems Inc.
1121 East Meadow Drive
Palo Alto, CA 94303

Global Village
454 Broome Street
New York, NY 10002

Gratton Video Services Ltd.
711 Third Avenue
New York, NY 10017

Great Plains National Instructional
Television Library
Box 80669
Lincoln, NE 68501

Handel Film Corporation
8730 Sunset Boulevard
Los Angeles, CA 90069

Hartley Productions
Cat Rock Road
Cos Cob, CT 06807

Hewlett-Packard Company
1819 Page Mill Road
Palo Alto, CA 94304

Hunter & Hunter, Inc.
150 Fifth Avenue, Suite 1101
New York, NY 10011

IBM Data Processing
1133 Westchester Avenue
White Plains, NY 10604

Images
4696 North Millbrook
Fresno, CA 93726

Indiana University
Audio-Visual Center
Bloomington, IN 47401

Instructional Television Center
Dallas County Community College
District
12800 Abrams Road
Dallas, TX 75231

Instrument Society of America
400 Stanwix Street
Pittsburgh, PA 15222

Integrative Learning Systems Inc.
326 West Chevy Chase Drive
Suite 11
Glendale, CA 91204

International Communications
Company
244 Thorn Street
Sewickley, PA 15134

International Film Bureau
332 South Michigan Avenue
Chicago, IL 60604

Kaydan Records
(division of Stacy Keach
Productions)
5216 Laurel Canyon Boulevard,
North
Hollywood, CA 91706

Allan Keith Productions, Inc.
243 West 56th Street
New York, NY 10019

Walter J. Klein Company Ltd.
6301 Carmel Road
Charlotte, NC 28211

Lab-Volt Ltd.
(subsidiary of Buck Engineering
Company Inc.)
5368 13th Avenue
Rosemont, Quebec, H1X2X8,
Canada

Lawren Productions Inc.
Box 1542
Burlingame, CA 94010

Lacy Sales Institute
80 Union Street
Boston, MA 02159

Library Filmstrip Center
3033 Aloma
Wichita, KS 67211

J. B. Lippincott
(Division of Higher Education)
East Washington Square
Philadelphia, PA 19105

Management Video Publications Ltd.
Box 369
Toronto Dominion Centre,
Royal Trust Tower
Toronto, Ontario, Canada

Manpower Education Institute
127 East 35th Street
New York, NY 10016

Marathon International
10 East 49th Street
New York, NY 10017

McDonnell-Douglas Corporation
Film and Television Communications
2525 Ocean Park Boulevard
Santa Monica, CA 90406

McGraw-Hill Films
(Webster Division)
1221 Avenue of the Americas
New York, NY 10020

Medcom, Inc.
2 Dag Hammarskjold Plaza
New York, NY 10017

Media Arts Productions
6501 Winchester Avenue
Ventnor, NJ 08406

Media One
10 Davis Drive
Belmont, CA 94002

Medical Electronic Educational
Services Inc.
1802 West Grant Road
Suite 119
Tucson, AZ 85705

Melody House Company
(subsidiary of A.B. LeCrone
Company)
819 N. W. 92nd Street
Oklahoma City, OK 73114

Memorex Corporation
1200 Memorex Drive
Santa Clara, CA 95052

Metropolitan Pittsburgh Public
Broadcasting Inc.
4802 Fifth Avenue
Pittsburgh, PA 15213

Milady Publishing Corporation
3839 White Plains Road
Bronx, NY 10467

MIT Center for Advanced
Engineering Study
Room 9–232
Massachusetts Institute of Technology
Cambridge, MA 02139

Modern Media Services
2323 New Hyde Park Road
New Hyde Park, NY 11040

Monarch Releasing Corporation
330 West 58th Street
New York, NY 10019

Monumental Films Inc.
2160 Rockrose Avenue
Baltimore, MD 21211

Motorola Teleprograms, Inc.
4825 North Scott Street
Suite 26
Schiller Park, IL 60176

National Education Association
(NEA)
1201 16th Street, N.W.
Washington, DC 20036

National Educational Media Inc.
15250 Ventura Boulevard
Sherman Oaks, CA 91403

National Geographic Society
17 and M Streets, N.W.
Washington, DC 20036

Nauman Films Inc.
Box 232
Custer, SD 57730

Nebraska Educational Television
Council for Higher Education
Inc. (Netche)
Box 83111
Lincoln, NE 68501

New York State Colleges of
Agriculture & Life Sciences
& Human Ecology Cornell
University, Media Services
201 Roberts Hall
Cornell University
Ithaca, NY 14853

Nightingale-Conant Corporation
6677 North Lincoln Avenue
Chicago, IL 60645

Northern Illinois University
(division of Communication Services)
Altgeld Hall, Room 116
DeKalb, IL 60115

Ohio Historical Society
Ohio Historical Center
Columbus, OH 43211

Olympus Publishing Company
1670 East 1300 South
Salt Lake City, UT 84105

Our Sunday Visitor, Inc.
Noll Plaza
Huntington, IN 46750

Pacific Coast Community Video
121 East De La Guerra Street
Santa Barbara, CA 93101

Parthenon Pictures
2625 Temple Street
Los Angeles, CA 90026

Perennial Education, Inc.
1825 Willow Road
Northfield, IL 60093

Pergamon Press, Inc.
Maxwell House
Elmsford, NY 10523

Pictura Films Distribution
Corporation
43 West 16th Street
New York, NY 10011

Playback Associates, Inc.
30 Rockefeller Plaza
New York, NY 10020

Polymorph Films Inc.
331 Newbury Street
Boston, MA 02115

Prentice-Hall Media Inc.
(subsidiary of Prentice-Hall, Inc.)
150 White Plains Road
Tarrytown, NY 10591

Professional Arts Inc.
Box 8003
Stanford, CA 94305

Professional Development, Inc.
2915 Terminal Tower
Cleveland, OH 44113

Professional Research Inc.
(subsidiary of American
Medical International)
660 South Bonnie Brae
Los Angeles, CA 90057

Professional Selling Institute, Inc.
625 North Milwaukee Street
Milwaukee, WI 53202

The Public Television Library
475 L'Enfant Plaza, S.W.
Washington, DC 20024

Purdue University
116 Stewart Center
West Lafayette, IN 47907

Purpose Film Center
(division of Parthenon Pictures)
2625 Temple Street
Los Angeles, CA 90026

Pyramid Films
Box 1048
Santa Monica, CA 90406

Raindance
71 West Broadway
New York, NY 10006

Ramic Productions
58 West 58th Street
New York, NY 10019

Ramsgate Films
704 Santa Monica Boulevd
Santa Monica, CA 90401

Reader's Digest
(Television Division)
200 Park Avenue
New York NY 10017

The Reading Laboratory Inc.
55 Day Street
South Norwalk, CT 06854

RMI Film Productions Inc.
701 Westport Road
Kansas City, MO 64111

S. C. Educational Television
Commission
2712 Millwood Avenue
Columbia, S.C. 29205

Salenger Educational Media
1635 12th Street
Santa Monica, CA 90404

William Schlottmann Productions
536 East Fifth Street
Suite 18
New York, NY 10009

Scientificom
(division of LaRue Inc.
Communications)
708 North Dearborn Avenue
Chicago, IL 60610

Al Sherman Films
Box 6, Cathedral Station
New York, NY 10025

Sister Kenny Institute of the
American Rehabilitation
Foundation
1800 Chicago Avenue
Minneapolis, MN 55404

Sleeping Giant Films, Inc.
3019 Dixwell Avenue
Hamden, CT 06518

Smith-Mattingly Productions, Ltd.
310 South Fairfax Street
Alexandria, VA 22314

Ken Snyder Enterprises
2032 Alameda Padre Serra
Santa Barbara, CA 93103

Social Psychiatry Research
Institute Inc.
150 East 69th Street
New York, NY 10021

Society of Manufacturing
Engineers
20501 Ford Road
Dearborn, MI 48218

Society of Petroleum
Engineers of AIME
Public Relations Department
6200 North Central Expressway
Dallas, TX 75206

Southam Viodeotel Ltd.
1450 Don Mills Road
Don Mills, Ontario,
Canada

Southern Baptist Radio
& Television Commission
6350 West Freeway
Fort Worth, TX 76116

Sterling Institute
1600 Virginia Avenue, N.W.
Watergate Conference Center
Washington, DC 20037

Stockdale Corporation
2211 West 2300 Street
Salt Lake City, UT 84119

Martha Stuart Communications
66 Bank Street
New York, NY 10014

Sunburst Communications
39 Washington Avenue
Pleasantville, NY 10570

TAD Produtct Corporation
TAD Institute
135 Cabot Street
Beverly, MA 01915

Tampa Manufacturing Institute
619 Emerald Lane
Holmes Beach, FL 33510

Teach 'Em, Inc.
625 North Michigan Avenue
Chicago, IL 60611

Teletronics International, Inc.
231 East 55th Street
New York, NY 10022

Tel-A-Train, Inc.
1600 East Main Street
Chattanooga, TN 37404

Texas Instruments, Inc.
13500 North Central Expressway
Box 5012
Dallas, TX 75222

Time-Life Films
Multimedia Division
100 Eisenhower Drive
Paramus, NJ 07652

Time-Life Video
Time & Life Building
Rockefeller Center
New York, NY 10020

Total Video Library
Corporation
514 West 57th Street
New York, NY 10019

TVTV
Box 48-455
Los Angeles, CA 90048

United States History
Society Inc.
5425 Fargo
Skokie, IL 60076

U.S. Navy Office of
Information
Production Services Division
Pentagon, Room 2D340
Washington, DC 20350

United Synagogue of America
Department of Education
155 Fifth Avenue
New York, NY 10010

University of Minnesota
Audiovisual Library Service
3300 University Avenue, S.E.
Minneapolis, MN 55455

University of Missouri
Academic Support Center
505 East Stewart Road
Columbia, MO 65201

University of Texas at
Austin
Petroleum Extension Services
Box S, University Station
Austin, TX 78712

University of Washington
Press
Seattle, WA 98105

University of Wisconsin-
Extension
Electronic Media Programming
in Engineering
432 North Lake Street
Madison, WI 53706

Unusual Films
Bob Jones University
Greenville, S.C. 29614

Valley Forge Films Inc.
Box K
Paoli, PA 19301

G. W. Van Leer & Associates
1850 North Fremont
Chicago, IL 60614

Video Tape Center of Marin
150 East Blithedale
Mill Valley, CA 94941

Video Tape Network
115 East 62nd Street
New York, NY 10012

Videoplay Merchandising
1512 Merchandise Mart
Chicago, IL 60654

Visual Education Service
Yale University Divinity School
409 Prospect Street
New Haven, CT 06511

Visual Instruction Productions
(A dept. of Victor Kayfetz
Productions, Inc.)
295 West Fourth Street
New York, NY 10014

Vocational Films
(Division of Telecine Film
Studios, Inc.)
111 Euclid Avenue
Park Ridge, IL 60068

West Virginia University
Morgantown, WV 26505

Western Instructional Television,
Inc.
1549 North Vine Street
Los Angeles, CA 90028

Weston Woods Studio
Weston, CT 06880

Ruth White Productions
(Subsidiary of Rhythms Productions
Records)
Whitney Building, Box 34485
Los Angeles, CA 90034

Wilson Learning Corporation
6950 Washington Avenue, South
Eden Prairie, NM 55343

WOI-TV
Iowa State University
WOI Communications Center
Ames, IA 50010

Women Make Movies, Inc.
257 West 19th Street
New York, NY 10011

Xicom, Inc.
Clinton Woods
Tuxedo, NY 10987

List of Packaged Materials Offered for Sale—Gleaned From Material Coming Across a Continuing Education Directors Desk

The following is a list of packag [illegible] rials that are offered for sale by variou [illegible] universities throughout the country. There is no central clearinghouse for this kind of information. One learns of its existence by flyers in mailings put out by each of the industries. As a result only those programs that have a large potential are produced or disseminated to the public. In addition, the industrial training director is primarily oriented towards management and supervisory training programs because he is most knowledgeable in this area.

As one goes down the list, it becomes obvious that video tape, audio-tape slide programs, filmstrips and 16mm film are the predominent methods of teaching a particular subject. Although the list contains many types of material that would be considered "nonengineering/scientific", the reader should exercise caution in judging whether or not it is appropriate for the list, since most engineers begin to handle some kind of supervisory responsibility five to ten years after completing an undergraduate degree.

Probably the best list available of programs that utilize multi-media is "The Catalog" which is edited by Professor Lauer from the University of Colorado. He has evaluated many of the materials that have been produced by multi-media package and has available the most up to date list.

It should be noted in the charts that the modules all seem to use some kind of workbook or manual to help the viewer understand the material better. Most of the films and video tapes are now in color to help satisfy the psychological market towards color presentation.

[illegible] r should also be attracted to the price of [illegible] the individual modules or the sets. It is obvious that only the large companies can afford such an extensive library in any one particular field. It behooves the continuing education directors of universities, and also of industry, to come up with different models to help reduce this cost sufficiently so that larger numbers of people can use the material. Consortia and other associations will have to move into the field if we hope to expand this market to make it cost effective for the small-to-medium size companies who have small numbers of engineers working in their organizations.

It should be noted also that there are only a few colleges and universities listed, since they do not have the marketing capability of developing and distributing programs. Certainly consortia like AMCEE are one way to go and should be encouraged on the national scene by the appropriate government agencies interested in promoting continuing education among engineers and scientists. This would help reduce the cost and get the information out to business and industry. This author is surprised at the number of companies in his state that do not know that this material is readily available. This is not surprising, however, when one begins to realize that the primary objective and goal of the engineering leader and manager in industry is to produce products and maintain efficient, effective work flow. Training becomes very secondary in their everyday work situation.

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Supervising By Objectives	Addison-Wesley Pub. Co., Inc.		Yes		Yes		12	Yes				
Performance Appraisal Instr. Kit George L. Morrisey	"		Yes					Yes			75.00	
Mini Management Conference Curtis H. Jones & Peter F. Drucker	"		Yes				3	5.95			(3)120.00 (1) 50.00	
Executive Writ. Speak. & List. Skills	AMACOM		Yes				6	Yes			95.00	85.AMA
The Selection Interview Raymond F. Valentine	"		Yes				1	Yes			25.00	20.AMA
Appraisal & Career-Counseling Inter. Don Faber	"		Yes				1	Yes			25.00	20.AMA
The Problem-Employee Interviews Glenn A. Bassett	"		Yes				1	Yes			25.00	20.AMA
The Exit Interview John R. Hinrichs, Ph.D.	"		Yes				1	Yes			25.00	20.AMA
The Information Interview John R. Hinrichs, Ph.D.	"		Yes				1	Yes			25.00	20.AMA
Time Management for Mgrs. & Secys.	American Information Service					Color 16mm			100.00 3da 20.00ea.da.	25.00	460.00	
Transactional Analysis	CRM McGraw-Hill Films					Yes			45.00		450.00	
Productivity & the Self-Fulfilling Prophecy	"					Yes			45.00		450.00	
Leadership: Style or Circumstance?	"					Yes			45.00		450.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Group Dynamics: "Groupthink"	"					Yes			35.00		345.00	
Communication: The Nonverbal Agenda	"					Yes			45.00		450.00	
Women in Management	"					Yes			45.00		450.00	
Business, Behaviorism & The Bottom Line	"					Yes			35.00		295.00	
Successful In-Company Training Progs	Dartnell		Yes					Yes			—47.50	
Instructional Development Learning System	Educational Systems for the Future		Yes	Yes				19.95			275.00	
Speedway Reading Dr. Wayne Otto	HY CITE Corporation		Yes				16	33.00			130.40	
Manager-Level Overview of Microprocessors & Microcomputers	Integrated Computer Systems, Inc.		Yes				5 hrs.	Yes			135.00	
Microprocessor Project Management	"		Yes				5 hrs.	Yes			135.00	
Microprocessors/ Microcomputers	"		Yes				9 hrs.	Yes			185.00	
Software Development	"		Yes				9 hrs.	Yes			185.00	
Bit-slice Microprocessors, PLA's and Microprogramming	"		Yes				9 hrs.	Yes			185.00	
Military & Aerospace Microprocessor	Integrated Computer Systems, Inc.		Yes				9 hrs.	Yes			185.00	
Microprocessors & LSI in Telecommunications Applications	"		Yes				9 hrs.	Yes			185.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Microprocessors in Manufacturing & Industrial Control			Yes				9 hr.	Yes			185.00	
Speed Learning	Learn Incorporated		Yes				3	Yes			83.00	
The Employment Interview	Felix M. Lopex & Assoc., Inc.		Yes				6	Yes			60.00	
The Departmental Interview.	"		Yes				2	Yes			22.50	
The Campus Interview	"		Yes				2	Yes			28.00	
The Unique Applicant Interview	"		Yes				4	Yes			30.00	
The Assessment Interview	"		Yes				4	Yes			40.00	
How Successful Managers Manage	Management Resources, Inc.		Yes				6	Yes			125.00	
The "How To" Drucker	Masterco Press		Yes				4	Yes			120.00	
Odiorne/Objective-Focused Management	"		Yes				6	Yes			115.00	
Chris Argyris On Organization	"		Yes				4	Yes			100.00	
Warren Bennis On Leaders	"		Yes				5	Yes			125.00	
Richter/Everyday Creativity	"		Yes				7	Yes			115.00	
Morrisey/Management By Objects and Results	"		Yes				6	Yes			69.50	
Hardesty/TA for Secretaries	"		Yes				3	Yes			47.50	
Carter/Career Planning for Women			Yes			3	Yes				90.00	
Rutherford/Time Management for Executive Sect. & Admin. Asst.	"		Yes				Yes	Yes			85.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Producing Effective Audiovisual Presentations	Media Research & Development		Yes		Yes		8	Yes			160.00	
Executive Seminars in Sound	Nations Business		Yes				8	Yes				
Management by Objectives	Penton/IPC Education Division		Yes				1					
Management by Exception	"		Yes				1				85.00	
You - The Supervisor	Professional Development, Inc.		Yes		Yes			Yes			60.00	
Appraisals in Action	"		Yes		Yes			Yes			60.00	
The Making of a Salesman	"		Yes		Yes			Yes				
Organizational Transactions	"		Yes		Yes			Yes				
Performance Reviews	"		Yes		Yes			Yes				
Managerial Game Plan	"		Yes		Yes			Yes				
The Joy of Achievement	Salenger Educational Media					Yes			60.00	25.00	280.00	
The Peter Principle: Why Things Always Go Wrong	"					Yes			85.00	35.00	475.00	
Management Theory and Practice "Theory X and Theory Y"	"					Yes			55.00	25.00	275.00	
Case Studies in Leadership	"					Yes			70.00	25.00	340.00	
Break-Even Point Analysis	"					Yes			65.00	25.00	325.00	
The People Factor: Hawthorne Studies for Today's Managers	"					Yes			60.00	25.00	310.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Job Enrichment: Managerial Milestone or Myth?	"					Yes			70.00	25.00	325.00	
Management Training Film Program	"					Yes			60.00	25.00	310.00	
Maslow's Hierarchy of Needs	"					Yes			65.00	25.00	325.00	
The Finance & Accounting Cassette Program	Schrello Assoc. Inc.		Yes				12	Yes			295.00	
Management by Objectives & Results	"		Yes				6	Yes			295.00	
Collecting Money by Telephone	"		Yes				1	Yes			69.95	
New NRA Sex Discrimination awareness program	Science Research Assoc., Inc.		Yes		Yes			Yes			295.00	
Attitude Surveys	"		Yes				6	Yes			95.00	
Manager Under Pressure	Stephen Bosustow Productions					16mm			50.00		245.00	
Instructional Skills Assessment Lab	Training House										150.00	
A New Sales Training Program	Training Systems Division, Bill Sandy Co.		Yes				5	Yes				
Winning Techniques for Goal Setting	Women and More		Yes				2	Yes			29.50	
Basic Arc Welding	Westinghouse Learning Press				Yes			12 lessons			425.00	
Advanced Arc Welding	"				Yes		8	Yes			280.00	
Gas Metal-Arc Welding	"				Yes		3	Yes			297.00	
Gas Tungsten Welding	"				Yes		5	Yes			175.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Basic Math: An Individualized Course	"		Yes				22	Yes			265.00	
You Pack Your Own Chute	RAMIC Productions					16mm						
You Can Surpass yourself	"					16mm						
Training Film Profiles	A.S.T.D. & Olympic Media Information					16mm	9				525.00	
How to Manage the Boss	BNA Communications, Inc.	Yes				16mm			69.00	25.00	475.00	
How to Work with Your Fellow Managers	"	Yes				16mm 8mm			69.00	25.00	475.00	
Helping People Perform, What Managers are Paid for	"	Yes				16mm 8mm			69.00	25.00	475.00	
Planning & Coal Setting, Time-Waste or Management Tool?	"	Yes				16mm 8mm			69.00	25.00	475.00	
How to Take the Right Risks, The Manager as Decision Maker	"	Yes				16mm 8mm			69.00	25.00	475.00	
How to Make the Organization Work for You	"	Yes				16mm 8mm			69.00	25.00	475.00	
Entire Series of (6) Films	"	Yes				16mm 8mm			414.00	90.00	2,730.00	
Applause (7 Steps to Effective Speech)	The Cally Curtis Company	Yes				16mm 8mm			100.00	25.00	460.00	
When I Say No, I Feel Guilty	"	Yes				16mm 8mm			100.00	25.00	460.00	
The Managerial Grid in Action	BNA Communications, Inc.	Yes				16mm 8mm			69.00	25.00	480.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
The Grid Approach to Conflict Solving	"	Yes				16mm 8mm			69.00	25.00	480.00	
(Both of the above together)	"	Yes				16mm 8mm			138.00	30.00	940.00	
I Understand, You Understand	Creative Media, Inc.	Yes				16mm 8mm			85.00	25.00	450.00	
The Commonsense Way to Deal with Complaints	Dartnell	Yes				16mm 8mm			80.00	15.00	295.00	
What Your Supervisor/Trainees Will Learn	"	Yes				16mm 8mm			80.00	15.00	295.00	
The Tough-minded Salesmanship	"	Yes				16mm 8mm	3		256.00 1-95.00	—	1,74.00 1-435.00	
Sell Like an Ace . . . Live Like a King	"	Yes				16mm 8mm			95.00	30.00	435.00	
Salesman!	"	Yes				16mm 8mm			95.00	30.00	435.00	
How to Raise Your Batting Average in Selling	"	Yes				16mm 8mm			95.00	30.00	435.00	
How to Take the Butt Out of a Sales Rebuttal	"	Yes				16mm 8mm			95.00	30.00	435.00	
Charge - Arnold Palmer (Motivation Magic)	"	Yes				16mm 8mm			95.00	30.00	450.00	
Take Command	"	Yes				16mm 8mm			95.00	30.00	435.00	
Run Smart	"	Yes				16mm 8mm			95.00	30.00	435.00	
Explode Those Sales Myths	"	Yes				16mm 8mm			120.00	30.00	450.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film /16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Pour It On	"	Yes				16mm 8mm			95.00	30.00	435.00	
Think Win	"	Yes				16mm 8mm			95.00	30.00	435.00	
Second Effort-Vince Lombardi	"	Yes				16mm 8mm			95.00	30.00	435.00	
Make It Happen	"	Yes				16mm 8mm			95.00	30.00	435.00	
The Professional	"	Yes				16mm 8mm			95.00	30.00	435.00	
Top Salesman's Talk Show	"	Yes				16mm 8mm			95.00	30.00	435.00	
Lest We Forget	"	Yes				16mm 8mm					100.00 (only)	
The Boss	"	Yes				16mm 8mm			80.00	30.00	295.00	
Wheelchair	"	Yes				16mm 8mm			80.00	30.00	295.00	
Earl Nightingale's The Strangest Secret	"	Yes				16mm 8mm			80.00	30.00	295.00	
GiGo	"	Yes				16mm 8mm			95.00	30.00	435.00	
Rx for Absenteeitis		Yes				16mm 8mm			80.00	30.00	295.00	
Fair Warning	"	Yes				16mm 8mm			80.00	30.00	295.00	
This Matter of Motivation	"	Yes				16mm 8mm			150.00	30.00	435.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Closing the Sale	"	Yes				16mm (B&W) 8mm			45.00	30.00	150.00	
Overcoming Objections	"	Yes				16mm (B&W) 8mm			45.00	30.00	150.00	
Presenting Your Sales Case Convincingly	"	Yes				16mm (B&W) 8mm			45.00	30.00	150.00	
Opening the Sale	"	Yes				16mm (B&W) 8mm			45.00	30.00	150.00	
Autopsy of a Lost Sale	"	Yes				16mm (B&W) 8mm			45.00	30.00	150.00	
Developing Your Sales Personality	"	Yes				16mm (B&W) 8mm			45.00	30.00	150.00	
How to Make an Effective Sales Presentation	"	Yes				16mm (B&W) 8mm			45.00	30.00	150.00	
How to Prevent Objections in Selling	"	Yes				16mm (B&W) 8mm			45.00	30.00	290.00	
What It Takes to Be a Real Salesman	"	Yes				16mm (B&W) 8mm			45.00	30.00	290.00	
How to Succeed in the People Business	"	Yes				16mm (B&W) 8mm			45.00	30.00	290.00	
The Power of Enthusiasm	"	Yes				16mm (B&W) 8mm			45.00	30.00	150.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
How to Sell Creatively	〃	Yes				16mm (B&W) 8mm			45.00	30.00	290.00	
How to Sell Quality	〃	Yes				16mm (B&W) 8mm			45.00	30.00	150.00	
The Bottger Story	〃	Yes				16mm (B&W) 8mm			45.00	30.00	150.00	
The Selling Secrets of Ben Franklin	〃	Yes				16mm (B&W) 8mm			45.00	30.00	290.00	
Solid Gold Hours	〃	Yes				16mm (Color) 8mm			95.00	30.00	335.00	
How to Select Salesman Who Can and Will Sell	〃	Yes				16mm (B&W) 8mm			45.00	30.00	290.00	
Herman Holds a Sales Meeting	〃	Yes				16mm (B&W) 8mm			45.00	30.00	125.00	
Herman's Secrets of Sales Success	〃	Yes				16mm (B&W) 8mm			45.00	30.00	125.00	
Keys to Human Relations in Selling	〃	Yes				35mm- Color w/sound					250.00	
Selling . . . The Great Career	〃	Yes				35mm- Color w/sound					350.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
The Challenge of Objections (From England)	"	Yes				16mm- Color w/sound			95.00	30.00	375.00	
A Reason to Buy (From England)	"	Yes				16mm- Color w/sound			95.00	30.00	375.00	
Time Well Spent (From England)	"	Yes				16mm- Color			95.00	30.00	375.00	
Selling On The Telephone (From England)	"	Yes				16mm- Color w/sound			95.00	30.00	345.00	
A Matter of Confidence (From England)	"	Yes				16mm- color w/sound			95.00	30.00	345.00	
Managing Salesmen (From England)	"	Yes				16mm- Color w/sound			95.00	30.00	345.00	
Learning From Experience (From England)	"	Yes				16mm- Color w/soud			95.00	30.00	345.00	
Starting The Interview (From England)	"	Yes				16mm- Color w/sound			95.00	30.00	345.00	
The Supervisor and Equal Employment Opportunity	Datafilms - Los Angeles					Yes				35.00	295.00	
The Confidence Game	Educational Resources Foundation	Yes				16mm		Yes	Com.375.00 Ind.125.00	25.00	Com. 1,000.00 Ind. 400.00	
A Woman's Place	The Cally Curtis Company	Yes				16mm 8mm			100.00	25.00	460.00	
How to Manage by Objectives	MBO, Inc.					16mm Color	4		325.00 1-95.00		985.00 1-285.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Profile of a Manager	National Educational Media, Inc.	Yes				16mm 8mm + $14.00		Yes	60.00		385.00	
Strategy for Winning	"	Yes				16mm 8mm + $14.00		Yes	80.00		495.00	
Your Personal Appearance	"	Yes				16mm 8mm + $14.00		Yes	45.00		250.00	
Professional Management Program	"	Yes				16mm 8mm	12	Yes	60.00		290.00 304.00	
General Business	"	Yes				16mm 8mm	3	Yes	40.00		195.00 209.00	
Behavior Modification Skills	Research Media, Inc.		Yes	80			5	Yes			395.00	
This Matter of Motivation	ROA Films					16mm	12		150.00		435.00	
Equal Opportunity	Salenger Educational Media					16mm		Yes	60.00	25.00	285.00	
Case Studies in Leadership: Doctor, Lawyer, Merchant, Chief	"	Yes				16mm		Yes	70.00	25.00	340.00	
Focus on Ethics	"					16mm	3	Yes	120.00	60.00	990.00	
Alternatives to Dicharge: A Case Stdy	"	Yes				16mm		Yes	65.00	25.00	300.00	
Overmanagement, or How an Exciting idea Can Become a Dull Project	"	Yes				16mm		Yes	55.00	25.00	250.00	
Case Studies in Communication: What Do You Mean, What Do I Mean	"	Yes				16mm		Yes	70.00	25.00	340.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Courage To Succeed	Saxton Communications Group, Ltd.	Yes				16mm 35mm Super 8			150.00	25.00	550.00	
Two Person Communication	BNA Communications, Inc.	Yes				16mm Super 8	5		345.00 1-69.00	75.00 1-25.00	2,305.00 1-480.00	
Search for Achievement	Teleometrics Int'l.					Yes			75.00	30.00	475.00	
Where are You? Where are You Going?	Roundtable Films	Yes				16mm 8mm		Yes	60.00	Yes	400.00	
You're Coming Along Fine	"	Yes				16mm 8mm		Yes	60.00	Yes	375.00	
How Good is a Good Guy?	"	Yes				16mm 8mm			55.00	Yes	325.00	
The Discipline Interview	"	Yes				16mm 8mm			50.00	Yes	325.00	
The Counsel Interview	"	Yes				16mm 8mm			50.00	Yes	325.00	
The Making of a Decision	"	Yes				16mm 8mm			60.00	Yes	400.00	
The Way I See It	"	Yes				16mm 8mm			55.00	Yes	325.00	
Thanks A'plenty Boss Series 1-The Rewards of Rewarding	"	Yes				16mm 8mm			60.00	Yes	375.00	
2-The Correct Way of Correcting	"	Yes				16mm 8mm			60.00	Yes	375.00	
Something To Work For	"	Yes				16mm 8mm			55.00	Yes	375.00	
Management, Motivation & The New Minority Worker	"	Yes				16mm 8mm			55.00	Yes	400.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
The Will To Work	"	Yes				16mm 8mm			50.00	Yes	325.00	
I'd Rather Not Say	"	Yes				16mm 8mm			55.00	Yes	400.00	
The Engineering of Agreement	"	Yes				16mm 8mm			55.00	Yes	325.00	
Tell Me About Yourself	"	Yes				16mm 8mm			60.00	Yes	425.00	
Conflict	"	Yes				16mm 8mm			60.00	Yes	425.00	
A Case of Insubordination	"	Yes				16mm 8mm			55.00	Yes	350.00	
Overcoming Resistance to Change	Roundtable Films	Yes				16mm 8mm			55.00	Yes	350.00	
Is It Always Right To Be Right?	"	Yes				16mm 8mm			25.00	Yes	175.00	
Time To Think	"	Yes				16mm 8mm			55.00	Yes	375.00	
Breaking The Delegation Barrier	"	Yes				16mm 8mm			55.00	Yes	350.00	
If You Want It Done Right	"	Yes				16mm 8mm			55.00	Yes	400.00	
Pattern for Instruction	"	Yes				16mm 8mm			55.00	Yes	400.00	
Critical Path In Use	"	Yes				16mm (B&W) 8mm			40.00	Yes	200.00	
A Matter of Method	"	Yes				16mm 8mm			50.00	Yes	300.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Value for Money	"	Yes				16mm 8mm			50.00	Yes	300.00	
The Bob Knowlton Story	"	Yes				16mm 8mm			55.00	Yes	400.00	
An Extra Five Knots Series	"	Yes				16mm (B&W)^3 8mm			100.00	30.00	3-675.00 1-250.00	
Styles of Leadership	"	Yes				16mm 8mm		Yes	60.00	Yes	400.00	
Manager Wanted	"	Yes				16mm 8mm			55.00	Yes	350.00	
Imagination At Work	"	Yes				16mm 8mm			50.00	Yes	250.00	
Problem Solving: Some Basic Principles	"	Yes				16mm 8mm			50.00	Yes	350.00	
Problem Solving: A Case Study	"	Yes				16mm 8mm			50.00	Yes	350.00	
Meeting In Progress	"	Yes				16mm 8mm		Yes	65.00	Yes	500.00	
The Goya Effect	"	Yes				16mm 8mm			55.00	Yes	350.00	
The Uncalculated Risk	"	Yes				16mm 8mm		Yes	50.00	Yes	375.00	
The Anatomy of a Presentation	"	Yes				16mm 8mm			55.00	Yes	400.00	
Communicating with a Group	Roundtable Films	Yes				16mm 8mm			50.00	Yes	325.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Person to Person Communication	"	Yes				16mm 8mm			45.00	Yes	250.00	
Welcome Aboard	"	Yes				16mm 8mm		Yes	60.00	Yes	425.00	
National Managerial Test	"	Yes				16mm 8mm			80.00	Yes	425.00	
Getting Ahead: The Road to Self-Development	"	Yes				16mm 8mm			55.00	Yes	350.00	
That's Not My Job	"	Yes				16mm 8mm			50.00	Yes	300.00	
Talkback: A Study In Communications	"	Yes				16mm (B&W) 8mm			35.00	Yes	185.00	
A Measure of Understanding	"	Yes				16mm 8mm			55.00	Yes	400.00	
Judging People	"	Yes				16mm (B&W) 8mm			35.00	Yes	160.00	
Listening	"	Yes				16mm 8mm			55.00	Yes	350.00	
The Telephone at Work	"	Yes				16mm 8mm			50.00	Yes	325.00	
Who Killed the Sale?	"	Yes				16mm 8mm			55.00	Yes	375.00	
Letter Writing at Work	"	Yes				16mm 8mm		Yes	55.00	Yes	350.00	
Writing Letters That Get Results	"	Yes				16mm 8mm		Yes	55.00	Yes	300.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Count to Ten	"	Yes				16mm 8mm		Yes	55.00	Yes	400.00	
I just Work Here	"	Yes				16mm 8mm		Yes	55.00	Yes	275.00	
Sam's Secret	"	Yes				16mm 8mm			50.00	Yes	195.00	
Close That Sale	"	Yes				16mm 8mm		Yes	50.00	Yes	195.00	
The Hidden Side of Selling	"	Yes				16mm 8mm			55.00	Yes	375.00	
I'll Buy That!	"	Yes				16mm 8mm		Yes	70.00	Yes	425.00	
First and Goal	ROA Films					Color			100.00	50.00	400.00	
The Future is Now	"					Color			100.00	50.00	400.00	
Manage Your Time to Build Your Territory	"					Color			95.00	30.00	435.00	
Defense! Defense!	"					Color			100.00	25.00	400.00	
The Habit of Winning . . . ?	"					Color			100.00	25.00	400.00	
Ask for the Order and Get It	"					Color			95.00	30.00	435.00	
Your Price is Right . . . Sell It	"					Color			95.00	30.00	435.00	
Kup's Show on Salesmanship	"					Color			95.00	30.00	435.00	
The Time of Your Life	"					Color			100.00	25.00	440.00	
This Thing Called Change	"					Color			100.00	25.00	250.00	
Transactional Analysis	"					Color			45.00	-		

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/Workbook	Cost: Rental	Cost: Preview	Cost: Purchase	Miscellaneous
One by One	"					Color			100.00	25.00	300.00	
Twelve Like You	"					Color			100.00	25.00	360.00	
The Eye of the Beholder	"					Color			25.00			
Farewell to Birdie McKeever	"					Color			25.00			
I Told 'Em Exactly How To Do It	"					Color			20.00			
Inner Man Steps Out	"					Color			15.00			
Krasner, Norman . . . Beloved Husband of Irma	"					B&W			15.00			
Let's Be Human	"					Color			15.00			
Pattern for Instruction	"					Color			25.00			
Shoplifter	"					Color			15.00			
Acceptance Sampling	"					7-Col. 3 B&W	10		25.00ea.			
Reliability Training Films	"					Color	8		25.00ea.			
Communication for Safety	"					Color	5		12.50ea.			
An Accident Happens to Sam	"					Color			10.00			
Falls are No Fun	"					Color			12.50			
Falls Can Cripple	"					Color			17.50			
Eyes, Hands & Feet Series	"					Color	3		22.50 or 8.50 ea.			
Friendly Machines	"					Color			12.50			
Housekeeping Means Safekeeping	"					Color			20.00			

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
How to Avoid Muscle Strain	"					Color			10.00			
How to Have an Accident at Work	"					Color			10.00			
If You Hear the Explosion, The Danger has Passed	"					Color			20.00			
The Industrial Weightlifter	"					Color			15.00			
Punch Press Guarding	"					Color			12.50			
Safety Wise	"					Color	2		12.50ea.			
A Simple Choice	"					Color			100.00	25.00	350.00	
Slips and Falls	"					Color			7.50			
The Split Second	"					Color			15.00			
Striking Against Objects									7.50			
Supervising for Safety	"					Color	3		12.50ea.			
The Unplanned	"					Color			25.00			
You and Office Safety	"								20.00			
You Can Handle It	"					Color			12.50			
Alcohol: A New Focus	"					Color			25.00			
Alcohol and the Human Body	"					Color			4.50			
Alcohol and You	"					Color			20.00			
Go Sober and Safe	"					Color			20.00			
The American Alcoholic	"					Color			35.00			
America on the Rocks	"					Color			15.00			

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
What's Your Excuse?	"					Color			15.00			
Snort History	"					Color			15.00			
The Summer We Moved to Elm Street	"					Color			15.00			
Accidentally Yours	"					Color			15.00			
Congratulations You Made It Through Another Vacation	"					Color			20.00			
How to Have an Accident in the Home	"					Color			10.00			
The Life You Save	"					Color			25.00			
Self Defense for Girls	"					Color			15.00			
Nobody's Victim	"					Color			20.00			
Post Mortem	"					Color			20.00			
That They May Live	"					Color			12.50			
Freewayphobia	"					Color	2		15.00ea.			
Help is . . .	"					Color			20.00			
I'm No Fool on a Bicycle	"					Color			10.00			
Motor Mania	"					Color			10.00			
Story of Anyburg, U.S.A.	"					Color			10.00			
Not So Easy	"					Color			25.00			
Ride On	"					Color			20.00			
Signal 30	"					Color			15.00			

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Before They Happen	″					Color			10.00			
Cause for Alarm	″					Color			12.50			
The Challenge	″					Color			10.00			
The Chemistry of Fire	″					Color			10.00			
Donald's Fire Survival Plan	″					Color			10.00			
Fire -- and Your Hospital	″					Color			15.00			
The First Five Minutes	″					Color			15.00			
How to Call the Fire Department	″					Color			7.50			
I'm No Fool With Fire	″					Color			10.00			
Stop the Fire Thief	″					Color			12.50			
Stop a Fire Before it Starts	″					Color			20.00			
A Tale of Two Towns	″					Color			12.50			
Train We Must	″					Color			10.00			
Until The Fire Department Arrives	″					Color			7.50			
Cooling of Electronic Equipment	Cooling Courses	Color					6	Yes	390.00			
Formula for Survival-Stress/ Distress (Exercise, Relaxation & Retirement by Degree) Dr. Robert J. Samp	Magnetic Video Corporation	Yes					3					
What You Are Is Where You Were When . . . Morris E. Massey	″	Yes				16mm Color	2			10days No charge	750.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Realistic Cost Estimating	Society of Manufacturing Engineers	Yes					5	Yes			925.00	
Metric Series	"	Yes					5	Yes			925.00	
Technology for Tomorrow	"	Yes					6	Yes	35.00pertape		200.00 per tape	
Manufacturing Engineering Opportunity	"	Yes					1		35.00		200.00	
Positional Tolerances	"	Yes					1		35.00		200.00	
Powder Coating	"						1		35.00		200.00	
Noise Abatement	"	Yes					1		35.00		200.00	
The Industrial Robot	"	Yes					1		35.00		200.00	
The Interview. EEO Considerations	XICOM Inc.											
1-Interviewing Women Candidates	"					Yes				50.00	395.00	
2-Interviewing Minority Candidates	"					Yes				50.00	395.00	
I'll Think About It	"					Yes				50.00	350.00	
Artificial Intelligence Patrick H. Winston	Massachusetts Institute of Technology	Color					24	Yes	743.00		5,825.00	
Calculus Herbert I. Gross	"	B&W				16mm B&W	6	Yes	215.00		1,365.00	
Differentiation	"	B&W				16mm B&W	11	Yes	313.00		2,135.00	
The Circular Functions	"	B&W				16mm B&W	2	Yes			13.50	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
The Definite Integral	"	B&W				16mm B&W	4	Yes	127.00		870.00	
Transcendental Functions	"	B&W				16mm B&W	4	Yes	100.00		695.00	
More Integration Techniques	"	B&W				16mm B&W	4	Yes	105.00		725.00	
Infinite Series	"	B&W				16mm B&W	6	Yes	157.00		1,040.00	
Calculus of Several Variables	"	B&W				16mm B&W	26	Yes	625.00		4,700.00	
Complex Variables, Differential Equations & Linear Algebra	"	B				16mm B&w	20	Yes	520.00		3,800.00	
Colloid and Surface Chemistry J. Th. G. Overbeek	"	B&W				16mm B&W	55	Yes	1,595.00		12,800.00	
Computer Languages Michael L. Dertouzos	"	Color					39		1,529.00		9,945.00	
Digital Signal Processing Alan V Oppenheim	"	Color					21	Yes	778.00		6,165.00	
Economics Robert S. Pindyck	"	Color					12	Yes	495.00		3,670.00	
Macroeconomics	"	Color					10	Yes	454.00		3,245.00	
Engineering Economy Sanford B. Thayer	"	Color					10	Yes	306.00		2,100.00	
Friction, Wear & Lubrication Ernest Rabinowicz	"	Color					12	Yes	476.00		3,405.00	
Introduction to Experimentation Ernest Rabinowicz	"	B&W				16mm B&W	14	Yes	370.00		2,685.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/. Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Management Sloan School of Management and the Innovation Group	″	Color					7		300.00		1,200.00	
Building an Innovative Organization	″	B&W					8		600.00		2,780.00	
Mechanics of Polymer Processing J. R. A. Pearson	″	Color					32	Yes	1,200.00		9,500.00	
Modern Control Theory Michael Athans	″	Color					11	Yes	461.00		3,295.00	
Deterministic Optimal Control	″	Color					10	Yes	382.00		2,745.00	
Deterministic Optimal Linear Feedback	″	Color			20	Yes	20	Yes	665.00		5,220.00	
Stochas[illegible] Estimation	″	Color					18		675.00		5180.00	
Stochastic Control	″	Color					15		538.00		3,985.00	
Network Analysis	″	Color					8	Yes	343.00		2,355.00	
The Operational Amplifier	″	Color					12	Yes	475.00		3,395.00	
Nonlinear Vibrations Jacob P. Den Hartog	″	B&W					23	Yes	583.00		4,315.00	
Probability and Random Processes	″	B&W				16mm	49	Yes	920.00		7,090.00 (Probability)	
Harry L. Van Trees	″	B&W					48	Yes	985.00		7,590.00 (Random Pro.)	
Quality Control	″	Color					10	Yes	360.00		2,485 00	
Thermostatics & Thermodynamics Myron Tribus	″	Color					10		460.00		3,305.00	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Management by Objectives John Humble	Advanced Systems, Inc.	Yes					6	Yes			2,250.00 425.00ea.	
Supervisory Training Allan H. Mogensen	"	Yes					2	Yes			696.00 348.00ea.	
Effective Organization Saul Gellerman	"	Yes					6	Yes			2,550.00 480.00ea.	
Modern Management	"	Yes					7				910.00 160.00ea.	
Effective Communication Dr. David K. Berlo	"	Yes					5				1,540,00 348.00ea.	
Motivation & Productivity Saul Gellerman	"	Yes					9				2,983.00	
Managing Discontinuity Peter Drucker	"	Yes					9				2,205.00 285.00ea.	
Management Self Development Joe Powell	"	Yes					9				3,080.00	
The Effective Executive	"	Yes					5				1,925.00 425.00ea.	
The Motivation to Work Dr Frederick Herzberg's	"	Yes					5				2,200.00 480.00ea.	
Organizational Renewal Gordon Lippitt	"	Yes					5				1,925.00 425.00ea	
Tough-Minded Management Joe Batten	"	Yes					5				1,925.00 425.00ea.	
Loss Prevention	"	Yes					4				504.00 425.00ea.	
Employee Orientation	"	Yes					3				1,080.00 450.00ea.	
How to Advance Your Husband's Career Mildred Johnson	"	Yes					2				696.00 348.00ea.	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Management Practice John Humble	"	Yes					6				1,950.00 670.00ea.	
Training & Instruction	"	Yes					4				1,755.00 450.00	
The Sales Grid Drs. Blake & Mouton	"	Yes					2				940.00 480.00ea.	
The Managerial Grid Drs. Blake & Mouton	"	Yes					2				940.00 480.00ea.	
Communicating	"	Yes					4				1,800.00 450.00ea.	
Interviewing	"	Yes					2				880.00 450.00ea.	
The Gellerman Effective Supervision	"	Yes					3				1,380.00 480.00ea.	
General Safety	"	Yes					5				1,574.00 395.00ea.	
Construction Safety	"	Yes					8				1,950.00 350.00ea.	
Know the British	"	Yes					1				500.00	
Reaching European Markets	"	Yes					6				3,500.00	
Profit by Risk Control: Safety and Security	"	Yes					6				3,000.00	
Motivation: The Management of Success. Dr. Frederick Herzberg	"	Yes					10				5,000.00 600.00ea.	
Job Enrichment Dr. Herzberg & Roy Walters	"	Yes					12				3,000.00 720.00ea.	
The Emerging Resource	"	Yes					3				1,545.00 615.00ea.	
The Desk Set	"	Yes					3				1,045.00 415.00ea.	
Transactional Analysis & Successful Management	"	Yes					6				3,600.00 720.00ea.	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost: Rental	Cost: Preview	Cost: Purchase	Miscellaneous
The Managerial Game Plan S. Collier, D. Guyon & Dr. W. Jones	"	Yes					5				1,250.00 250.00ea.	
Effective Interviewing Drs. Richetto and Zima	"	Yes					6				3,000.00 615.00ea.	
Performance Reviews that Build Commitment. Dr. Jones & D. Guyon	"	Yes					6				1,450.00 300.00ea.	
You - The Supervisor Dick Guyon & Dr. W. Jones	"	Yes					8				1,950.00 350.00ea.	
The Art & Science of Professional Supervision Gene Michelon	"	Yes					8				3,200.00 400.00ea.	
Effective Supervision	"	Yes					3				945.00 365.00ea.	
Manufacturing Management by Objectives Dr. George O'Diorne	"	Yes					6				2,000.00 400.00ea.	
Improving Managerial Performance Herb Cohen & Robert Alberts	"	Yes					10				3,000.00 350.00ea.	
Introduction to Mathematics	"	Yes					6				1,000.00 200.00ea.	
Finance for Non-Financial Managers - Profitability & Cash Flow	"	Yes					4				3,000.00 750.00ea.	
Introduction to Statistics	"	Yes					[illegible]				1,800.00 250.00ea.	
Success Through Efficient Reading	"	Yes					12				3,600.00 300.00ea.	
Business of Writing Prof. Michael E. Adelstein	"	Yes					8				4,000.00 600.00ea.	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Presentations that Work	"	Yes					6				3,600.00 700.00ea.	
Review of Basic Calculus Prof. James Hall	"	Yes					8				3,200.00 400.00ea.	
Intermediate Calculus Carl J. Vanderlin	"	Yes					8				3,200.00 400.00ea.	
French	"	Yes					4				130.00	
German	"	Yes					4				130.00	
Spanish	"	Yes					4				130.00	
Italian	"	Yes					4				130.00	
Misc. Languages (9)	"	Yes					4 ea.				130.00(set of 4)	
Operatios Research	"	Yes					4				800.00 200.00ea.	
PERT/CPM	"	Yes					3				600.00 200.00ea.	
Data Processing Concepts	"	Yes					8				2,400.00 700.00ea.	
Introduction to S/360	"	Yes					7				1,500.00 200.00ea.	
S/370 Concepts & Facilities	"	Yes					10				3,000.00 700.00ea.	
Computer Technology Video Updates	"	Yes					several				900.00	
Systems Network Architecture & SDLC	"	Yes					1				500.00	
Fine-Tuning VS for Efficiency	"	Yes					1				500.00	
Systems Analysis	"	Yes					17				9,400.00 400.00ea.	
Data Communications Concept & Facilities	"	Yes					10				5,000.00 600.00ea.	

TOPIC	ORGANIZATION	TV Tap	Audio T	Slides	Filmstr	Film 16mm/8	Number Modules	Manual/ Workbo	Rental	Preview	Purchase	Miscellaneous
File Organization & Accessing Methods	″	Yes					6				2,000.00 600.00ea.	
VSAM Concepts	″	Yes					3				500.00	
Data Base Concepts & Methods Leo J. Cohen	″	Yes					8				1,500.00 300.00ea.	
IMS Concepts	″	Yes					2				1,000.00 600.00ea.	
IMS Application Programming Leo Cohen & Alan Stutz	″	Yes					6				3,600.00 700.00ea.	
CICS/VA Application Programming	″	Yes					4		55.00permo.	(ONLY)		
Controls in DP Systems	″	Yes					6				1,200.00 250.00ea.	
DP/User Department Relationships	″	Yes					1				200.00	
Project Management	″	Yes					4				2,400.00 700.00ea.	
Getting the System You Want: A User's Guide to Project Management	″	Yes					6				2,600.00 500.00ea.	
Cost/Benefit Analysis	″	Yes					4				2,400.00 700.00ea.	
Decision Tables	″	Yes					4				800.00 200.00ea.	
Designing Effective Programs: Programming Logic & Techniques	″	Yes					5				3,000.00 700.00ea.	
Assembler Language Coding (ALC)	″	Yes					16				3,300.00 250.00ea.	
ANS Cobol Essentials	″	Yes				6					3,000.00 600.00ea.	
ANS Cobol	″	Yes				16					3,000.00 200.00ea.	

TOPIC	ORGANIZATION	TV Tape	Audio Tap	Slides	Filmstrip	Film 16mm/8mn	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
ANS Cobol Programming Efficiencies	"	Yes					4				1,600.00 500.00ea.	
Report Writer/ANS Cobol	"	Yes					4				1,200.00 300.00ea.	
Report Program Generator (RPG)	"	Yes					12				3,600.00 300.00ea.	
Fortran	"	Yes					5				1,500.00 300.00ea.	
Mastering PL/1 for The Optimizing Compiler	"	Yes					16				5,000.00 350.00ea.	
1400 Autocoder/IOCS	"	Yes					11				3,300.00 300.00ea.	
Structured Programming	"	Yes					6				3,500.00 700.00ea.	
Univac 1108 Assembler Language	"	Yes					16				4,800.00 300.00ea.	
BASIC	"	Yes					4				1,200.00 300.00ea.	
OS Concepts & Facilities	"	Yes					3				12,00.00 400.00ea.	
OS Systems Control	"	Yes					5				2,000.00 400.00ea.	
OS MVT Dumps (Debugging) I	"	Yes					4				1,600.00 400.00ea.	
OS MFT Dumps (Debugging) II	"	Yes					4				1,600.00 400.00ea.	
OS System Service Programs	"	Yes					4				1,600.00 400.00ea.	
OS Data Management/ Sequential	"	Yes					8				2,100.00 300.00ea.	
VSI Planning Seminar	"	Yes					5				2,000.00 400.00ea.	
Virtual Storage Concepts	"	Yes					2				1,000.00 600.00ea.	
VSI Concepts & Facilities	"	Yes					4				2,000.00 600.00ea.	

TOPIC	ORGANIZATION	TV Tape	Audio Ta	Slides	Filmstrip	Film 16mm/8m	Number Modules	Manual/ Workboo	Cost			Miscellaneous
									Rental	Preview	Purchase	
VS2 Concepts & Facilities	″	Yes					4				2,000.00 600.00ea.	
VS1 JCL	″	Yes					5				3,000.00 700.00ea.	
VS2 JCL	″	Yes					5				3,000.00 700.00ea.	
VS System Service Program-Utilities	″	Yes					3				1,600.00 600.00ea.	
VS2 Dumps	″	Yes					6				3,600.00 700.00ea.	
MVS/JES2 System Control Statements	″	Yes					6				3,600.00 700.00ea.	
DOS Concepts & Facilities	″	Yes					3				900.00 300.00ea.	
DOS JCL	″	Yes					6				1,800.00 300.00ea.	
DOS/VS Concepts & Facilities	″	Yes					3				1,500.00 600.00ea.	
DOS/VS System Control Statements	″	Yes					6				3,000.00 600.00ea.	
DOS to OS Planning		Yes					5				1,500.00 300.00ea.	
Computer Operator Training-I/O Devices ″		Yes					10				3,000.00 300.00ea.	
Computer Operator Training - 370 I/O Devices	″	Yes					6				2,400.00 400.00ea.	
OS System Operator Training	″	Yes					8				2,400.00 400.00ea.	
OS HASP	″	Yes					4				2,000.00 500.00ea.	
DOS System Operator Training	″	Yes					10				3,000.00 300.00ea.	
VS1 System Operator Training	Advanced Systems Inc.	Yes					7				3,000.00 500.00ea.	
VS2 System Operator Training	″	Yes					7				3,000.00 500.00ea.	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Systems Design & Analysis Series	"	Yes					6				4,200.00 700,00ea.	
Minicomputers: Cost Effective Computering Power (SDA)	"	Yes					2				1,000.00 700.00ea.	
Production & Inventory Control	"	Yes					9				3,000.00 350.00ea.	
Material Requirements Planning	"	Yes					6				2,100.00 350.00ea.	
Capacity Planning & Shop Control	"	Yes					5				3,000.00 700.00ea.	
Purchasing: Management & Techniques	"	Yes					6				3,600.00 700.00ea.	
Introduction to Numerical Control	"	Yes					12				4,800.00 450.00ea.	
Introduction to Materials Science	"	Yes					16				5,200.00 350.00ea.	
Gas Metal Arc (MIG) Welding		Yes					12				3,000.00 250.00ea.	
The Lee Dubois Course in Creative Selling	"	Yes					17				10,000.00 715.00ea.	
The Fred Herman Planned Creative Selling Program	"	Yes				12					4,800.00 500.00ea.	
Professional Police Training	"	Yes					10				1,125.00 200.00ea.	
Cleaning Services Training	"	Yes					5				950.00 200.00ea.	
Introduction to Calculus Profs. R. H. Niemann & R. Woolley	Colorado State University, College of Engineering	Color					19-1hr	Yes			90.00 per person	
Engineering Economy Sanford B. Thayer (Prof.)	"	Color					10-25min.	Yes			60.00" "	

TOPIC	ORGANIZATION	TV Tape	Audio Tape	Slides	Filmstrip	Film 16mm/8mm	Number of Modules	Manual/ Workbook	Cost			Miscellaneous
									Rental	Preview	Purchase	
Fundamentals of Vacuum Technology Profs. R. M. Anderson, Jr. & P. J. Wilbur	"	Color					20- 15min.	Yes			90.00" "	
Manufacturing Quality Control Sanford B. Thayer	"	Color					10- 30min.	Yes			51.00" "	
Designing with Microprocessors Prof. Thomas A. Brubaker	Colorado State University, College of Engineering	Color					16-30min	Yes			100.00" "	
Digital Subsystems	"	Color					16- 30min.	Yes			65.00" "	
Network Analysis and Design in the Frequency Domain	"	Color					20- 40min.	Yes			100.00" "	
Semiconductor Memories Carl W. Wilmsen	"	Color					11-1hr.	Yes			75.00" "	
Microprocessor Technology & Applications Prof. Michael Andrews & Eugene R. Fischer	"	Color					39-1hr.	Yes			200.00" "	
Personal Money Management Prof. J. A. Hoeven, T. E. Bailard and D. L. Biehl	"	Color					12-50min	Yes			56.00" "	
Financial Planning for Retirement	"	Color					20- 50min.	Yes			56.00" "	
The Management of Technological Innovation	"	Color					6-45min.	Yes			275.00" "	
Time Management	"	Color					6-40min.	Yes			28.00	

THE UPDATING PROCESS

By
Samuel S. Dubin
The Pennsylvania State University

July 1, 1977

This paper is one of the six prepared in response to a request of the Science Education Directorate of the National Science Foundation as part of its consideration of current and possible future activities in continuing education in science and engineering. Any opinions, findings, conclusions or recommendations expressed herein are those of the author and do not necessarily reflect the views of the National Science Foundation.

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During the working years of a professional man or woman, roughly between the ages of 25 and 65, a critical issue is whether he or she can maintain a high level of competence against the eroding effect of the passage of time. Scientists and engineers are especially threatened by the potentiality of becoming outdated in their skills and their knowledge. It is not enough for workers in these fields to maintain the competence acquired in the years of formal education. Their information bank is anything but static; the norm is perpetual change. Scientists and engineers have no choice but to plan for a life of continuous self-education and self-renewal by keeping abreast of new developments and new knowledge which are constantly being generated by research.

Keeping current with new developments in science and technology is what we refer to as *updating*. The reverse of updating is *obsolescence*. In order to understand the necessity for updating, we shall first look at the causes and effects of obsolescence.

OBSOLESCENCE

What Does Obsolescence Mean?

Up until the present time only descriptive and operational definitions of obsolescence have been advanced. Comparatively little experimental work has been done in this field. Most of the inquiry and literature to date have come from engineering, management and medicine. However, several investigators have focused on factors underlying obsolescence. Shearer and Steger (1975), Burack and Pati (1970), and Shumaker (1963) have defined obsolescence in terms of a reduction of efficiencies of performance over time. According to Shearer and Steger, a person is obsolete to the degree that, relative to other members of his profession, he is not familiar with or is otherwise not competent to apply the knowledge, methods and techniques that are generally considered to be important by members of his profession Burack and Pati found that obsolescence exists when there is a discrepancy between job needs and managerial or professional capabilities as a result of innovation, or when the knowledge and skills of a professional are not sufficient to accomplish his job. Shumaker describes obsolescence as a reduction in technical effectiveness resulting from a lack of knowledge of the new techniques and of entirely new technologies that have developed since the acquisition of the individual's education.

In the field of engineering, Zelifoff (1969); Mali (1970), and Siefert (1964) use the word *obsolescence* to mean the erosion of the applicability of knowledge. Zelikoff analyzed catalog course offerings for five engineering colleges from 1935 to 1965 at five-year intervals. By identifying courses that were dropped and courses that were added, he developed engineering erosion curves for five areas of engineering. Figure 1 shows the potential obsolescence of knowledge in electrical engineering as measured by the number of course additions and deletions in the curriculum. The steeper curves in the later years represent the rapid increase in technological advancement. For example, for the class of 1935 the percentage of applicable knowledge in 1965 is about 5%; for the class of 1960 it is about 55%.

Another approach to the definition of obsolescence has been advanced by Mali in the form of an obsolescence index (OI):

$$OI = \frac{\text{current knowledge understood by engineers}}{\text{current knowledge in the field}}$$

This equation is based on the rate of change versus time. A high rate of technological obsolescence is related to a high rate of growth. The growth curve expresses the exponential rate of technological obsolescence. Siefert defined obsolescence for engineers as the measurement at some point of time of the difference between the knowledge and skills possessed by a new graduate of a modern engineering curriculum and the knowledge and skills actually possessed by the practicing engineer who may have completed his formal education a number of years ago.

Ferdinand (1966), Norgren (1966), and Mahler (1965) found several types of obsolescence for the purpose of identifying the nature and causes of obsolescence among engineers and scientists. Ferdinand described three types: professional (professionally obsolete independent of competence in his own area of specialization); areal (one whose technical skills in present area of specialization are no longer sufficient to the present state of the art); and ex officio (technical skills and knowledge impaired when engineer or scientist becomes a manager). Norgren classified the major types of skill obsolescence as technology-based and product-based.

The foregoing definitions of obsolescence have relied chiefly on the idea of discrepancy. Thus they do not take into account the multidimensional character of the condition of being obsolescent or obsolete. Mere identification of deficiency in the knowledge and skills of an individual does not provide an understanding of the dynamics of other factors such as attitude or motivation. These factors may indeed be critical in instances where skills and knowledge are sufficient but where individuals still perform in an obsolescent fashion (Hinrichs, 1973).

In the section on the updating process, we will expand upon the wider dimension of factors involved in the problem of obsolescence, as motivation and organizational climate.

Estimating the Size of the Problem

From the limited data available, it would appear that concern about creeping obsolescence may be widespread within the community of scientists and engineers. Ironically, it is they themselves who generate the vast quantity of new information which daily contributes to the

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PAGE 169 - FIGURE 1 - EROSION CURVES OF ELECTRICAL ENGINEERS FROM SELECTED GRADUATING CLASSES - REMOVED DUE TO COPYRIGHT RESTRICTIONS short "half-life" of their previously acquired knowledge. For example, the number of entries in *Biological Abstracts* rose from 40,000 in 1957 to about 140,000 in 1976. *Chemical Abstracts* published about 244,000 in 1967 (Glass, 1970) to 390,000 in 1976.

The size of the problem still can only be estimated rather than stated in exact figures. Estimates to date have been generally based on interviews and questionnaires which solicit opinions of professionals and their supervisory technical managers in regard to self-perceived obsolescence and updating needs The Stanford Research Institute (1968) estimates that approximately one in five engineers and one of fifteen scientists may be affected by job assignment obsolescence. More seriously, the report estimates that more than half of the engineers and a quarter of the scientists may be professionally obsolete. Scientists and engineers engaged in R&D work are most likely to be current in their fields while production engineers are likely to be most obsolete. Data collected by Raudsepp (1970) on 690 engineers and managers indicates that 25% consider technical obsolescence a serious problem. Three-fourths of his sample recognized that a problem of obsolescence exists. In Ritti's (1971) study, 41% of the engineers felt they were "only fairly well" or "not at all" up-to-dae. Only 7% saw a "significant" problem in the obsolescence of technical skills among their fellow professionals He reported the reasons given by engineers for causes of obsolescence of technical skills: work assignments do not require knowledge of the latest developments, 51%, the press of schedule demands leaves no time or energy for further study, 43%, work is so specialized that the broader base of knowledge is unused and forgotten, 40%, developments in the field are coming so rapidly that it is very difficult for anyone to keep up, 30%; lack of interest in the technical end of their work, 26%; managerial duties require little knowledge in depth of new technical developments, 20%.

Technological obsolescence was one of the twenty-five critical scientific issues facing the country in the opinion of seventy-eight respondents who are presidents and directors of major technological industries, members of an NSF Industrial Panel on Science and Technology. This finding was reported by the National Science Foundation Board (1976) in a publication entitled *Science at the Bicentennial*. In the same survey the NSF found that directors of fifty-five government laboratories rated continuing education of older scientists and engineers as one of two priority needs in order to maintain vitality in the research system.

Lest it be mistakenly assumed that scientists and engineers are unique in being afflicted by obsolescence, parallel investigations of other occupational groups also reveal tendencies toward becoming obsolete in their skills and information. Lindsay, Morrison, and Kelley (1974), in an excellent study of physical educators, found that, in the five areas of knowledge being tested, more than three-fourths of the teachers fell below the minimum score established by experts Obsolescence in the medical profession was the subject of a report in the New York Times (December 18, 1975) which gave the results of a fifty item test on the National Antibiotic Therapy Test administered by closed circuit television to 4,513 practicing physicians. Half of the doctors scored 68% or less on the test The highest scores were achieved by the most recent graduates of medical schools. Those who had been out of medical school for five years or less scored an average of 70% correct Doctors with six to fifteen years of practice averaged 68%. Those who had been in practice more than fifteen years averaged 62% correct.

As for measuring the size of the problem in terms of cost, precise figures are difficult to come by. Yet Branscomb (1973) does attempt to assess numerically the capital value of scientists and engineers and the cost of obsolescence of technical staff. "We do know that the graduate education a new Ph.D brings his first employer costs the individual and society upwards of $50,000. But this asset becomes small in comparison with the employer's own investment in the individual in a few years. Viewed as a possible liability, the technical man with forty years of employment ahead of him will cost somebody something approaching a million dollars before he retires. It is clear that the cost of allowing the individual to lose his capabilities and his confidence is both a tragedy and a corporate waste. Furthermore, the cost of maintaining the employee's vitality—even by formal training comparable to a second Ph.D., if it is necessary—is a small price to pay in comparison with the cumulative salary obligation of (the) employer."

Detecting Obsolescence in Individuals

Given the apparent widespread threat of obsolescence which hovers over professionals in scientific and technological work and the vast waste in money, time and talent of individuals, their employers, and society presumably, which is incurred in the decrement of their competence by obsolescence, it is obvious that a good detection device for obsolescence would be a helpful invention. No such accurate invention exists at the present time.

The present most commonly used method of detecting obsolescence is the performance appraisal by the supervisor of the competence of individuals under his supervision. It is assumed that the appraisal will be made on the basis of observation of the individual at work, and the product of his work, as well as on the basis of open interviews or discussions. The appraiser should be able to detect weaknesses as well as strengths, to detect gaps in information or decrement in other aspects of competence of the individual being appraised. The presumption is that the supervisor himself is well abreast of new developments and that he has the insight and objectivity to note symptoms of obsolescence in the early stages.

Malmros (1963) suggested five signs of obsolescence in the professional engineer: he became less and less inclined to apply rigorous mathematical techniques to obtain solutions to his problems, he encountered increasing difficulty in reading new technical papers and felt frustrated because he could not follow the mathematics, new technical concepts were confusing to him, new tasks and assignments began to look too difficult to be practical; and contemporaries did not seek his advice. Burack and Pati (1970) pointed out to managers some danger signals that should alert them to obsolescence in themselves. Conditions indicative of managerial obsolescence: lack of awareness of change, lack of aptitude to learn, outdated education, lack of motivation for self-education because of age and low level of aspiration, desire to maintain status quo, lack of broader education for the development of conceptual skills, and failure to perceive potential future change. Roney (1966) reported a number of characteristics associated with obsolescence. rejection of new ideas, lack of flexibility and spontaneity, inability to deal with conflict, resistance to change, making no apparent effort to improve, avoiding goal setting.

Assessment centers offer a systematic approach to judging an individual's promotion potential and job development needs. In the process of assessment of candidates, a portion of the total audit of the individual touches on weaknesses as well as strengths, areas which need development, and degree of "obsolescence threat."

Symptoms of obsolescence appear not only in the decrement of knowledge and skills but behaviors and attitudes. Both the nominal grouping technique (Delbecq et al., 1975) and the critical incident technique can be used to elicit honest responses from individuals on specific attitudes and behaviors which they possess. The author has used the nominal grouping technique with the faculty of a two-year community college to identify signs of obsolescence in the faculty. Symptoms of obsolescence proffered by faculty members, working in discussion groups, were revealing and hit close to the heart of the real situation at the college. Some sample items: lack of knowledge of new technical developments, reluctance to read professional journals, lack of interest in advanced study, failure to use innovative teaching methods, lecture notes retained and used unchanged for an excessive length of time, the same exams used over and over. Kaufman (1973, 1974) has used the critical incident technique to identify cognitive and motivational aspects of obsolescence. Loss of technical ability and information are classified as cognitive; lack of interest and drive, motivational.

Measuring Obsolescence

No one has as yet devised an exact quantitative measure of obsolescence in individuals. Measuring obsolescence in any given individual must be attempted in a less than mathematical way. One method involves the use of questionnaires in which the individual assesses his own deficiencies as he perceives them. Using this self-perceived approach, the Department of Planning Studies in Continuing Education at The Pennsylvania State University has carried out a series of studies over the past ten years. These studies centered on the self-perceived educational needs of several professional groups in mid-career. Based variously on state and national samples, the researchers studied engineers (Dubin and Marlow, 1965), natural resource managers and scientists (George and Dubin, 1971); solid waste engineers, consultants and managers (Dubin and Regan, 1977); managers in business and industry (Dubin, Alderman and Marlow, 1967) and physical educators (Lindsay, Morrison and Kelley, 1974).

In addition to providing data on their professional background, education, employment, job responsibilities, and so on, respondents were asked to give information regarding their attitudes toward the need for updating, the factors that motivate them to keep abreast of new developments, methods they use to keep up-to-date, etc. Each professional group was provided with a list of some 50 to 60 areas of knowledge specific to its own field. Respondents were asked to estimate the extent of their personal updating needs in each area. In the final section of the questionnaire, respondents were given the opportunity to write in the specific courses they would like to include in a personal self-development program of study. Analysis of the data collected in these studies showed that mid-career professionals of all groups perceived considerable need for updating, but invariably there were numerous factors which interfered with the attainment of this goal: lack of time, family priorities, distance from school, no reward for getting an additional degree, job did not require further education.

Another method of assessing obsolescence is measuring the up-to-dateness of specific knowledge by objective tests. Dubin and Cohen (1970) developed a preliminary test for measuring and evaluating quantitative competency of industrial engineers. Analysis of a sample of 40 engineers identified their weakest areas in mathematics. The year in which the engineering degree was received made a difference on the test score. The more recent the degree, the higher the test score. Engineers with higher graduate degrees performed better than those with undergraduate degrees.

The objective test method has been little used in assessing the information of engineers and professionals in science. However, it has recently been adopted extensively in the profession of medicine. Rosenow (1971) reported the results of a 700-item objective test of medical knowledge. Physicians out of school less than five years scored the highest; those between five and fifteen years scored slightly lower. Physicians who graduated before 1956 consistently received somewhat lower scores. Medical specialists, however, scored higher than nonspecialists, irrespective of their date of graduation. As a consequence of this experiment in testing, about ten

Figure 2.—Technical Knowledge and Skills

Person Being Rated ______________________ Section ____________

Being Rated By (check one) Self _____ Co-Worker _____ Supervisor _____

Scale	Description
Very High 2.00	Up-to-date in the technical aspects of his field; has extensive knowledge of latest processes and procedures; generally knows what is going on in related technical fields.
1.75	Could be expected to have a continuing program of education that keeps him current with the full range of newer technologies in his discipline. Knows and applies technical advances and practices in his field.
1.50	Could be expected to become proficient rapidly in the new work activity with a minimum of instruction because of his relative up-to-dateness.
1.25	Could be expected consistently to apply the state-of-the art techniques and processes in his present job.
1.00	Up-to-date in the current technologies and skills required for his present job.
.75	Could be expected to perform adequately on current job but with some recognized deficiencies in newer technologies.
.50	Could be expected to perform adequately on routine and formulated jobs but will require technical assistance when working on anything that involves use of new techniques.
.25	
.00 Very Low	Strong need for technical updating to perform adequately on the job.

medical societies have initiated self-assessment tests. The anticipated outcome of this self-assessment approach in medicine may be to reduce pressure for relicensure and recertification by federal agencies who intend to require some indication of competency in order for a physician to participate in federal health programs.

In an effort to get closer to objectivity in the measurement of a worker's technical knowledge and skills relative to the state of the art—the degree to which he is current or obsolescent—Dubin (1975) developed a behavior-anchored rating scale (Figure 2). The behavior-anchored scale satisfies three criteria: the dimensions are well-defined for the rater, the behavior-anchor points adequately define the response categories of the scale, and the response made by the rater is well-defined. Such a scale, used by supervisors as part of the professional appraisal, facilitates grouping of individuals or making comparisons between them as to behaviors indicative of obsolescent tendencies, calling attention explicitly to weakness in the area of updating in technical personnel.

Causes of Obsolescence

The causes of obsolescence are many, and a number of interacting factors appear to be involved. These may be divided initially into two groups: those pertaining to and arising chiefly from the individual himself, and those which pertain to what can be described as his work environment, causes which arise from situations external to the individual.

Individual Aspects

Within the sphere of the individual, there may be several sources of obsolescence. Obsolescence may arise from physical causes. The physical aspect of obsolescence is not within the province of this paper. Premature aging or other pathological conditions would have to be passed on to the gerontologists. But it should be added immediately that the decline of competence in professional persons which often accompanies the passing of years is not inevitable or necessary except in the presence of ill health or other extreme debilitating conditions.

The other aspects within the individual sphere are the cognitive and the motivational aspects (Kaufman, 1973). It is within these two areas that we are delving to find our causes of obsolescence. Briefly, the cognitive aspects comprise two bodies of skills and knowledge—those which the individual has already acquired in the past, and those which remain to be acquired in the present and future. If the individual is obsolescent he may not retain or review that material he has learned in the past which is relevant in the present. Or he may be remiss in his efforts to keep abreast of new knowledge and skills. Within the rapidly changing technological scene, today's competence will not enable the professional to work effectively on tomorrow's project. In a study by Mali (1970) 50% of the engineers in his sample were unaware of new developments. Thompson and Dalton (1976) point out that while knowledge is being produced at a dazzling rate, our ability to collect and transmit information is also increasing. Thus we may conclude that individuals who are not keeping current in their fields are failing to make use of the enormous assistance available in the new systems for retrieving and transmitting information.

As for the motivational aspect, there is little doubt that a major factor underlying an individual's obsolescence is his lack of motivation in maintaining and improving his competence. Motivational characteristics which impinge on obsolescence are lack of interest, lack of drive, lack of curiosity about new developments, lack of interest in solving new problems, lack of motivation for self-education because of age and low level of aspiration, satisfaction with status quo. The central role of positive motivation and positive reinforcement in combatting obsolescence and promoting updating activity will be discussed at greater length in a later section.

Some professionals are made obsolete by conditions external to themselves which constitute the extended work environment, and with which they have not been altogether successful in coping. Chief among these conditions which produce individual obsolescence are the rapid rate of change and the generation of vast quantities of new information in current scientific and technical fields.

Rate of Change of Knowledge

Precise indexes for evaluating or predicting the rate of change or decay of technical knowledge do not exist at present. We have for the most part only educated guesses about the half-life of information in various technical and scientific areas.* Lukasiewicz (1971) estimated that while the half-life of the 1940 engineering graduate's knowledge was twelve years, it had shrunk to five years for the 1970 graduate. Armer (1976) estimated that the half-life of computer knowledge is five to ten years. Bromley (1971) in a National Academy of Science report assigned a half-life of eight years to a physics paper. Rosenow (1971) of the American College of Physicians gave a half-life of five years to a medical internist's knowledge. Hozid (1969) attributed a half-life of five years to knowledge in dentistry. Mali (1970) developed an obsolescence index for engineers, defining it as the ratio between current knowledge as understood by the practitioner and current knowledge in the field. Using the index he reported that approximately 50% of engineering practitioners met half of the model's criterion of up-to-dateness.

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* In this context, we borrow from physics the phrase half-life, applying it to information. For example, a half-life of five years means that after five years a given body of information is only 50% applicable.

Dubin (1972) estimated that a psychologist's half-life of knowledge averages 10 to 12 years. Chaphanis (1971) calculated that a compulsive well-read engineering psychologist would have to read 30 to 40 articles and reports a day merely to keep abreast of current literature in his field. A degree obtained in 1960 would provide less than one-half of what the average technical graduate would need to know in 1970 (Mueller, 1970). Glass (1970) stated that a scientist must constantly review his knowledge or he would be beyond hope as a teacher or practitioner in approximately eight years. Even more rapid rates of decay of information have been suggested in microbiology and in the completely new fields of bacterial genetics and genetic engineering.

An enlightening example of the rate of change in technical information is provided by Rosenstein (1968). He stated that the rate of curriculum revision in an undergraduate electric circuits course is five years. While Ohm's Law does not change, course philosophy and analytic methods are changing, and changing with increasing frequency. He describes the sequences of changes. "In the early 1940's, electric circuits were usually presented in two courses, one giving d.c. circuits and the other steady state a.c circuits. By the late 1940's, transform theory was introduced to provide the first major change and to give a simultaneous treatment of steady state and transient conditions. The course changed again when circuit synthesis techniques found their way into the curriculum shortly thereafter. Additional major revisions followed as the methods of signal flow and then of state space were introduced. The specialized course in electrical circuits is now yielding to the unified treatment of lumped parameters. The impending computerization of linear, lumped parameter analysis provides the sixth major revision in twenty-five, resulting in an average turnover of one every five years."

Zelikoff's study of curriculum obsolescence, cited earlier (Figure 1), provides additional quantitative evidence of the erosion of knowledge in five fields of engineering—electrical, aeronautical, chemical, civil, and mechanical. In 1965, thirty years after graduation, only 10% of an aeronautical engineer's information was applicable. For the chemical engineer, applicable information stood at 15%, for the electrical engineer the figure was 5%. Five years after graduation, the 1960 aeronautical engineering graduate's applicable knowledge retained from school was 40%, the chemical engineer's, 40%; and the electrical engineer's, 60%.

Much needed today are refined and current appraisals of the half-life of knowledge in specific subject areas in science and engineering. Such data would be useful in determining the rate of change in these areas and provide warning signals to those which require accelerated retaining or further education programs.

Management Policies and Practices

Most professional scientists and engineers spend their working years within an environmental structure which is an organization. Unfortunately, many professionals are made obsolete by the organizations in which they work. An organization's policies and practices are not set up necessarily to promote the professional careers of its employees. On the contrary, for the purposes of the organization a professional may be kept obsolete by the limited demands and rigid controls that prevent him from enlarging his scope. An engineer may be required to specialize to the point where he operates on a low level of use of his technical knowledge. On the other hand, an organization with more enlightened management may see a long-term cost/benefit in promoting the updating and professional development of its highly qualified workers. Mutual expectancies between the individual and the organization can create or combat obsolescence. This is what Levinson (1971) calls the "psychological contract". "What the person expects from the organization, his experiences dealing with the organization, and how much he trusts the organization for need fulfillment influences his updating."

One of the most common organizational practices which leads to obsolescence is the underutilization of skills. This combines both light intellectual demands and light time demands (Ritti, 1971). According to Mali (1970), half of the work assignments of engineers were within the range of a technician's capability. More importantly, obsolescence occurs from the motivational correlates of underutilization: general lack of interest, boredom, lack of sense of purpose and commitment to the job, frustration at not using one's capabilities to the fullest, alienation and focusing on other sources of gratification. Tingey and Inskeep (1974) cite the underutilization of professional qualifications as a major cause for job dissatisfaction.

The pattern of misutilization differs from underutilization in that it combines light intellectual demands with heavy time pressures. In this case, professionals work under severe time limitations at assignments so routine or trivial that they could be done by a clerk or low level technician (Ritti, 1971). However, time pressures are such that "you have to produce like a machine." There is no time for making changes, for innovation, for making an elegant solution, for a better way to do the job.

The management practice of overspecialization is conducive to obsolescence in the specialist. When a person is kept in the same assignment for an extended period he tends to develop a narrowness of outlook and narrowness of expertise which poorly equips him for other or broader assignments in the future. Further, task specialization can lead to boredom, and apathy in regard to professional updating in a wider range than his speciality. So called functional or organizational obsolescence occurs when the professional is cast in a function which he has performed over a period of time and which is no longer required by the organization (Miller, 1974).

Management practices in handing out rewards, incentives and recognition, or the lack of these, can have adverse rather than positive effects on professional employees. If there is little reward or recognition forthcoming when a person attempts to investigate new lines of thinking, to innovate in a product or system, there will be little incentive to update, to read widely or deeply in the field. In short, the horizon shrinks; employees will take the line of least resistance. Obsolescence sets in.

One of the most frequent complaints of professionals in industry is the lack of time allocated in the budget of work time for updating—reading professional journals, taking courses, interfacing with other professionals in the same organization and others. This is an integral ingredient of career planning. Furthermore, professionals would like to see their work assignments as compatible with and in line with their abilities, interests and career goals; where company and individual goals conflict, the former is apt to win out and the employee becomes a good candidate for obsolescence George and Dubin (1971) recommend that 20% of a professional's time should be allocated to updating.

There is often a built-in bias for youth in the making of job assignments The technical manager may frequently deal out the most challenging job to a young professional, a more recent graduate with up-to-date knowledge and skills (Miller, 1974). Senior professionals are thereby deprived of a fresh chance to expand, update themselves to meet the challenge. Instead, they are pushed a little further in the direction of being topped out or obsolete.

Recent Evidence on Age in Relation to Obsolescence

The recent finding by Price, Thompson and Dalton (1975) concerning age in relation to obsolescence has contributed significantly to a change in understanding of the competence of older engineers. A previous study by Dalton and Thompson (1971) had reported that the engineer's performance as measured by supervisory ratings peaked in the early or middle thirties. Pelz and Andrews (1976) had set the peak in the forties. In the new study by Price et al., a longitudinal instead of the earlier cross-sectional study was carried out in which engineers were grouped in four age categories of ten years: 20–30; 30–40; 40–50; and 50 plus. Within each category engineers were subdivided on the basis of performance rankings into three groups of equal size: high, medium, and low performers. The results showed that the high performers in the forty-year age group and the fifty-plus age group have higher average ratings than do the middle and low performers in the younger age groups. The differences in performance are greater within each age group than between them. Those engineers in the top third of each age group were doing an excellent job in maintaining their competence.

What differentiates the higher performers from those with lower ratings? The authors' most important finding was that certain job-related factors as job complexity and challenge were strongly associated with high performance. The individual's performance rating correlated more directly with his type of work assignment than with his participation in college or in-house courses or reading professional journals This conclusion is a hopeful one because it suggests that obsolescence is not inevitable and that age is not a major determinant of performance differences.

THE UPDATING PROCESS

A Model for Updating

During the past two decades professional updating in engineering and science has increasingly become a topic of concern. Behind this emerging concern are two pressures. the growth of specialized knowledge and the state of environmental flux in contemporary organizations. Environmental flux. according to Hinrichs (1971), "is evident in the increasing complexity of current technologies and organizations, the changes taking place in our society, and the many ambiguities faced by decision makers in our society. High levels of skills, broad perspectives, flexibility and competence in the leading edge of the appropriate technology are the hallmarks of successful enterprise in today's environment. This implies a need for professional updating."

Updating is a learning process. Learning is basically change. It is a complex growth process facilitated by numerous factors, among which the most important are motivation, meaningfulness, reinforcement, generalization, participation, coaching, experience and feedback of results. Updating is a dependent variable resulting from a combination of psychological and work environment conditions. In the updating model presented here motivation is the chief psychological component. But an individual's motivation is strongly influenced by his work environment. In the context of our model, work environment is described as consisting of five components: organizational climate, the work itself, managerial subordinate relationships, colleague interaction, and management policy. It is assumed, therefore, that all these factors in the work environment will have some impact on the learning process which is updating (Dubin; 1974, 1972a,b,c.).

The reverse of learning is obsolescence. Obsolescence is a decremental process comprising both the loss of acquired learning and the non-acquisition of new learning. This retrograde process occurs unless effort is consistently made to repair erosion and to stimulate growth.

Definition of Keeping Up-to-Date

When we speak of keeping up-to-date in one's profession we refer to such behaviors as making use of current concepts, practices, theories and points of view in both one's field and allied fields which bear on the work of one's organization. Keeping up-to-date also means being familiar with what others in the same field are working on, what problems they are trying to solve; what approaches to solutions they are taking (NSF, 1969). This definition requires that the professional be conversant with the latest technological developments in his field and that he be able to use recently developed techniques to solve problems assigned to him. It assumes that he has not overlooked significant implications nor neglected significant facts arising from his work. Being current in his field enables him to translate theory into practice. He is capable of detecting new features in an environment and of responding to them effectively.

In summary, we describe the updated professional engineer or scientist as showing the following behaviors: keeps current with advanced technology and knowledge in his field; effectively organizes and applies his knowledge in the performance of his work; is current in recent developments outside his special field; uses all available sources of information in reaching decisions; provides information that is accurate and reliable; contributes ideas relating to activities outside his immediate responsibility; demonstrates ingenuity in solving problems and seeks methods and means of continuously improving his proficiency.

Self-Motivation for Updating

Most engineers and scientists, especially those engaged in R&D work, are aware that keeping current with new technology and information is essential for maintaining professional competence. Only a minority of highly-trained professionals hold the opinion that the idea of rapid obsolescence in scientific and technological skills and knowledge is being overplayed (Dubin, 1975). Recognition that there is a problem—that knowledge is a perishable commodity—is the first step in the diretion of updating.

The individual's motivation to update is a corollary to his motivation to perform well. Generally speaking, the same motivators which spur him to improve his performance are those which motivate him to update. Some of the behaviors which are recognized as motivators are: interest and curiosity, achievement need, advancement, challenge, recognition, autonomy, and responsibility. These can be classified as intrinsic or self-motivators arising from the individual's personality and personal needs, as distinguished from extrinsic or external motivators which arise from outside the individual, or, in this case, from the work environment Motivational factors arising from the work environment will be considered later.

It should be pointed out that while motivation is undoubtedly an important variable in updating behavior, only a few motivation studies have been made to date which relate directly to updating *per se*.

The close parallel between the motivation to perform well and the motivation to update is evident in responses by scientists and engineers themselves in answer to the question: What motivates you in your work?

The most frequent answer is: a challenging problem (Marqulies and Raia, 1967). Why? Because it arouses curiosity and interest. It has not been solved. Little information is readily available about it. It requires an innovative solution. It is on the leading edge of knowledge. It can lead to new technological output. It means freedom to explore, carry out my own ideas and initiative (Dubin, 1975). Obviously, the person who wishes to tackle a challenging problem for these reasons is one who needs and desires to keep himself current with the frontier of knowledge in his field.

Shearer and Steger (1975) investigated six dimensions of motivation in relation to keeping up-to-date. Five of the six hypotheses were confirmed.

1. The higher the career expectations, the less obsolescent the person.
2. Individuals who perceive a duty to stay current spend more off-work time in updating activities in their field.
3. People with a future time orientation spend relatively more time off work keeping up-to-date.
4. High achievement need influences behavior to prevent or retard obsolescence.
5. People with strong beliefs that they control their future have an orientation which tends to prevent obsolescence.

The Expectancy Theory of Motivation

The expectancy theory of motivation postulates that motivation consists of a complex combination of individual judgments concerning the accomplishment of job goals and the immediate rewards or outcomes gained from these goal accomplishments. It has practical application to the updating process. It is a theoretical model of personal motivation which sees an individual as behaving primarily as a function of the rational forces within him. Applied to work motivation, it conceptualizes man as one who chooses to behave in a way which maximizes his chances of acquiring future desired rewards. As a process theory it attempts to explain relationships among variables in a dynamic state. The theory does not specify the important variables which impinge on an individual to create what is called "work motivation." Rather it provides a theoretical structure to describe any cognitively controlled behavior—within any set of individuals—not just professionals. The most important characteristic of expectancy theory is its flexibility, the result of its process nature.

Another approach to understanding the individual's motivation for professional updating was advanced by Porter (1971) making use of expectancy theory. According to Porter, the professional evaluates different kinds of potential rewards and selects that combination of rewards which is most appealing to him. "From the motivational theory standpoint, this would utilize high valences of outcomes to increase each individual's overall motivation to exert effort in this particular direction—engaged in updating activities." Porter presented a number of provocative hypotheses that require testing: it must be clearly demonstrated to the employee that his effort will lead to effective updating performance; subgoals for updating should be set which are obtainable and identifiable for the individual; organizational emphasis should show that updating is an important activity; the reward value of updating behavior should be enhanced by tying it to other more obvious organizational rewards such as promotion and salary.

Hinrichs (1971) reported the results of the application of two theoretical models of motivation—content and process—to the problem of skills updating in a large technology-based organization. He found that higher-order content needs based on Maslow's need hierarchy model were not substantiated. He concluded that the expectancy process model seemed more predictive of skills updating. "The reward system of the organization is the individual's perception of the outcomes that will accrue to him for updating behavior. This is significantly related to the effort which he devotes to updating." McIntyre (1977) relates how expectancy theory can be applied to updating in three ways. First, the theory dictates that an individual's goals should be elicited from the person himself. The same set of goals should never be assumed to be had by all. If management discovers that a professional is not aware of certain potential goals of the organization, it can intervene and make the goals known to him. Second, the organization must determine the importance . . . of a set of goals and the perceived likelihood (expectancy) of the occurrence of a set of goals by probing at the level of the individual professional. Once again the organization may intervene to try to influence an individual's valence or expectancy of a particular goal. Third, because it is a process theory, it allows the organization to be flexible in its outlook towards its professionals. There is no need to establish a specified set of goals and outcomes for all. At the same time, the theory does not invalidate the existence of a set of common goals. Finally, the organization can use expectancy theory as a tool with which to diagnose the individual's obsolescence. The theory provides the organization a means of asking the important questions aimed at the following logical sequence of theoretical concepts: ultimate goals, instrumentality, valence, expectancies, and behaviors. This is the most valuable aspect of expectancy theory—its ability to stimulate the appropriate set of questions.

Goal Setting

Keeping up-to-date can be stimulated through goal-setting activities. Management by objectives is a mutual goal-setting method used between managers and subordinates. The technique aims to elicit commitment and effort. Locke (1968) has demonstrated that individuals who set hard goals will produce at higher levels of performance than individuals who set easy goals; and that individuals who set specific goals produce at higher levels than individuals who do not set goals or who are told to do "their best." In performance appraisal situations, the process of setting down and formulating mutually agreed upon performances and explicit updating goals may increase effort to accomplish the goal of keeping up-to-date.

Work Environment

The work environment for most professionals is an organization. The climate of the organization in which an individual works can be a positive motivator for updating or it can be a demotivator which ultimately produces obsolete workers.

Organizational Climate

Pritchard and Karasick (1973) redefined organizational climate based on a number of previous definitions: Organizational climate is a relatively enduring quality of an organization's internal environment distinguishing it from other organizations; (a) which results from the behavior and policies of members or organizations, especially top management; (b) which is perceived by members of the organization; (c) which serves as a basis for interpreting the situation; and (d) acts as a source of pressure for directing activity.

Updating behavior by professionals is strongly influenced by the organizational climate in which they work. Organizational and management practices affect motivation, condition attitudes, and shape the behavior of members of the organization (House and Rizzo, 1972). Campbell and Dunnette (1968) have identified a high organizational climate as having some of the following characteristics: (a) achievement—a desire of the group to do a good job and contribute to the performance of the company; (b) concern for excellence—degree to which the group is concerned with improving individual performance, being flexible, innovative and competent; (c) problem-solving emphasis—extent to which the group anticipates and solves problems related to group functioning; (d) reputation—organization reflects status and reputation of individual's work group as compared with other work groups; (e) training opportunities—degree to which the organization provides training for individuals; (f) atmosphere—degree to which supervisors generate a supportive and friendly atmosphere; (g) initial job orientation—individuals are informed of what to expect when they first start on the job.

Organizational climate is a major factor in maintaining the technical vitality of professional workers. Corporate policies and practices as implemented by management create the working environment. The environment can stimulate growth, innovation, and updated professionals, or it can stunt growth and stifle creative effort so that men work at less than their full potential. A vital organizational climate is characterized by high productivity, sense of purpose among its employees, sense of personal opportunity, feeling of accomplishment and excitement. The climate that offers the potential for recognition and reward, openness to change and new ideas, strong contact with new developments, and outside the organization is one which fosters updating (Dubin. 1975).

Management Policy in Updating

A company should have a written policy statement that requires updating for its employees. An example of such a policy statement is that of the Sandia Laboratories (Appendix I). Many companies have educational assistance funds that reimburse employees who complete education courses, but few companies make continuous updating mandatory. In our study of engineers (Dubin and Marlow, 1965), 79% reported that their companies had educational assistance programs, but three fourths of the engineers reported that this availability had no effect in motivating them to undertake additional course work. Similarly, in a study of natural resource managers and scientists (George and Dubin, 1971) 52% indicated that existence of a policy on educational assistance did not motivate to undertake further education. Yet 83% of the same group considered keeping up-to-date important and 80% said that their job performance and job competence increased as a result of participation in continuing education. Only 50% of the natural resource managers and scientists felt that the organization rewarded them for their participation in continuing education. The main reasons given for lack of participation in further education are lack of time, pressures of family and the job, and the fact that the job does not demand more education (Dubin and Marlow, 1965) (George and Dubin, 1971).

W. E. Wilson (1969), a vice president at General Motors, warned that "engineers who ignore the meaning of technical obsolescence become technically obsolete, because then they approach problems with outdated viewpoints, theories and techniques." While he stressed that the individual must be basically responsible for his own development and updating, he pointed out that the employer has an equal responsibility to provide the environment and incentive to encourage the engineer that there is a premium put on up-to-date education. "That premium is going up for the man who is fluid enough to adjust to change. We must make the engineer aware of his needs and help him plan to meet them. We must let one engineer know that his one formal brush with education is not going to be enough and that he should expect to reevaluate continually and reeducate himself two or three times in his lifetime." This is an explicit statement of management policy that specifically shares the burden between the individual and the organization. If technical obsolescence is to be minimized then the organization's commitment to the management of change and development of people must have top management approval and implementation.

Anders (1976), a Texas Instrument personnel man, states his company policy: "The company has specific corporate goals and objectives that it must meet. One of these objectives is to create a working environment where all individuals are motivated to participate in the achievement of company goals through the pursuit of their personal goals to the maximum possible extent."

A. G. Anderson (1973), vice president and director of research at IBM, states a management policy aimed to put new life in R&D:

> "We appear to be entering a period where emphasis will need to be placed on policies which maintain the intellectual vigor of the staff which is in R&D now. Such policies must address the issues of making the organization better through capitalization on its experience and strength while preserving and extending its vitality. Some individuals will not need help to remain intellectually alive. However, thousands of others would be benefited by policies designed to maintain intellectual vitality. Those policies must address issues of individual and group productivity, intellectual receptivity and openness, broad contact with all pertinent science and technology, and continuing efforts to educate and be educated. The growing strength of R&D outside the U.S. makes the mandatory broad efforts to maintain contact on a worldwide basis."

Anderson proposes to do this through: an extensive visitor policy to provide continual contacts with people with new insights and experiences as consultants, faculty, etc.; aggressive efforts through training to keep people up-to-date; special efforts to insure that organizations provide opportunity to ideas and people, and an organizational policy to develop their best men not only internally but externally.

The NSF (1969) report concludes its study of organizational policies and practices by noting:

> The three key points in top laboratory management philosophy of continuing education are: management accepts the responsibility to provide at least some opportunities for scientists and engineers in the R&D work force; management expects R&D employees to keep themselves up-to-date, particularly in their own fields of specialization; and, finally, management accepts only limited responsibility for motivating the individual. Managements which provide opportunities for continuing education believe that those who do not take advantage of them are not worth attempting to salvage. The initiative is left to the individual.

Thompson and Dalton (1976) have formulated a career-stage model in an R&D organization that helps explain the difference between high and low performers at different age levels. A close analysis reveals that the more effective organizations have policies and practices more consistent with the concept of career stages. They identified a number of management policies that have interfered with the updating process and contributed to obsolescence. These are:

Devaluation of the technical contribution of the engineer: "In engineering organizations the reward system is designed to provide an incentive to the brightest people to move out of technical work and into management as fast as possible."

Management structures that overemphasize product planning: "The domination of product planning over career planning contributes to obsolescence. When a project ends engineers find their skills obsolete and unsalable. An obsolete organization is a major cause for creating obsolete engineers."

Cost systems that work against career development.

Inadequate manpower planning.

An organizational approach that facilitates the updating of the personnel is matrix management. Under this dual system each professional has two bosses—a project or technical manager and a functional manager. The technical manager worries about getting the task completed; the other worries about staffing, job assignments, updating of personnel, etc. The functional manager has the responsibility for the career development of the engineers in his group. If a person has been working in a narrow specialty too long, the functional manager has the power to move him into a new area to help him develop greater breadth. This type of management policy does not leave the updating process to chance; it is integrated into a career development program.

Technical Vitality

Miller's (1977) vitality concept is an experiment in management policy to reward updating It has as one of its objectives the redesign of the working environment, the work and rewards to improve the performance of scientists and engineers. Its intent is to improve the capacity of the environment to provide learning and growth opportunities and appropriate rewards for growth. These activities enhance updating and minimize obsolescence. Similarly Anderson's (1973) efforts at IBM to put new life into R&D is directed to the redesign of the organization climate dimension.

Miller (1974) uses the term technical vitality as a shorthand way of describing a set of activities designed to help engineers and scientists become more productive. He describes three combined conditions which affect vitality: rapid advances in technology that lead to a form of human obsolescence; slowed personal growth leading to aging in professionals—which raise questions about the decline in productivity and the need for extending it; reassessment of the value and cost of technological progress—this creates questions about motivating engineers and the quality of an engineering education. He believes that technical vitality is the key to future productivity of scientists and engineers. Further, he describes the technically vital engineer as one who is able to work effectively at the frontier of his field by contributing both to increasing and applying knowledge that improves equipment and systems.

Miller (1977) has revised his thesis for improving productivity and personal commitment by introducing the quality of life concept. He has broadened considerably the use of the behavioral sciences in attacking both productivity and person commitment by emphasizing the psychological requirements of work as: challenge, greater personal decision involvement, continued stimulation to learn, social support in the work environment, and a job that leads to a desirable future. In this context, he defines vitality as the desire and ability to perform effectively and vigorously in life and at work and to derive personal growth and satisfaction from life and work. The force behind this effort is the condition that management is under pressure to improve output and reduce costs and is simultaneously pushing hard for innovation and new products.

Miller suggests that for the engineer to be turned on to his work he must feel a sense of personal contribution and growth. He suggests a series of steps for improving the working environment and commitment to growth and development:

1. Raise the value and priority of continued learning, growth, and personal vitality in the work environment.
2. Find out what causes engineers to grow throughout life and then provide a better growth environment. This may involve the redesign of organizations, changes in styles in management, and rewards.
3. Define professional productivity and describe its elements in a way that makes it possible for engineering managers to talk about it and manage it.
4. Encourage engineers to increase their self understanding so that each individual can maximze both this contribution to organizational goals and satisfaction he derives from [illegible] job.

To accomplish these overall goals, a number of improvement strategies at both the individual and corporate level have been initiated at IBM.

1. Raise the value of personal growth. To accomplish this goal IBM set up two committees: one to obtain management's understanding and involvement in the problem, and second to elicit specific action proposals.
2. Redesign the organizational environment, work and rewards. The intent here is to improve the capability of the environment to provide learning and growth opportunities through job rotation, job redesign, and increasing continuing education offerings based on need.

3. Improve understanding of productivity. Comprehending the productivity of the knowledge worker—the engineer or scientist, is one of the most complex tasks.
4. Build self-confidence and understanding. Increasing self understanding makes it possible for the individual to represent himself more effectively at the interface and negotiate for improved congruence between the individual and the organization.

Miller's program represents some of the most advanced applications of the behavioral sciences to the updating process. It should be watched with great interest by all organizations.

Branscomb (1973) describes two key attributes of a vital technical staff member: adventurous and inquiring attitude, and a sense of professional accomplishment. Other indicators of vitality mentioned are: evidence of intellectual competitiveness with peers, professional activity, and publications; self confidence, as evidenced by vigorous, well prepared defense of ideas; willingness to use good ideas of others; willingness by managers to hire and promote young people who are more able than they are; entrepreneurial in spirit and willingness to take risks as evidenced by courage to bootleg projects; to champion unpopular concepts and be willing to do battle with market forecasters for truly new products. A person whose behavior is similar to the ones described above cannot help but keep up-to-date.

Thompson and Dalton (1976) conclude that in technology-based organizations the most critical factor is the development and maintenance of an up-to-date and motivated work force. They recommend three broad areas in which managers can make improvements and thus avoid an obsolete organization:

1. Reward technical contributions by paying for performance, not position; seek inputs in decision making from scientists and engineers; increase the visibility for contributors by giving recognition for accomplishments.
2. Reduce barriers to movement by limiting tenure in supervisory positions; revise cost accounting procedures so that senior people are not excluded by accounting procedures from working on projects using new technologies; more effective use of lateral transfers.
3. Focus on careers: use matrix organization methods to insure career development; provide semiannual manpower review to assess career professionals; and career monitoring to insure new assignments every four years.

A Challenging Job—Its Relation to Updating

Margulies and Raia (1967) asked research and development scientists and engineers, "What was the most fruitful learning experience you have had over the past year or two?" The most frequent response was on-the-job problem solving (42%). This was described as being assigned to "interesting tasks," "broadening projects," and "writing proposals which force me to dip into the literature and become current on everything connected with the project." When on-the-job activities include challenging assignments, the exploration of new tasks enables scientists and engineers to assess their own knowledge and fill in gaps and deficiencies.

Challenging jobs provide learning experiences that can be interesting, even exciting. They provide experiences of success that play an important role in motivating an individual to keep up-to-date and grow professionally. Responsibility, job involvement, and challenging work assignment all contribute to the first steps in continuing education—awarenes of needs and individual motivation.

Pelz and Andrews (1976) reported some findings about scientists and engineers in their job functions. The more kinds of research and development functions the scientist is engaged in, the better his performance. Maximum performance seems to occur with four to five functions. To stimulate updating and build diversified skills in scientific personnel, Pelz and Andrews recommended: "The next time you need to probe a specialized area, give the job to a man (or a small group) who is working in a related area. Don't give the job to a man who already is a specialist in that area. The man in a related specialty will dig into the field with new zest and excitement. He will develop fresh ideas that experts in the area would overlook."

A challenging and meaningful job is critical to keeping the engineer updated. However, a number of on-the-job conditions, job pressures, and heavy workload—no time allocated in the daily budget for reading journals, etc.—interfere with the professional's ability to keep current in his field, to further his education, and to perform his job more adequately. Engineers who work on routine production jobs express the need for more interesting, challenging, and more significant work. In fact, engineers consistently point out that 50–90% of their work is routine and could be more easily done by a technician (Dubin, 1975). Ritter (1971) reported that the lack of opportunity to perform meaningful work is at the root of widespread frustration and dissatisfaction among engineers.

When engineers were asked to describe various aspects of their job, less than 50% of the engineers agreed with the following statements: my job is technically challenging and broadening; my job makes use of my skills; my job measures up to what I want out of a job; and my job forces me to work up to the limits of my ability (Dubin, 1975).

Bray's (1975) study of AT&T managers reports a significant finding. A challenging job is of great importance to maintaining managerial motivation and serious effort should be made to expand the scope of the manager's job to fit his ability. Jobs which provide challenge, a sense of achievement, responsibility, and accomplishment provide a basis for continuous self-development.

Shearer and Steger (1975) tested three hypotheses relating the work experience of engineers and managers to obsolescence. All three hypotheses were positive. They found that varied job assignment provided opportunities to use and maintain previously learned skills and for increasing a person's exposure to new developments and ideas. The second hypothesis stated: the less a person feels he has used his skills, the more obsolescent he is likely to be. Their findings show that the more a person is willing to invest the time and effort to develop new skills, the less likely he is to become obsolescent. The third hypothesis dealt with participation in decision making. Perceived participation in decision making was found to be the best predictor for keeping current and preventing or retarding obsolescence.

Hackman and Lawler (1971) have utilized job design as a method of enriching jobs Job design refers to a deliberate purposeful planning of a job, including any and all of its structural or social aspects. Job enrichment attempts to make the job more challenging and interesting, by adding the following dimensions: skill variety; task significance; task identity; autonomy and feedback. A professional is motivated to work more effectively on a job that allows him to feel personally responsible for a portion of the work, provides outcomes that are intrinsically worthwhile, and provides feedback on what is accomplished.

Susman (1974) offers four job enrichment suggestions which can contribute to the reduction of underutilization and misutilization of engineers: the partition of projects into modules of subtasks which represents a psychological whole and a contribution which the engineer can identify with; the use of horizontal rather than vertical decision nodes as a means of introducing greater equality in the decision making process; the authority for the supervisor and his subordinates within each module to make appropriate decisions rather than the project manager who is several levels higher; and allowing engineers to participate in decisions before the final design is approved. Such involvement gives the engineer a larger piece of the action in the organization His responsibility motivates him to insure that he maintains his competency in his field.

The Supervisor's Role in Updating

The supervisor or technical manager plays a crucial role in the professional development of his subordinates especially in updating, and continuing education. A study by the NSF (1969) found three separate styles of supervision in R&D organizations employing scientists and engineers. The study classified the supervisors by the manner and degree to which they stimulate and attempt to motivate their subordinates to engage in continuing education:

The "Administrator" is seriously concerned with implementing management policy including policy concerned with continuing education, and tries to arouse the interest of subordinates in whatever employer-sponsored activities are provided.

The "Innovator" is vividly aware of the potency of new knowledge and of continuing education and regards these activities as central to his supervision of others. The Innovator is alert to opportunities to create continuing education activities in addition to pushing those sponsored by management. He is sensitive to the continuing education needs of his subordinate and keenly perceptive of the resources available in the wider community, both which do and which don't fit these needs. His enthusiasm for continuing education is such that he will contrive and create both stimulation and utilize such resources as specific workshops, courses or special seminars. He sees these techniques as a way to keep his staff at the frontiers of knowledge by incorporating the latest available knowledge into easily digestible and accessible form.

The "Inactive" type of supervisor is basically passive and non-committal in his attitudes. Because he conceives of self-development (and continuing education) as a responsibility of the employee apart from the working environment, he neither stimulates subordinates to pursue additional knowledge nor initiates continuing education activities on their behalf. He is aware of, and deplores, the lack of motivation shown by particular individuals, but he undertakes positive action only if the employee takes the initiative and the activity is within the framework of existing policy. He will make pious statements about the desirability of continuing education, but in fact he subscribes a rather fatalistic and resigned view of people and, indeed, of leadership.

Prior to the NSF study quoted above, Dubin and Marlow (1965) reported that 64% of 2,094 engineers indicated that their supervisors took a non-committal attitude towards their education and development. Corroborating evidence of the Dubin and Marlow findings is found in the NSF (1969) study, where almost half of the engineers and approximately one-third of the scientists reported attitudes of non-interest in their professional development by their supervisors. Similarly, 42% of 5,598 natural resource managers and scientists reported that their supervisors were non-committal to their growth and development (George and Dubin, 1971). Landis (1969) in an industrial study of engineers asked, "How does your immediate supervisor feel about further job-directed education and training?" Thirty-seven percent replied, "not encouraging at all"; 47%, "somewhat encouraging;" and 16%, "very encouraging." He concluded that it is the immediate supervisor that counts in the development of subordinates, "If the boss does not encourage a man, he will not take further course work."

Far more serious and frequent are the barriers created by supervisory pressures for immediate results. Daily pressures are stressed to the exclusion of any ability to concentrate on what may be required for tomorrow. Competence is defined with respect to the present, not the future, so that little if any support is given to self-development efforts beyond the employees presently defined technical specialty. Under these working environments, professional obsolescence is virtually certain. Frequently these supervisory practices reflect organizational reward norms, policies to the contrary. Many organizations base rewards on short term results which seem to imply that personal development efforts should occur before joining or at least not on company time (Miller, 1972). These findings would suggest that the pressures of the job as exerted by supervisors may hinder the engineer's self-development even if the organization has a policy to provide educational updating.

Most engineers believe that the development of their professional competence, though basically self-motivated, can benefit from the guidance and support provided by experienced and technically competent first-line supervisors. But many engineers believe that management in its policies and priorities does not place a high enough value on professional developments and career goals of its engineers. In terms of performance appraisal, many engineers feel that their supervisors do not give them a detailed performance review on a regularly scheduled basis to discuss with them their specific strengths and weaknesses.

Engineers proposed numerous suggestions on how supervisors can develop and update subordinates: establish good rapport and provide a supportive atmosphere for the group; establish two-way communications; provide feedback on day-to-day performance; do regular and thorough performance appraisal and coaching; show tolerance of occasional mistakes as part of the learning process; assign jobs that involve added responsibilities and variety, as well as extends the boundaries of knowledge, technology and experience; provide recognition and reward for superior performance; allow participation by engineers in design decisions; give engineers the authority and respect appropriate to his professional standing (Dubin, 1975).

Pelz and Andrews (1976) report a study of 21 small teams in a NASA research center. They report that human relations skills mattered little. Innovations occurred under supervisors who know the technical details of their subordinate's work, could critically evaluate that work, and could influence work goals.

Colleague Interaction and Updating

A stimulating organizational environment which provides opportunities for peers to interact promotes learning, innovation, and the development of ideas. Learning experiences come from interchange with colleagues, discussion with managers and experts, talking with colleagues from other disciplines, or participating on panels and committees.

Colleague interaction is one of the preferred methods of engineers for gaining needed information. Rosenbloom and Wolek (1970) conducted a study on the flow of technical information in engineering and scientific groups in industrial laboratories. They studied technology transfer—how new knowledge that originates in one place gets communicated and used in another place. They found that most information that engineers in industrial laboratories acquire comes to them by word of mouth from colleagues and local sources.

They described two types of professionals working in laboratories, each with different personal characteristics and sources of information. The people who use sources outside the laboratories tend to comprise an easily defined group who publish papers, attend professional meetings, have higher education, and work on more basic problems. They belong to professional organizations and report a lot of oral communications with other professionals employed in organizations outside their own. The other group go to meetings less frequently, rarely publish, and get their information by talking to people in their own location. A person in this group talks to the boss, the man in the next department, to marketing people, and production people. He keeps up-to-date by talking to people in other divisions in his company and by reading trade magazines. The existence of an organizational climate that encourages interaction among colleagues, superiors and subordinates, cannot be overstated for this group. Much learning occurs through informal discussion and consultations.

In the acquisition and transfer of knowledge Rosenbloom and Wolek (1970) report two different modes: the use of interpersonal relationships between knowledgeable persons and the use of professional literature. Engineers rely heavily on interpersonal communication with people in other parts of their own corporation while interpersonal communication by scientists tend to be with individuals employed outside their own corporation. When using documents engineers tend to consult reports in trade publications, while scientists make greater use of professional literature and written sources of information.

Colleagues are important sources of information. Often the most up-to-date information is available from fellow engineers. In a large organization young engineers initially seek out a mentor in a more experienced engineer. Co-workers are sources for answers to emergency questions. Face to face discussions are considered by engineers to be more productive and speedier than searches of the literature. Colleagues trade information, questions and answers freely. They teach each other, exchange tips and suggest warnings about pitfalls which may be encountered on certain kinds of assignments (Dubin, 1975).

Engineers and scientists look to their colleagues within their working unit for approval and recognition for a job well done, especially if this recognition is not forthcoming from the immediate supervisor or higher management. They are motivated by the desire for approval of their peers and to keep up with their peers.

The degree of interaction and communication among colleagues was vividly described by one engineer, "We are constantly moving in interlocking circles." The chief complaint that engineers have in respect to their colleagues in the job is that they do not have enough time for job related discussions with their peers. More than 75% of engineers responded affirmatively to each of the following questions:

Agree that engineers have the opportunity to discuss technical and other problems with colleagues on the job.
Agree that colleagues on the job help to identify pertinent sources of information.
Agree that colleagues assist the engineer in approaching and understanding a problem better.
Agree that colleagues provide the engineer with information on what approaches have been tried by others and what results have been obtained.
Agree that colleagues can help an engineer to confirm the best approach and improve his ability to decide on a problem (Dubin, 1975).

Pelz and Andrews (1976) found a positive relationship between colleague contacts and performance even when differences in experience, supervisory status, are taken into account. How can colleagues enhance performance? "One way is by providing new ideas—jostling a man of his old ways of thinking about things. But colleagues may do much more. Sometimes a colleague may know something another man needs to know."

"Then there is the possibility of a colleague catching an error which the man himself is too engrossed to see. Still another way colleague contacts may help in keeping the engineer and scientist on his toes—like providing some friendly but real competition for promotion or recognition. Frequent contacts with many colleagues seem more beneficial than frequent contacts with a few colleagues. Similarly, having many colleagues both inside and outside one's own group seemed better than having many colleagues in one place and just a few in the other. Set up teams, committee evaluation groups, lunch gatherings, but keep the situation loose. After all, the goal is good communication between individual men, not a complicated or rigid set of formal meetings. One important thing that you can do is to make sure that men working in related areas are aware of each other's activities, interests, and problems. If this condition is met, your men can themselves see the contact which promise to be useful."

In short, contacts with colleagues provide intellectual stimulation, new ideas, a lot of error catching, coordination, and even some needed relaxation. These are the kinds of activities that foster updating.

Schwartz, Goldhar, and Gambino (1976) report some interesting ideas regarding the nature, source and flow of important information used by innovators in the chemical industry. A large number stated that the open literature was their most important source of information. Yet a surprising 80% got their important information by listening, not reading; and a third reported that the key information was readily available in the industry. Second, internal sources are much more fruitful than external. Finally, informal communications channels are three times more commonly used than formal ones.

The updating process which we have been examining is necessary and complex. It requires the combined forces of individual motivation and organizational support. The common goal is to preserve and promote one of our most valuable resources—the talents of highly qualified engineers and scientists.

Recommendation for Active Intervention

A Pilot Project: What Management Practices Can Reduce Obsolescence In Scientists and Engineers?

A number of common management practices have been suspected of contributing to obsolescence in scientists and engineers. Some of these practices which concern work assignment are: underutilization, misutilization, and overspecialization. Concerning motivation for improved work performance and updating, certain practices appear to have a stifling effect: failure to reward innovation and excellence rather than position, not allowing participation in decision making, not granting responsibility or a degree of autonomy, not allocating time in the budget for updating and career development.

I recommend that the NSF sponsor a pilot project to be developed and installed in several cooperating industrial or governmental organizations. The project will have as its objective to test the effects of certain improved management practices against a set of identified criteria.

Personnel practices which could be tested: revising cost accounting procedures so that senior professionals are not excluded from working on new projects with new technologies, limiting tenure of supervisors to an agreed period of three to five years, more frequent lateral transfers, use of matrix organization to test career development, semi-annual performance reviews with emphasis on professional development, reassigning professionals at four-year intervals. Prerequisite would be the approval of top management and the training of managers or supervisors in specific behaviors and procedures.

The evidence derived from this project would make it possible to demonstrate the applicability and transfer of techniques to other similar organizations.

Recommendation for Active Intervention

A Pilot Project: What Management Practices Can Extend the High Performance Years of Older Engineers?

Approximately half the working engineers in the United States at present are over forty years of age.

Demographic studies indicate that the proportion of older workers in the total work force will be increasingly larger in future years. If technology continues to expand and advance even at its current rate, we may expect that older engineers in the future will be under increasing threat of becoming obsolete in their skills and knowledge in the latter part of their professional careers. If the prospect for the individual engineer is bleak, it is all the more threatening to industry and national economy for which the skills of professional workers are the most valuable capital investment. The magnitude of the problem may be perceived graphically by visualizing the approximately 500,000 engineers who are in the category of forty-plus, or "older engineers" today.

I recommend a pilot project designed to retard or prevent obsolescence in older engineers by the application of specific management practices. The project would be in every respect parallel to the previous project except that the subjects in the sample would be restricted to engineers in the 40-plus age group.

Recommendation for Further Study

Studies in the Rates of Change in Science and Engineering Knowledge

It is a generally accepted opinion that the information explosion is a contributing cause of technological obsolescence. The so-called half-life of information can be used as a measure of the rate of change in science and engineering knowledge. To determine the rate of change in a given field, it is necessary to identify concepts, theories, methods and other information that have evolved over a period of time and to determine the extent to which new developments are modifying or making obsolete previously held information.

I recommend that studies in specific fields and subfields in science and engineering be undertaken to quantify more realistically the rate of change in these specific areas of knowledge and skills.

Data derived from this study would enable the NSF to chart the pace of knowledge decay and knowledge generation in various scientific and engineering fields. The NSF could then intervene in those fields where the most rapid change is occurring with assistance in the form of training seminars or whatever methods are indicated.

Recommendation for Further Study

An Empirical Model for Measuring Updating in Scientists & Engineers

The empirical model for measuring updating, described in this paper elsewhere, has not been tested experimentally. Further investigation is needed:

1. To identify the specific variable of each of the six components: motivation, organizational climate, the job, supervisor-subordinate relationships, colleague interaction, and management policy.
2. To develop a series of scales for each of the variables in each of the updating components.
3. To measure each variable against a set of criteria.
4. To test each of the components individually, and all of the components combined on an experimental basis.

The instrument is designed to detect both the motivational factors and the organizational climate factors which operate to inhibit the updating processes.

I recommend that the NSF support experimental testing of this empirical model for measuring updating in scientists and engineers. Data derived from the study could be used in counseling for individual motivation and career development, and for instituting corrective practices in organizations.

Recommendation for Further Study

A Behavior-Anchored Scale for Defining and Measuring Updating

Definitions of technical obsolescence are often confined to technological knowledge and skills in a given subject area. Perhaps more important are the behavioral aspects—motivation, personality and social variables in updating, learning and growth. (External variables in the work environment—organizational climate, job assignment, etc. would be the topic of another study.)

I recommend that the NSF support a study to identify the precise motivational and personality variables which are operative in the updating behavior of an individual. After certain variables have been established, they can be used to build a set of behavior-anchored scales, parallel in format to the scale for measuring technical knowledge and skills described in this report. (See Figure 2.) Measurements on a behavior-anchored scale would produce data which is relatively more precise and objective than the usual rating scale descriptions of behavior, and which is capable of being analyzed and used quantitatively for comparative purposes.

Practical benefits to be derived from such a scale:

1. Accurate measurement of strengths and weaknesses provide a reasonable basis for constructing a remedial action plan for the individual.
2. A reliable instrument for measuring the *extent* of obsolescence in behavioral terms.

Recommendation for Further Study

A Pilot Project; An Assessment-Development Center for Scientists and Engineers at Mid-Career

Assessment-development centers are being used today by a number of industries as a method of selection and promotion of managers which is more reliable than the current performance appraisal. The U.S. Civil Service uses this method to select personnel for positions of GS–15 and higher levels. Assessment-development has in recent years been assigned a new function—the professional development of managers. Candidates are put through a two-day series of tasks and interviews on which they are judged by a panel of experts. Heretofore, organizations have used the assessment-development chiefly for managers and administrators; this method has not yet been applied to engineers and scientists.

I recommend that the NSF support a pilot project to set up an assessment-development center in cooperation with an organization, private or governmental, expressly for professional scientists and engineers at mid-career. Tests and tasks would have to be designed precisely for candidates in general and specific fields of science and engineering. Performance in tasks and interviews would reveal the individual's strengths and weaknesses, special capabilities; would identify training needs toward specific goals, and updating or other programs for career development.

If the project proves successful as a technique for professional career development, it could be applied to professionals in other technology-based industries.

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Continuing Education Policy Statement

Sandia Laboratories supports and encourages, as a matter of Company policy, continuing education that assists both the individual employee and the organization to overcome obsolescence, prevent obsolescence, and build for future competency.

The Company realizes that technical obsolescence is not an all-or-nothing proposition. It is a relative process, with the degree of obsolescence being a function of new knowledge and new techniques along with work pressures, specialization, and lack of opportunity to use certain skills and knowledge. Sandia Laboratories, consequently, recognizes that there is a mutual responsibility to be shared by the Company and by the employee for activities that tend to overcome and prevent obsolescence. It is the feeling of top management that *continuing education* contributes significantly to maintaining a high quality staff.

Sandia Laboratories, through the leadership of its management, desires to maintain an organizational climate that tends:

1. to develop a strong sense of purpose and direction on the part of the employee toward his own development on the job and his responsibility for the job,
2. to stimulate the employee to use his own initiative, innovative talent, and creative ability past fulfilling management expectations of what should be done on the job, and
3. to encourage the employee to use his time, energy, and abilities not only to carry out present assignments but to do some critical thinking about possible new assignments.

To enhance the possibilities of attaining such a climate, the management feels that the organization should support and encourage continuing education activities of its employees:

1. to achieve specialization or acquire capability in particular disciplines, new fields, or techniques,
2. to make progress in their job situation by acquiring knowledge needed as a basis for progress as part of the job time,
3. to take advantage of refresher and updating opportunities in order to maintain them at a high level of work performance,
4. to reorient themselves in mid-career according to their own needs and the needs of the company, and
5. to keep up-to-date by providing opportunities to attend technical and professional meetings, publish papers, participate actively in technical societies, and other ways of keeping in touch with the world of science outside the Laboratories.

Stimulating subordinates to participate in activities which keep them up-to-date is an integral part of the supervisor's job. Supervisors are encouraged to discuss continuing education needs with each subordinate and to devise plans for meeting these needs.

CONTINUING EDUCATION FOR SCIENTISTS AND ENGINEERS

The Academic-Industrial Interface

By George W. Hazzard, President, Worcester Polytechnic Institute, July 1, 1977

This paper was one of six prepared in response to a request of the Science Education Directorate of the National Science Foundation as part of its consideration of current and possible future activities in continuing education in science and engineering. Any opinions, findings, conclusions or recommendations expressed herein are those of the author and do not necessarily reflect the views of the National Science Foundation.

INTRODUCTION

When I agreed to write an essay on "The Academic/Industrial Interface" as part of a series of writings on the continuing education of scientists and engineers, I thought I knew what those terms meant. After all I had spent many years in both academe and industry working largely with scientists and engineers. Arranging for continuing education programs from both sides certainly had me crossing that interface many times and in many ways.

But as I worked my way through the various aspects of the academic/industrial interface in the continuing education of scientists and engineers it became very clear to me that I could propose a goodly number of integrating ideas or provocative questions but that both ideas and questions were hard to back up or respond to with good solid facts. Not a comforting realization for a former scientist though possibly a normal state for a college president.

What follows, therefore, is a loose aggregation of ideas and speculations that might possibly suggest to the National Science Foundation some avenues to pursue in this field for the benefit of many individuals and organizations and thus for the United States as a whole. It is my hope that the expression of these ideas is at least clear enough to set others to thinking and to their creation of fine solutions of an important national problem.

Where Are The Interfaces?

Motivation and Continuing Education

Continuing education means many different things—from dining each night with your spouse to a full-blown program at the Harvard Business School. It is that very diversity that makes the clarification of roles and results in continuing education so elusive and difficult. My own feeling is that continuing education really starts in the pre-career learning period during secondary school and college. If, through that period, attitudes are established that will lead a person always to want to learn, then almost every form of continuing education presently devised will be a resounding success for that person. If such attitudes are not developed, there is of necessity a large effort in motivation to be carried out before any form of continuing education can be successful. Unfortunately there seems to be a general belief that all who seek continuing education have that motivation, a belief that is badly in error.

Later on I will come back to the impact of undergraduate education on the adult learner. At the moment I would look at motivation as a differentiating device that could determine the way one delivers or provides continuing education. How one helps adults to learn depends on their motivation and this in turn depends on the shaping of their learning attitudes by earlier educational experiences.

Simply put, the person highly motivated to learn on his own can readily utilize the book, the video tape, the programmed learning unit, or any other *individualized* learning mechanism. On the other hand, most who have been through the American educational system have come to rely on a *group* learning process. A teacher in front of a class organizing and dispensing dollops of information, helping to motivate through rewards and punishments, and providing guideposts for progress through periodic examinations is synonymous with "education" for the great majority of scientists and engineers. It may be the teacher and the structure or it may be the classroom competition but that group experience is the way to learn. Thus there is no "right" way to provide continuing education. Having numerous and varied delivery modes, equally validated and rewarded, seems essential in a society as individualistic as ours.

Motivation considerations lead us to another continuing education problem, that of "credentials." Whether one is an individual or group learner one generally seeks recognition for the learning one does. Almost universally such recognition comes through courses, grades, and degrees or certificates. American society seems to be "credential happy" but is it really in the best interests of both the learner and the learner's employer to have it that way?

It seems as if industry has adopted as its motivations for the continuing education of scientists and engineers those developed by academe. But these seem to have developed as replacements for those normally seen in the real world. A fruitful interface between academe and industry could well be the motivation of the learner with discussion centered around such topics as individualized versus group instruction or credentialing versus performance rewards for learning.

Content and Continuing Education

Continuing education for scientists and engineers faces a divergence in purposes that both enlarges and complicates the design of programs Some divergence comes from the differences between academe and industry but most comes from content in the material to be taught.

On the one hand there is a need for continuous renewal of the scientific or engineering knowledge that enables the scientist or engineer to perform well in his present job. On the other hand there is the need for knowledge in new areas that will enable a person to "advance," either in his professional area or out of a technical area into the realm of management. As discussed later, this divergence is much greater in industry than in academe, but it exists for both, primarily because the world of technology is a world of rapid and constant change.

In all circumstances one can sort out perhaps four kinds of learning content. First, are presentations that bring people up to the very cutting edge of the knowledge state of the discipline. Second, are presentations that initiate people into a new area of science or technology (they might be called "mature science for other mature scientists"). Third, are all those courses in management for aspiring managers. And fourth, are those broad philosophical courses or seminars where the globe is one's oyster and never mind the shells for experienced or senior managers. Obviously the same person might participate effectively in several categories at the same time, but these varying audiences and content pose some real challenges to both academe and industry.

These varieties of learning content lead to academic-industrial crossovers that could benefit all but that can also create complications. In some of the above areas the expertise resides in academe; in others it resides in industry. What kind of interface bridge will bring the best knowledge source in contact with those who need to know? What mechanisms will assure sufficient attention to teaching by either the academic or the industrialist whose main job is something else? It seems as if content in continuing education for scientists and engineers is as much a challenge as motivation.

Time and Continuing Education

Motivation and content both show up some of the many points of overlap and conflict in continuing education between industry and academe. But another common problem is that of time. Frequently continuing education best takes place in the college or industry library in the middle of the day. It is considered "work," but why isn't it continuing education? The college professor preparing his lecture is always incorporating something new but the time spent in doing so is rarely thought of as continuing education. So one can't help but ask about time spent in learning on the job and whether it is counted in all our considerations of continuing education.

I raise the question of time because it reflects so many attitudes that might be modified if time were taken to think about them. In one sense questioning time spent is fruitless for the person who continues to grow in his job must be learning new things constantly. On the other hand, many less motivated people could be helped to grow if their learning time were spent in more visible and organized ways. Admittedly, the latter approach is rather like recognizing long service to an organization. Time spent is recognized rather than quality of effort. But if that leads to motivation and performance it is all to the good.

In considering time we then come back to an enlarged concern about measuring continuing education either through credentials or performance. Who decides, and how, what is the best expenditure of time in the various modes of continuing education? Is it the industrial employer or is it the academic purveyor (university or professional association).

Since time is money, the enlarged concern appears in who pays or gets paid. If the continuing education is measured by performance and the learning takes place wholly within the company, all payments are internal. But if academe provides the learning it surely wants and deserves to be paid. One can't help but wonder if measuring time through courses and credentials is not motivated by the desire to collect compensation. If that is the case, time is indeed of the essence.

Continuing Education Solutions

The interfaces between academe and industry are many indeed for the continuing education of scientists and engineers. One worth considerable thought and effort by the National Science Foundation is the method of response to the questions raised above. Is it best just to let the free market operate with supply responding to demand in the many ways already extant? Or should there be more bureaucratic ways of response—industry planned and promoted activities or joint academic-industry actions with direction and flow from the top down?

What is the proper way to pay the social costs involved? Should the individual pay, the employer, the government? How closely should programs be tied to immediate job relatedness or to enlarging future opportunity?

Finally who should discuss these problems? Can we rely on the academic director of continuing education talking to the industrial relations director? Or do we rely on the disciplinary professional societies? Or are there other groups in the silent majority who ought to be heard? Somehow one feels a need for facilitation without a strong sense of how best to proceed. In that situation a mixed strategy is usually best. What follows may help develop that strategy.

Crossing The Interface

Organizing Principles

In looking for solutions to the problem of continuing education for scientists and engineers, one looks for models whose characteristics might be transferable from one milieu to another. In academe, for example, the role of every professor is at least the transmission of knowledge and, as frequently as possible, the creation of knowledge. Every faculty member of quality is expected to be up-to-date in his or her technical field so that scholarly or learning activity is the order of the day. In a sense, some part of every week is devoted to continuing education and usually through the simple self-teaching mechanism of reading the literature or attending the departmental seminar.

Could one apply this model to industry? Unfortunately most industrial persons, while learning to resolve problems arising from work activities, are more frequently in situations that require action rather than reflection. Or they are not close to the sources of new knowledge—books, journals, video materials, etc. Or the need for group activity precludes opportunity for the disciplinary study that is a natural part of the role of a faculty member.

Looked at this way there might be a common organizing principle that industrial research people and those in universities who focus on research are alike in their continuing education needs. They are equivalent in their commitment to their disciplines and the rewards received through peer approval and the many forms of recognition available, from Nobel prizes on down. One might say for them that continuing education is automatic.

But looking deeper one sees a strong similarity between the industrial scientist or engineer described above and the great majority of faculty members whose major role is teaching. These faculty frequently have as little time or opportunity for continuing education as do their counterparts in the engineering, manufacturing, or marketing functions of industry. The renewal of these two groups of people in common programs could reemphasize the close ties between college teaching and industrial practice while giving each group that better understanding of each other that comes from learning together in both formal and informal settings. So another organizing principle is to treat these two groups of people as one when it comes to continuing education.

Another cross-sectional view would lead one to an opposite organizing principle. I have noted earlier that educational credentials seem to be more important to many of those seeking continuing education than does the resulting improved performance. But if one looks at the academic versus the industrial world, both of which relish credentials, one notes that academic credentialing is done almost completely at the start of a person's career. On the other hand, in industry it is rather common to add degrees and certificates for quite a period of a person's working life. Therefore the credentialing process for industrial scientists and engineers is not appropriate for their academic counterparts. The question then is "should academic or industrial policies be changed?"

An extension of this difference between academe and industry is the policy with regard to organizational support for continuing education. In academe the scientist or engineer faculty member rarely receives support for further learning experiences (except travel to the learned societies). But in industry full tuition payment is now the rule rather than the exception. If the organizing principle used by industry were applied to academe (as it already is to public elementary and secondary schools) there could be major changes in attitudes and behavior.

An alternative organizing principle is probably too horrendous in its financial implications to be seriously considered. But to ascertain true interest in continuing education it should be offered free to all participants. As several have proposed, society could guarantee so many units of time, credits, or knowledge to everyone. Then we would have equality of opportunity with no limitation on learning just for the current job but for total enlargement of ability to contribute to society. Experimented with in some area or region this principle might provide many answers to the questions about who wants and will work at what continuing education.

Given these rather conflicting organizing principles I see considerable opportunity for seeking out situations where one or the other might apply and analyzing them for future guidance of all of us.

Where Does It All Start?

I have indicated some of the differences in viewpoint and behavior between industrial and academic activities related to continuing education of scientists and engineers. Now I would like to move back one stage to the place where divergence first occurs—when the formal educational process as a full-time activity ceases, at graduation from college. It is subsequent to that time when organizational attitudes start to affect the behavior of the individual scientist or engineer. But those effects can only modify or reinforce attitudes developed from the sixteen to eighteen years of experiencing educational institutions.

Continuing education's effectiveness depends in many ways on what academe has done to the recipient of that education prior to the job experience. It depends strongly on attitudes about the need for continual learning and on a personal bias in favor of self-renewal and intellectual growth. If those are "conditioned out" of the person in high school or college, employers are going to have a very difficult time in restoring such attitudes. Therefore, it might well be that the basic need in good continuing education is undergraduate education that lays the groundwork in both the learning process and individual motivation.

What Process?

There are two aspects of the undergraduate learning process that are of concern. One is *who teaches*. The other is *what learning*. While both have been discussed at length and viewed from every possible angle, a quick review may be helpful.

First, *what learning?* Thinking in terms of life-long learning the undergraduate learning process faces conflicting forces: education for immediate effectiveness upon graduation versus education for the long pull. Thus the educational curriculum slides back and forth between teaching material that is immediately useful and material that emphasizes general principles. The latter was popular in the Sputnik era and took the form of strong emphasis on basic science on the grounds that the major scientific principles will last forever. The former was popular pre-World War II and is coming back into favor now as emphasizing current engineering practice. It is very clear that elements of both are essential and that a new round of Hegelian thesis, antithesis, and synthesis is in progress.

This new synthesis is a strong focus on "learning how to learn" that creates an active, participative learning environment for each student. Such is the case at my own institution with very positive effects in student motivation and strong preparation for further learning efforts, whether formal or informal. If such a synthesis is generally adopted, the work of all in continuing education would be eased and encouraged. NSF's past and future support in undergraduate science and engineering education has been and can be a major factor in such efforts.

Second, *who teaches?* Many have noted the impact on engineering faculty of the post-World War II emphasis on the "theoretical." Those who wished to teach engineering had to pursue their graduate studies through the Ph.D., emulating the science faculty preparation with its strong emphasis on research. This was eminently sensible in terms of the rapidly increasing level of sophistication of engineering research and practice. Engineering faculty would never have been able to stay ahead of their students otherwise nor provide the stimulation and excitement so necessary for good learning.

Unfortunately this method of preparation has led to almost a generation of engineering faculty without significant industrial experience. Without that experience, faculty find it most difficult to convey the sense and feel of the problems faced in operating environments that the classroom and laboratory cannot provide. The world of learning and the world of work appear as two distinct entities when they should be viewed as one.

Such a situation offers a major continuing education opportunity: the oft-proposed, modestly implemented use of industrial people as undergraduate engineering professors and the use of engineering faculty in various industrial positions. The latter was successful on a small scale under the aegis of the Ford Foundation and ASEE, but no large scale effort has taken place to my knowledge. The former is of course common practice at the continuing education level. In fact most continuing education programs could not operate were they unable to draw significant numbers of practicing professionals into the classrooms as teachers. In many respects their presence in the classroom may create an information diffusion network comparable in size and effect to professional society meetings.

Once again, using my own institution as an example, there can be a joining of these two (industrial and academic people) in the undergraduate teaching process. In carrying out each of two projects required for graduation a student frequently works at some corporation or government agency or non-profit institution (e.g. a hospital). The supervision of the project is done jointly by one of our faculty and a practicing professional. With this kind of involvement both faculty member and student get first-hand experience in dealing with real-life problems. At the same time the practicing professional gets the stimulation and psychic rewards that always come from the teaching process. All are involved and learn from each other.

If industry and academe could join more often in this way at the undergraduate level, motivation for further learning might be enhanced and the continuing education job made easier.

Implications for Continuing Education

For continuing education there are several points of importance deriving from the undergraduate educational process. These might be grouped under the headings of motivation, materials, and method.

If undergraduate students are more highly motivated in the classroom and laboratory by seeing direct applications of their work in real-life projects, would comparable motivating arrangements be possible in continuing education? Or do they already exist? True, most company support of employee education is for "job-related" courses. But would the learning in those courses improve if the teaching were more clearly related to the application? Frequently such is the case in company run courses. Does this mean that more and more continuing education should be done inside the corporation? Should universities give more courses to selected corporation people on teaching methods? Should more comparative studies be done on learning environments and teaching methods that relate specifically to scientists and engineers?

One example comes to mind. Much has been done with various forms of individualized instruction generally following the concepts of Fred S. Keller of Columbia and Georgetown Universities. Such methods have the great advantage of portability to people in locations remote from university centers. They take advantage of various forms of modern technology and are said to have the potential of more effective use of faculty time. But there is an interesting hypothesis, with minimal experimental proof, that these methods do not work well for those who thrive on competition and do work well for the contemplative or introspective types How, then, does one match the teaching method to the individual for maximum motivation? More feedback between regular undergraduate-instruction and continuing education instruction might be very profitable to both. Method and motivation are closely related.

When one looks at material taught the same challenges appear In undergraduate education the majority of the material is discipline oriented, treating of some aspect of engineering or science. The students are being brought up to the knowledge level current in the discipline. Most are being socialized to see the acquisition and application of technical knowledge as the source of psychic and financial rewards. Relatively few take, or are ready for, "management" courses and those who do major in management and engineering rarely end up as the scientists and engineers we are considering.

But once out in the producting world, the scientist or engineer generally comes to see things differently Technical work is important alright, but equally important is the management of the people who do it. Working with and through people, understanding and utilizing organizational structure, recognizing the sources of bureaucratic power, the scientist and engineer comes to see the need for all kinds of new and different knowledge. The shock of re-socialization is great.

This big swing in perceived ways to "success" seems to me to lead to an interesting challenge in the materials area. Could one see a sort of life cycle of interest in material roughly divided between the pure and applied physical sciences and the pure and applied social sciences? It might go like this.

In the early years after graduation from college a person still wants to grow in his discipline. Hence there exists strong interest in continued study in the original or a related discipline. But then corporate socialization takes over for many. Then applied social science (management) courses appear as extremely important to upward mobility for those in their 30's or early 40's Following this there is then a bifurcated demand that develops for persons in their late 40's or early 50's. Both lead back to scientific disciplines but in quite different ways. The non-manager desperately needs updating in his field or working knowledge in a new technical field if he is to continue his technical contributions successfully. He needs very detailed technical knowledge. Otherwise that bright young new engineer will take his job. The manager, on the other hand, needs to know of similar new developments but over a much wider spectrum and in much less detail. At the same time the manager is likely to welcome more knowledge in the "pure" social sciences—history, sociology, psychology.

Rarely do undergraduate teachers have such a diversity of audiences. And because of extrapolation tendencies from regular educational processes to continuing education, we can't help but wonder if many continuing education programs don't try to make one do the work of two or three.

In fact this variation in need for material, or the way it is presented, may be part of the reason so few older (50's) non-managers seem to be involved in continuing education. Several studies have seen little (even negative) correlation between continuing education participation and professional success when this success is judged by their managers. That is, it seems as if the scientist or engineer who contributes the least is more likely to take continuing education. Could it be that the way the material is presented makes its acceptance and use by the middle-aged student either too difficult or too ego-threatening? Or is there something to the concept that only the non-creative, by-passed, lower paid engineer or scientist "individual contributor" ever takes courses after age 45? Would that person be that way had he had better continuing education experiences earlier in his career?

Method of presentation or delivery is thus intertwined with both motivation and material. Are there ways that are "best" for older scientists and engineers that are not so for those in the early years of their lives? Most studies of human behavior as it affects learning deal with children and young people. Once one becomes adult there seems to be no further interest in how one learns—it must be the same as when you were 18. If more were known about adult learners, could we not then base our continuing education teaching methods on at least as good grounds as we supposedly do in earlier years?

For example, if learning modes or motivations are different for adults from those for societal adolescents, one might decide they should never learn together. Even though we are supposed to have a "youth oriented" society that seems not to be the case inside most bureaucracies, be they industrial or governmental. There the hierarchy tends to put younger people at the bottom. So if one had young and old in the same learning situation the older person might be seriously threatened by the success of the younger.

On the other hand, the natural learning that always come from explaining things might be a positive factor if done in the right situations, as happens in our project teaching. Likewise the stimulus of the enthusiasm of younger people, even their idealism, might favor having more older people do their continuing education in regular day-time courses of the advanced undergraduate program.

More knowledge about adult learning could also affect the amount of technology applied to continuing education. Methods of teaching that make adult learning synonymous with video, computer-aided, or other technically based teaching modes might be just the wrong way to motivate older scientists and engineers. Here is an area that might be most effectively treated by having academe and industry join in studies and analyses.

For these older learners in the disciplinary areas there is a major difference in motivation between academe and industry. The faculty member is part of a community where lifelong activity in the same job is viewed as natural and good Pay and status and influence increase with time, especially relative to those in administrative positions. But the industrial engineer or scientist live under different social forces It is the exception to be or desire to be an older scientist or engineer and not a manager or administrator Thus there is a much greater driving force for the academic to relish and carry out actions that keep him up-to-date in his field.

This problem of the "dual track" in industry is well known to all who work to make the industrial work experience productive and interesting. But most of the analysis and resulting actions come from the administrative side. Could it be that continuing education providers listen too much to the managers or personnel directors and not enough to the people they want to teach? If so, it should be no surprise that older industrial scientists and engineers rarely take advantage of opportunities provided; their interests are not met. Surely this is an interface worth crossing.

Some Responses

Joining People and Purpose

Continuing education for scientists and engineers is a complex problem. As described above part of that complexity stems from diverging views of what continuing education is supposed to accomplish in either academe or industry. But another part of the complexity arises from differences in institutional mission and the traditional view that "real work" goes on only in industry and "real teaching" goes on only in academe

One way to reduce or eliminate such differences is to accelerate the breakdown of divergent views by the reality of good teaching in and for industry and real work being done in academe as part of the learning process Especially if managers with the same level of concerns in industry and academe were to talk to each other, much might be accomplished. For example, both Deans of Faculty and industrial Functional Managers want their professionals to develop new knowledge and skills. Should not they discuss the problems in concert with (or instead of) Directors of Continuing Education and Personnel Training Directors? Such direct exchanges might easily lead to creative new solutions benefiting both kinds of institutions through better benefits to their people.

Another way to cross the interface is greater use of the professional society. It already serves as an excellent continuing education mechanism through its national and regional meetings and its journals Could not the professional society act more than it does now as a broker? It could act as a non-profit, hopefully unbiased mediator between the needs and funds of both academe and industry It could provide a non-threatening forum where potential users of continuing education might speak out freely about their needs or their learning frustrations. It could certainly do well in the material of the disciplines. It might even do well by emulating golf and tennis with special series of courses developed for those "over 40" or "over 50" or even "over 60."

It may be useful to come back to the undergraduate learning experience where industry and academe do work together to teach young persons. There, if done properly, a continuing desire for further learning is built in along with the confidence to seek out and use learning opportunities. If that model works well for undergraduates, why shouldn't it work for alumni? Experimentation in this area is a good scientific way to find out

Achieving Optimization

Of considerable importance in joining people and in serving needs is the simple problem of price, a problem that takes several forms. How one responds to this price problem can have real effect on optimizing the quality and aptness of response to continuing education needs.

By price I mean the cost to the continuing education user. This cost can fluctuate as widely as do college tuitions. Because it does, the usual market test experienced by an industrialist ceases to exist. One cannot use consumer acceptance as a measure for success in creating a continuing educational product because of two things, governmental subsidy, and incremental pricing. Both intertwine sufficiently that a brief description is in order.

Subsidy usually takes the form of tax support to public universities so that the price to the consumer (tuition) is low. Incremental pricing is practiced by both public and private institutions by assuming that all overhead costs of operation and administration have already been paid by operation of the institution for full-time students. Both practices distort the pricing process by disguising the true cost of the services rendered.

This replacement of cost by price in the mind of the user complicates the decision about the social value of continuing education and the most cost-effective way to provide it. How much indeed should society help the individual through governmental subsidy or employer reimbursement? How best do you make individual free choice available and thus let the market or invisible hand prevail? *Should* you let the free market prevail?

If one were to abandon pricing as an optimizing mechanism, could one substitute some other? Quality of offering is a possible alternative, recognizing that much choice based on price considers the level of quality. Certainly, most students are experts on separating good teaching from bad and are never afraid to vote with their feet.

But again complications arise, this time in the form of credentials There seems to be a growing movement in engineering circles to adopt the long-time practice of the public elementary and secondary schools. They recognize the continuing education of an individual through the number of credits amassed almost irrespective of quality or content Throughout the continuing education field this use of "continuing education units" or CEU's leads us away from pay for performance to pay for time spent in the classroom. Should this movement become broad enough, quality of learning experience would fail as an optimization method.

Perhaps the only real optimization method is motivation. If the individual is internally motivated to learn he will select a learning format that is best for him. He will do so creatively if his employer, either academic or industrial, sees his performance as improved and rewards him accordingly Thus optimization might best come from a combination of revised undergraduate learning and managerial reinforcement based on clearer understanding of individual motivations A hopeless idealism? Not if we all see continuing learning as critical to societal survival.

Delivering the Goods

There are two places to deliver educational goods—academe and non-academe At the moment for all practical purposes only academe provides the credentialing function for academic goods Yet non-academic organizations can and do provide on occasion some of the most creative educational goods, credentialed or not Such a situation implies one of two things: either academics and non-academics should join forces, or non-academics should be credentialed competitors in continuing education for scientists and engineers.

If one looks at academe and industry one sees many instances of shared educational efforts. Undergraduate students acting as interns, as project participants, or as co-op students regularly learn in real world settings. Faculty consulting in industry helps keep many aware of new ideas and practices to work into their teaching. Many industrial people give seminars or series of lectures on university campuses. And of course, at the continuing education level many universities could not run programs if most of their teaching were not done by moonlighting industrial scientists or engineers.

Of perhaps equal importance is the gradual growth of undergraduate performance based programs which avoid much of the minutiae of course credit counting and promote or graduate people, as does industry, on demonstrated performance in problem-solving situations. Similar continuing education programs using job performance as indicator of teaching/learning success are developing in a few industries. In other words, the times seem right for joint ventures, for cooperation to the advantage of all.

But Americans and American institutions treasure their independence. Many colleges find continuing education programs to be budget balancers (or deficit reducers). Are there ways to be found by society to encourage cooperation without destroying important and necessary institutions? As I watch the cut-throat competition for continuing education students of all kinds, I am sceptical of successful cooperation without strong financial incentives. Can NSF develop such incentives on an experimental basis?

One possible answer to such a question might be regionalization. Could there be a common market in some reasonably defined geographical area? In that area all institutions, academic or not, might carry out the teaching functions, share credentialing, and share in the compensation for services. Student travel could be minimized, personal contact maximized, and use of the new technologies experimented with because of possible large audiences. The difficulties are obvious and numerous but the benefits could be very great in terms of net reduction in social costs. It would be a very challenging experiment in organizational and human relations with potentially big rewards.

Technology may be another answer even though its promise keeps on being unfulfilled. Video discs and tapes, cable or regular TV, and audio cassettes do make individualized instruction relatively easy and (if audiences are large enough) inexpensive. But once again a competitive market makes each institution or faculty member wish to produce its or his own version of a subject or course. Many times it is difficult to work out "residuals" in proper ways to compensate faculty who might prefer to be doing other and for them more profitable activities. Could there be cooperation in this area by some kind of network like PBS or a commercial TV network with the academic providers? How does one decide how much of the market is composed of those who like such individualized independent learning as opposed to those who prefer the friendly, competitive, challenging or threatening classroom? A little market research might be a big help in this area.

My conclusion about the problem of continuing education for scientists and engineers is terribly middle-of-the-road. Many experiments in new modes of delivery should be supported. No one answer exists but many answers (of high quality) are needed. And if undergraduate education really ignites the fire of desire for continued learning all our continuing education problems will be little ones.

APPENDIX E

CONTINUING EDUCATION IN SCIENCE AND ENGINEERING,
Audiences: Non-Academic

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CONTENTS

I. Sources of New Knowledge and Their Impact on the Educational Needs of Non-Academic* CE/S&E Audiences

Differentiation of individuals within groups of physical scientists, engineers and technicians into diverse audiences for various kinds of continuing education is critically related to their abilities to contribute to, cope with and remain abreast of the current fast pace of scientific and technological advances. Wide variations of competence, intellectual capacities and motivation to keep abreast of scientific and technological advances exist amongst individuals at all levels of contribution as well as with differing educational and experience backgrounds. Yet, such individuals usually work together on research, development or manufacturing programs and consequently require similar, if not identical, new information.

Estimates as to the rate of knowledge proliferation abound, although the sources, content and uses of that knowledge are not well understood. At present, estimates of the time period required for the doubling of knowledge range between 10 years on the conservative side to 7½ years on the radical side. Whatever the rate, new knowledge and techniques, particularly in the physical sciences and engineering, are growing at unprecedented rates.

Most physical scientists and engineers find that it is difficult to stay abreast of developments in their own fields and virtually impossible to remain in touch with developments generally or in other disciplines that touch upon their work. For these reasons, the "half-life" of an engineer is said to be 10 years. This estimate implies that without effective updating, engineers find that about half of their knowledge obsolesces or becomes inapplicable every 10 years.

Yet, where does this mass of new knowledge come from? It certainly does not grow on trees, nor does most of it now come from educational institutions or research laboratories. Most of the new knowledge comes from the fields of professional practice, from the minds of physical scientists and engineers working at the very frontiers of the technological advance. It is they who encounter the "barrier problems" on the job that yield grudgingly to the efforts involved in producing or recognizing new phenomena, improved materials, greater operating efficiencies, energy conservation, higher accuracy and better manufactured goods and services.

While enormous, the major portion of this newly generated knowledge is highly diffuse. Only developments in the schools and research laboratories are reasonably well organized to permit prompt sharing of new knowledge through publications, research results exchange, seminars, symposia and coursework. The vast body of knowledge being generated in the fields of professional practice is for the most part proprietary, but it needs to be harvested, concentrated, refined and transferred to appropriate users if it is to benefit society on a large scale. Universities that had been great fountains of new knowledge, but are not so any longer because of the expense, rejection of classified R&D support from some governmental agencies, attenuation of learned faculties, political restiveness and isolation from many current issues relating to real world developments, may be in a unique position to work with industry in implementing such functions.[1]

Drawing upon a variety of information sources such as the National Science Foundation, the McGraw-Hill Surveys and others, Battelle Memorial Institute publishes an annual forecast and analysis of the probable levels of R&D expenditures.[2] This report presents estimates of sources of all research and development funding for the United States of America and the principal categories of organizations that may actually perform that R&D. For example, Figure 1 shows how a total sum of $42.9 billion for R&D (about ½ of the world's budget for R&D in all fields) may be funded and performed during 1977. Assuming a near linear relationship between expenditures and work done, colleges and universities are expected to supply 2.1% of the funding but, by picking up additional monies from industry and government, may perform 12.2% of the work. Industry might supply 43.7% of the total funding, but perform 70.0% of the R&D with government support. The Federal Government may supply 52.8% of the money, but perform only 14.7% of the work.

The Battelle document does not address itself to the amount of new knowledge generated, but while an exact relationship between R&D performed and new knowledge generated has not been established, and probably never will be, it does not seem invalid to assume here that something close to a linear relationship also exists between R&D performed and new knowledge generated, considering that a great deal of new knowledge is generated on jobs associated with advanced project work both in industry and in government. On this basis, then, it seems reasonable to assume that approximately 70% of the new knowledge and techniques to be generated during 1977 will emanate from industrial R&D as well as professional practice, about 14.7% of the new knowledge may flow from governmental laboratories and other project activities, 12.2% may come from higher educational institutions, and 3.1% of the new knowledge may

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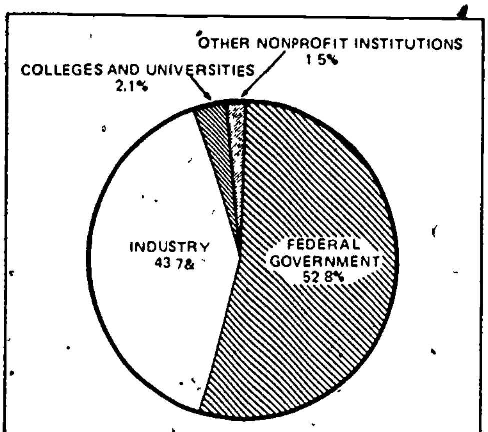
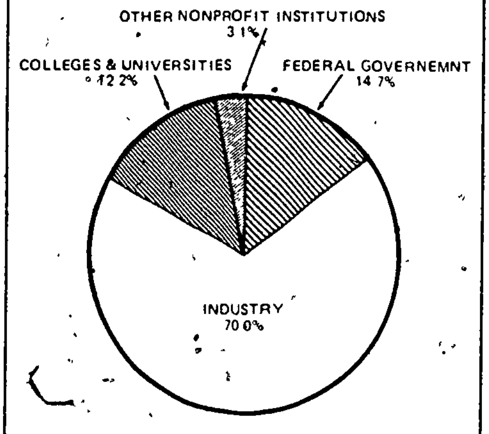
* Non-Academic CE/S&E consists of courses, workshops, seminars and other educational programs that may be either industry or university based but carry no academic credits, as differentiated from part-time undergraduate or part-time and full-time graduate studies that usually carry academic credits

Figure 1.—Expenditures in the United States, Calendar Year 1977



a. By Source of Funds



b. By Performance of R&D

The total forecast by Battelle's Columbus Laboratories is $42 9 billion Distribution shown here is by source and performance

be generated by other nonprofit R&D organizations. Considering the fact that more non-technology-oriented R&D is conducted by educational, research laboratory and governmental organizations than by industry, it seems further appropriate to assume that much more than 70% of the technical R&D is to be done by industry.

The important point here is to note that the bulk of R&D and related new knowledge generation comes from professional practice, but the results are diffuse and vulnerable to loss for lack of prompt harvesting, transfer and utilization amongst the practitioners themselves. In fact, CE/S&E can be an effective means for gathering such new knowledge, transferring and utilizing it amongst scientists, engineers and technicians, as well as injecting it into academic curricula as a benefit to the new crop of students through the involvement of regular college faculty as resource persons or learners in interactive educational experiences that focus the attention of a class on each participant's on-the-job problems with a view to either solving them or establishing a need for further R&D in the subject area.

Considering the rapid pace of technological advance and the interdisciplinary aspects that increasingly affect research and development work, learning on the job by doing it resourcefully becomes the principal conduit for new knowledge acquisition and generations, however modest. Why? Because scientists, engineers and technicians spend most of their alert time on the job. Given appropriate learning opportunities, a challenging job affords the greatest impetus to continued learning. In fact, unless learning on the job is a central feature of an individual's professional practice, no reasonable amount of formal study, reading of the literature or participation in professional symposia will have appropriate effect. Without learning on the job, the individual is bound to slip behind. The principal role of nonacademic CE/S&E, therefore, is to supplement learning on the job with subject matter that is too difficult, time consuming or peripheral for an individual to acquire alone or on the job. Together, the impact of these two modes of learning on updating can be particularly influential, and, therefore, the combination of learning on the job plus an appropriate measure of CE/S&E, perhaps 4 to 8 hours per week on a continuing basis, is optimal.

While learning on the job is the primary new knowledge and techniques acquisition conduit for professionals, formal continuing education coupled with perusal of the pertinent literature and participation in symposia enlarge upon an individual's background, extend the individual's interests and intensify comprehension of difficult subject matter at the very frontiers of knowledge.

What then are the current topics of important learning for scientists, engineers and technicians? Tables I and II are matrices of emerging and recently-emerged technologies having important impact on society in a variety of activity fields.[3] In the case of the emerging technologies, little has been published other than in proprietary or otherwise restricted documents. The related information is advanced, highly speculative and subject to frequent revision as the information becomes substantiated by experiment or practice. Obviously, textbooks covering such subject matter are virtually nonexistent, and in most cases related data has not yet appeared in the journals. In fact, if a continuing educational offering in one of these topical areas utilizes a textbook, its currency is open to suspicion as being "old hat."

Even the recently emerged technologies are in ferment, and text material becomes outdated in a year or so.

Table I.—Matrix of Emergent Technologies Applicable to Various Activity Fields

EMERGENT TECHNOLOGIES ACTIVITY FIELDS	Microprocessing/Control Instrumentation	Cryogenics	High Vacuum Techniques	Nucleonics/Radiation Effects/Shielding	Electro-optics/ Holography	Digital Techniques/Numerical Control	Computer Aided Design	Bio-Engineering/ Applied Physiology	Coherent Optics	Environmental Impact Analysis	Occupational and Product Hazards	Human Factors Engineering	Quality Assurance/Failure Analysis	Applied Plasma Physics	Analog/Digital & Digital/Analog Conversion	Automatic Assembly Techniques	Hydraulic/Pneumatic/ Electromechanical Servo	Data Communication Techniques	Infrared Spectroscopy/Materials Identification	Non-conventional Energy Sources	Advanced Materials Processing Techniques	Recycling Methodologies	Composite Materials	Superconductivity	Ultrasonics	3D Weaving/ Non-Woven Fabrics	Superpressure Techniques	Laser Function/Deuteron Function
Transportation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x		x		
Habitation	x						x	x		x	x	x	x			x				x	x		x			x		
Conservation	x	x			x	x	x	x		x			x							x		x		x				
Instrumentation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Communication	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x		x						x				
Production	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x	x				
Distribution/Mail	x					x	x			x	x	x	x			x		x							x			
Recreation/Entertainment	x						x	x			x	x	x				x						x		x			
Nutrition/Food Processing	x	x	x	x	x	x	x	x	x		x	x	x			x	x	x			x	x	x					
Sanitation	x			x	x	x	x	x		x	x	x	x				x	x		x	x	x	x					
Publication	x						x						x			x		x			x							
Energy Conversion	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x
Textiles/Clothing	x						x	x			x	x	x			x	x	x			x	x	x			x		
Health Services/Medicine	x		x	x	x		x	x	x		x	x	x			x		x	x	x	x				x	x		
Investigation/Research	x	X	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x		x			
Legislation							x	x		x			x					x										
Agriculture	x				x		x	x		x	x	x	x			x	x	x			x	x	x		x			
Mining/Oil Exploration	x			x	x		x			x	x		x		x		x	x	x				x		x			
Desalination/Irrigation	x	x			x		x	x		x	x	x	x								x	x	x	x				
Administration/Management							x						x					x										
Construction	x			x	x		x		x	x	x	x	x		x	x	x	x			x	x	x		x	x		
Defense	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x		x		x	x	x	x	x	x
Household Equipment	x						x	x				x	x			x	x				x		x		x			
Public Works/Safety/Security	x				x		x	x	x	x	x	x	x				x	x	x		x		x			x		
Fishing/Ocean Sciences	x						x	x		x	x	x	x		x		x	x	x	x	x				x			
Space Exploration/Operations	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x				x
Merchandizing/Restaurants	x						x	x		x	x	x	x					x										
Storage/Warehousing/Packaging	x	x	x	x			x	x			x		x			x	x	x	x				x					
Environment Conditioning	x				x			x			x	x	x				x	x		x								

Table II.—Matrix of Recently Emerged Technologies Applicable to Various Activity Fields

ACTIVITY FIELDS RECENTLY EMERGED TECHNOLOGIES	Computer Peripheral Techniques	Latent Image Techniques	High Density Data Storage/Retrieval	Dehydration/Fast Freezing	Coal Gasification/Liquification	Epitaxial Growth	Boundary Layer Control	Hydroponic Agriculture	Direct Energy Conversion	Solar Energy Conversion	Forensic Science	Fire Dynamics	Geothermal Energy Conversion	Liquid Crystal/Electroluminescence	Fluidics	Electro-Digital Techniques	Hot Gas Servos	Infrared Diagnostics	Chemical Milling	Magnetohydrodynamics	Electro-magnet Suspension	Analog/Hybrid Control	Dynamic Braking	Automation	Thermomagnetic Welding	Solid Waste Treatment	Heat Pump Space Conditioning	Hyperbaric Techniques	Microwave Techniques
Transportation							x		x			x			x	x	x	x			x	x	x	x			x	x	x
Habitation									x	x		x						x						x			x		
Conservation				x	x	x												x							x	x	x		x
Instrumentation	x	x	x			x								x	x	x		x						x					x
Communication	x	x	x			x										x		x						x					x
Production	x	x													x	x		x	x					x				x	x
Distribution/Mail	x	x																x						x					
Recreation/Entertainment				x																				x					
Nutrition/Food Processing				x				x										x			x			x				x	x
Sanitation										x								x						x		x		x	x
Publication	x	x																						x	x				
Energy Conversion	x				x		x		x	x		x	x		x	x	x	x		x		x	x	x					
Textiles/Clothing	x											x				x								x					
Health Services/Medicine	x	x									x			x				x						x				x	x
Investigation/Research	x					x								x				x						x					x
Legislation	x																												
Agriculture				x				x		x								x						x		x	x		
Mining/Oil Exploration																x		x						x					
Desalination/Irrigation										x														x					
Administration/Management	x	x																						x					
Construction	x									x	x							x						x	x			x	
Defense	x	x				x	x		x	x					x	x	x	x			x			x	x		x		x
Household Equipment														x		x								x					x
Public Works/Safety/Security	x	x									x	x						x						x			x		x
Fishing/Ocean Sciences			x			x												x						x			x		
Space Exploration/Operations	x	x	x			x			x	x					x	x	x	x						x	x		x	x	x
Merchandizing/Restaurants	x															x								x			x		
Storage/Warehousing/Packaging	x																							x					
Environment Conditioning									x	x														x			x		

Few if any graduate courses are given in these subject areas. The professional must depend upon nontraditional lines of education if the requisite technology transfer is not attainable on the job or through professional channels. Only a few continuing engineering studies programs across the nation deal with these subjects and at several levels to meet diverse audiences and mixtures thereof.

With the foregoing in mind, the principal professional needs for CE/S&E are as follows:[4]

1. *Stretching* the competencies of alert, up-to-date professionals in their own areas of specialization as well as in peripheral areas affecting their work.
2. *Boosting* the knowledge of engineers in emerging areas of technology so that they may respond promptly to related opportunities in their employment and integrate related techniques into their current activities as appropriate.
3. *Bridging the gap* between the theoretical background of recent engineering and science graduates and what they need to know about the reduction of new knowledge to practice, thereby becoming creative and productive on a specific job in a particular company.
4. *Converting* professionals who have been previously trained and experienced in areas or fields other than those in which they are now employed or seek employment.
5. *Updating* the knowledge and skills of engineers who have slipped behind in their own areas of specialization through either neglect or preoccupation with older technologies, possibly as related to high-production enterprise.
6. *Reorienting* engineers who have been transferred or promoted into jobs for which they are inadequately prepared so as to accelerate the process of learning on the job and becoming an effective contributor or manager in their new assignments.
7. *Retraining* engineers whose specialties are obsolete.
8. *Upgrading* the competence of engineers who have been inadequately prepared.
9. *Familiarizing* technicians and other support personnel with engineering concepts and terminology so that they may communicate effectively with professionals and thereby perform closely related work with greater understanding and proficiency.
10. *Transferring* new knowledge emanating from applied research and development activities into established patterns of graduate and undergraduate education.

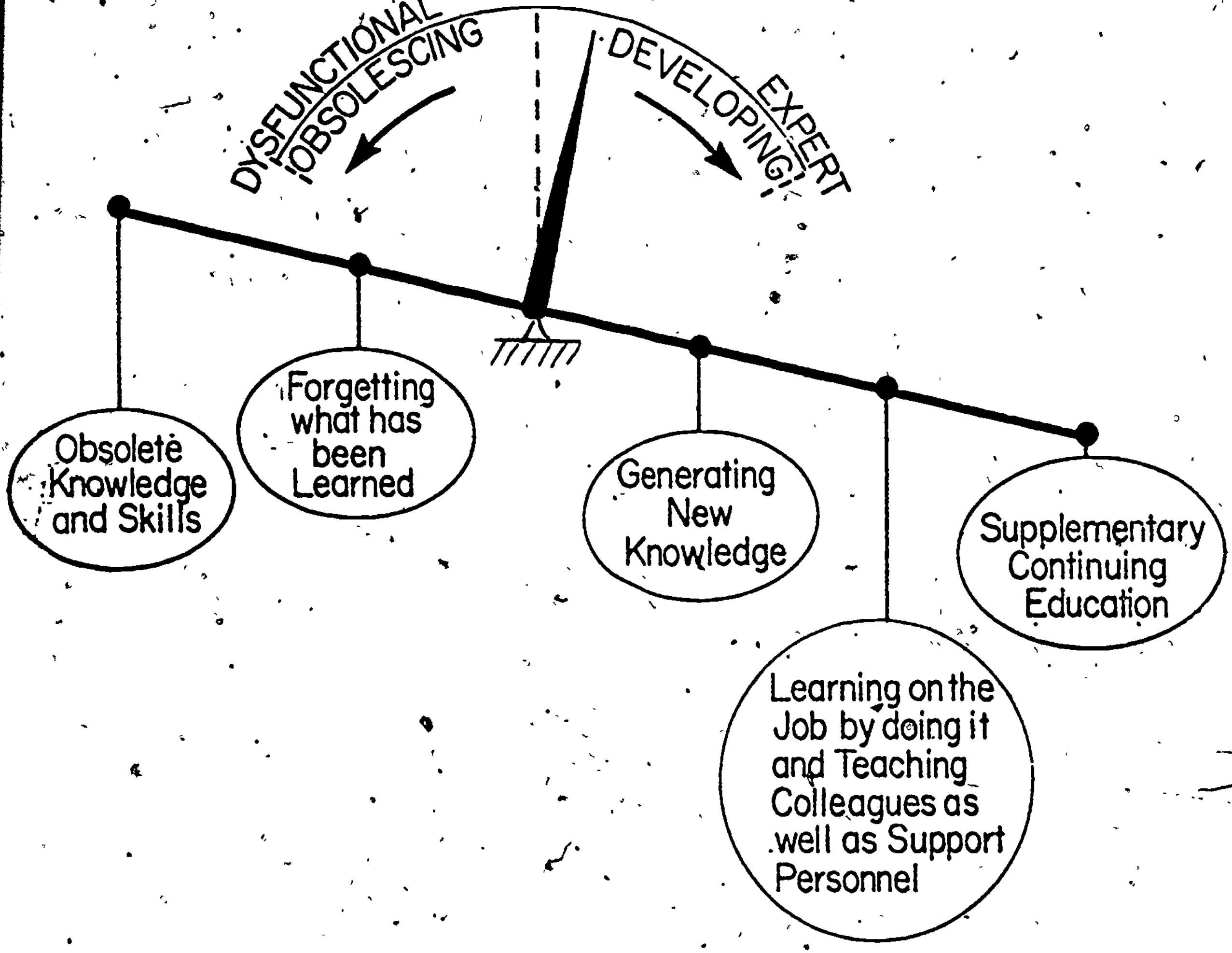
II. How the Challenging New Knowledge Environment and Penalties for Falling Behind Affect Scientists, Engineers and Technicians. Delineation of CE/S&E Audiences. Categorization of Various Target Audiences and Their Interrelationships

Professional contributions of most scientists, engineers and technicians are affected by their personal knowledge dynamics; the net difference between their individual knowledge losses (over which they have no control) and their knowledge gains (which they can control). Consider Figure 2, which represents a balance loaded by forgotten knowledge (that may still be applicable) plus obsolesced knowledge (that is no longer useful) on one side of the fulcrum, outweighed by retained useful knowledge consisting of new knowledge gained on-the-job by doing it, new knowledge generated in the course of one's work and new knowledge acquired through continuing education as a supplement to learning on the job. An individual who has such favorable dynamics is developing greater competences. The useful knowledge, which is considered to have a half-life of 10 years, attenuates through a combination of brain cell death and obsolescence by virtue of technological advances that replace it. Professionals who are not learning at least 100% of what they need to know to keep doing what they are doing by doing it are bound to slip behind unless they make up deficiencies by actually generating new knowledge or supplementing on-the-job learning with continuing education.

In time, obsolescent individuals will be at risk of unemployment with little likelihood of recouping their previous status amongst professionals. Obsolete scientists will not longer be active at the frontiers of knowledge. Obsolete engineers will not be asked to work on high-technology programs nor contribute to further advances in more mature areas of technology. Technicians who have fallen behind will no longer work with advanced techniques for reducing to hardware the R&D performed by scientists and engineers at the cutting edges of the technological advance.

It is important to recognize that a broad range of talent and intellectual acuity exists amongst these three major groups of nonacademic practitioners. At the very top of these groups are individuals who work alone or in mixed teams on creative contributions to the technological advance. They continuously need new information relating to similar lines of work, but at somewhat differing intellectual levels or from differing perspectives. Below this top grouping lies an almost continuous spectrum of contribution, and hence knowledge needs, that ranges from highly advanced to routine work in line with their functions and fields. Advances often occur in every work area and at every contribution level, but the pace of

Figure 2.—The Knowledge Balance



change usually falls off from very fast towards static with the maturity of the science or technologies involved. Practitioners in the more mature fields, however, are subject to replacement by individuals from the more advanced areas as they obsolesce or otherwise descend into the less-challenging jobs. Frequently, the replacements are younger people who have not kept updated in a higher technology job and are happy to accept lower paying employment. Sometimes the replacements are entry level individuals being exposed to company operations, but without much expectation for creative contributions.

A hierarchy of competences can be used to categorize CE/S&E audiences, but it is important to realize that a given individual can readily slip down this hierarchy by not doing enough to remain abreast of developments at a particular level. Of course a given individual can also ascend the hierarchy, but strenuous effort is required against fast-moving targets. Every professional faces this problem, but especially so the entry level scientists, engineers and technicians.

An educational hierarchy also exists that correlates accurately with the intellectual capacities of individuals. This hierarchy, given in Table III, categorizes the several levels of learning or teaching/learning processes that may be used to delineate differences between and within various CE/S&E audiences.[5]

Here, then, are the principal CE/S&E audiences which we must serve to maximize their contributions as scientists, engineers or technicians consistent with their intellectual planes, diligence in updating, creativity and energy.

a. Advanced Scientists and Engineers in Industry and Professional Practice

These persons are highly creative and generate most of the new knowledge in the physical sciences and technology. They often work together on R&D teams and in time acquire similar job functions. Differences between their competences and contributions tend to blur.

As a group, these individuals are highly motivated to continue their educations informally, but can benefit from interactive teaching/learning educational sessions during which they would exchange information, argue controversial points and invite experts in particular subject areas to present brief seminars and then remain as resource persons during subsequent discussions.

TABLE III.—The Teaching/Learning Hierarchy Applicable to Several Levels at Which CE/S&E Must Be Conducted

1. *Learning with the help and example of others* - possibly the most effective means for acquiring basic and even primitive information as in infancy, in adolescence, in secondary education and in many instances of what is called higher education. At this level, the mother helps the child, the teacher instructs the pupil and the professor lectures to the students. All learners pass through this level, but for many it is terminal, and the self-teaching component of the process is minimal.

2. *Learning from one's own experiences by applying what has been learned previously to problem solving*. This form of self-teaching/learning may occur at any age, but the frequency of such learning increases as the content becomes more advanced and pragmatic, particularly in professional fields. This hierarchical level of learning seems to be terminal for most people. When it becomes a matter of policy to accept only what one has learned by oneself, however, it is the beginning of a retrograde process toward primitive ignorance.

3. *Learning from the experiences of others in their efforts to [illegible] problems*. Few people, even professionals, realize the [illegible]age available by studying the experiences of others in the [illegible]tion of problems with which they are confronted. Libraries [illegible]at store information of the kind that could be of benefit to many are seldom used by engineers, and all too few engineers seek experienced help in solving their own problems. This form of self-teaching/learning is the key to job enrichment* and professional development.

4. *Learning in the process of teaching others*. Teaching usually includes formal classroom lecturing and recitation, writing or simply communicating with others. Learning occurs in teaching others because the competence of the teacher is challenged and thereby motivates teachers to stay ahead of their students. Professionals who learn on their jobs and teach what has been learned to others reinforce their own learning and become skilled in applying what was learned.

5. *Learning from one's own experiences in the process of generating new knowledge useful in recognizing it as such*. The generation of new knowledge usually implies that the professional has already acquired expertise in a learned field together with a sufficiently large body of information from which to draw as an aid in recognizing new knowledge useful for understanding new or previously unexplained phenomena and describing their effects.

6. *Learning by sharing with others one's own experiences in the process of generating new knowledge and benefiting from others' experiences gained in similar processes of generating new knowledge*. This level of teaching/learning suggests an information exchange among individuals working at the very frontiers of knowledge in their fields as well as abilities to [illegible]rmulate abstractions that can carry over from one field to [illegible]ther or to differing situations and circumstances so that subjective problem solving can be done in various fields.

7. *Learning by functioning as a catalyst who initiates a knowledge exchange among advanced professionals, keeps discussions heated as well as focused on the subject and helps the group over difficult, controversial or speculative points as they arise*. This function is the most demanding, but also involves the catalyst in a highly rewarding teaching/learning experience.

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* *Job enrichment* - the expansion of a job's content; hence the extension of its challenge and its incumbent's responsibilities, authority and accountability

In most instances, these persons already have their terminal academic degrees and are not interested in obtaining additional academic credentials. Nor do they particularly care for the usual academic controls of quizzes, examinations, detailed or lengthy assignments, grades and prerequisites. As a rule, they are interested in subject matter at the very frontiers of knowledge about which little has been published. In most cases, the topics covered are years ahead of insertion into academic curricula.

While considerable variation will be found amongst their formal educational backgrounds, they are individually capable of comprehending and contributing to classroom sessions because they have acquired the requisite background knowledge on the job.

b. Technicians Working in Support of Advanced R&D Activities

Inasmuch as advanced scientists and engineers tend to lose sight of the intellectual and educational differences amongst people with whom they work intimately, these technicians are expected to comprehend the hardware aspects of work in progress almost as if they were major contributors. In fact, they are expected to make creative contributions to the development of hardware, and their advice is sought for suggestions or recommendations whereby scientific and engineering ideas can be translated into equipment and their feasibilities demonstrated

For these reasons, technicians working in support of advanced scientists and engineers are expected to be conversant in the principles underlying the hardware involved, the theory of equipment operation, the applicable performance parameters and means for measuring them, methods of hardware fabrication and quality testing, general design requirements and means for determining correlation with design, compliance with materials specification, tests and standards, as well as recognition of errors in the design introduced by scientists and engineers who may lack sufficient practical expertise in the specification of hardware

These technicians learn most of the new knowledge required to perform their jobs in the processes of doing so, but since hardware designs and changes in materials, components, techniques, specifications and tests as well as standards are continuous and rapid, a variety of specially designed continuing educational programs are required to help them keep abreast of pertinent developments.

c. Scientists, Engineers and Technicians Working on Routine Assignments

Although a wide assortment and impressive number of scientists, engineers and technicians appear to be diligently at work, it is important to understand that only a small fraction of these persons are truly making significant progress and contributing to technological advances that require new technology transfer and continued learning.

Many scientists, engineers and technicians work on routine tasks, however advanced they may appear, and are quite complacent about not stressing their competences by needing to apply new theories, techniques, materials, tests, specifications or standards to the performance of new or even old functions under different or more difficult conditions and adverse constraints. Concentration on routine tasks contributes to obsolescence, but seldom forces the contributor to supplement on-the-job learning with new knowledge that simply is not obtainable on the job. One of the earliest indicators of falling behind is the inability of an individual to fully comprehend the technical literature in one's own field. Therefore, despite their seeming preoccupation with work, which often consists of brushing up on well-plowed ground, the contributor to routine tasks relies on proven techniques and components, that usually place less stress on equipment and operate at lower speeds but are understandable and useful until replaced by competitive equipment. For these reasons, the contributors to routine tasks are unduly conservative, seldom adventurous in the sense of specifying or utilizing radically advanced technology, they dislike change, are resistive to miniaturization and tend to avoid increases in automation for fear of losing control of equipment operation.

Unfortunately, scientists, engineers and technicians who are comfortable in routine work are seldom voluntary participants in continuing education. While they constitute the largest identifiable audience for CE/S&E, a measure of compulsion is required to make them participate. No doubt they can be persuaded to continue their educations, given sufficient pressure, but it is necessary to start at the job level and ensure that the climate is conducive to innovation and consistent with motivating factors that stimulate rather than compel participation in continuing education. The climate essential to stimulating participation in CE/S&E so that persons in this group can rise above routine tasks is as follows:[4]

1. Opportunities to learn and develop new knowledge on a challenging job.
2 Freedom to publish new knowledge within constraints imposed by security and proprietary considerations.
3 Opportunities for creative contribution on the job despite pressures imposed by contractual commitments.
4. Supportive attitudes of management toward innovation, particularly when not covered by contract.
5 Accessibility to resource persons and courses in the plant.
6. Adequacy of related engineering and shop support for creative activities:

7. Availability of pertinent in-service courses that can be taken on the job.
8. Opportunities for cross-functional experiences as a factor in professional development.
9. Encouragement to participate in the work of professional societies and contribute to engineering symposia
10. Absence of factors or policies that unnecessarily inhibit professional activity or development.
11. Favorable physical conditions in the work environment.
12. Congenial colleagues and generally good morale.
13. Encouragement of younger engineers to do graduate work on a tuition refund plan.
14. Support of quality continuing engineering studies that may or may not be job related.

d. Scientists and Engineers in Midcareer

Scientists and engineers in their forties have generally risen in salary to levels that cause management to wonder whether it is getting its money's worth. They have been on the job an average of 20 years and should either have transferred to management, accumulated a track record of solid accomplishments or fallen behind through complacency and routine assignments.

Whatever stage they are in, the technology affecting their work has usually undergone radical change Their abilities to hold on to their jobs, however (other factors such as business climate being favorable), indicates that they have somehow kept productive. Yet they may need to choose from a variety of CE/S&E educational opportunities to enhance their competence to operate at the forefronts of the technological advance.

Of this midcareer group, the outstanding contributors will probably need little if any formal coursework They will probably be the instructors of the science, engineering and management courses that their less able colleagues will take They may, however, participate in interactive teaching/learning sessions that are heated, speculative and stimulating while focused on difficult aspects of work in progress or difficult problems facing the field and apt to arise in new business ventures.

Midcareer engineers who have not established outstanding records are generally vulnerable to replacement by younger people at a fraction of their salaries or subject to reassignments to work that is less taxing. Given a measure of sympathetic career guidance, members of this group can be reoriented into activities that are productive, stimulate learning on the job, and are sufficiently challenging to require supplementary CE/S&E.

e. Unemployed Scientists, Engineers and Technicians as Well as Those Facing Termination or Designated as Surplus

The physical sciences and higher technology industries have not been stable in recent years. In part the "feast or famine" character of these industries is attributable to perturbations of the economy, but in most instances a lack of proper planning, political factors affecting defense procurements, and changes in technology account for the geographic as well as numerical shifts in manpower that force physical scientists and engineers to follow jobs around the country. Uprooting of families and loss of pension contributions by employers, in addition to losses of jobs, make the physical sciences and engineering less desirable career fields for young people.

Of course, not all scientists, engineers and technicians lose their jobs because of contract terminations; some become obsolete and leave their fields. A large number of scientists and engineers who have lost their jobs, however, did so often at the peaks of their careers. Their salaries were high, so their companies couldn't afford to keep them. For example, the reward for the successful completion of Project Apollo, for most engineers in the aerospace field, was termination of their employment.

Unemployment for a significant number of scientists, engineers and technicians, while traumatic, is relatively brief. Those that do get new jobs, however, usually do so at appreciable loss in salary and opportunity to contribute as they had been. A measure of reorientation plus retraining is required, but the principal concern is that of learning readiness. Virtually no learning can occur when the individual is preoccupied with financial concerns, lack of a job, family problems and unmet community commitments. The first requirement is a job with promise. Then, with a measure of competent counseling, the individual can learn on the new job and supplement such learning with appropriately designed CE/S&E.[12]

Probably the greatest waste of scientific and engineering talent, which is a great national resource, is the career damage that occurs when creative contributors are thrown out of employment. Yet, however strenuous the efforts of retraining, it is pointless to expect unemployed professionals to benefit from CE/S&E until their personal concerns are mitigated and they have a firm offer of a job upon completion of the reorientation or retraining program.

f. Entering Level Scientists and Engineers

Whatever their academic levels at the point of entry into professional practice, recent graduates of science and engineering schools face an ever-widening gap between their theoretical and increasingly liberal education and the requirements for creative contribution on a particular job in a specific industry.

[illegible] employers have formulated on-the-job training programs and special educational patterns that are effective in closing the gap, even though the recent graduates face fast-moving targets. CE/S&E programs for them are best accomplished on an in-plant basis. While such programs generally supplement learning on the job, they do not quite meet the need for creative contribution at high levels. Almost as a rule, recent graduates do not participate in out-of-plant CE/S&E programs until they have accumulated about 5 years of professional experience

g. Re-entering Scientists, Engineers and Technicians

Individuals who have been away from their professional practice for extended periods of time for reasons of illness, to raise a family, extended unemployment, to study full-time for advanced credentials, or leave for nontechnical service, find that their fast-moving fields have rushed past them and that a substantial gap in knowledge exists between their competence and that required for creative contribution. The problem is not unlike that of the entering recent graduate except that many younger people had in the interim moved into their jobs and are now competing with them. Women, in particular, find that their new colleagues are often 3 to 10 or more years younger and highly competitive.

Probably the most effective way to integrate re-entering individuals is to provide them with a challenging job that is supplemented by in-house CE/S&E aimed at compressing the time required to bridge their knowledge gaps.[4]

h. Scientists and Engineers Entering Without Formal Technical Backgrounds

With the growth of interdisciplinary aspects of R&D, many people with academic preparations in mathematics, theoretical physics, psychology and the like are to be found working in industry as engineers. In most instances, such people who have not achieved terminal degrees in their fields have found a career home in engineering. Their talents are welcome and they have made notable contributions, but because they are not particularly conversant in engineering, they cannot have as much impact on the job or learn as much on the job as they should

Some of these people have taken graduate work in engineering, on either a part-time or a full-time basis. Most of them, however, can benefit from a combination of CE/S&E in-plant and university-based programs to strengthen their engineering backgrounds so that they may be stimulated not only to enhance knowledge acquisition on the job, but also to upgrade their contributions

i. Support Personnel

One of the difficulties encountered by industry is a lack of adequate familiarity with technology on the part of support personnel. This situation contributes to inefficiencies in such functional work as finance, legal services, contract administration, purchasing, security, manufacturing, warehousing, computer operations and the like It is not necessary for personnel in such functions to acquire the conversance with technology expected of technicians (including laboratory assistants, draftsmen, test operators, inspectors, machinists, instrument repairmen, electricians and other technical production personnel), but they and the industry can benefit from a better understanding of their product lines and processes involved in creating them.

A variety of awareness programs should be made available for such personnel on a continuing basis to help them acquire insights that will help them do their own jobs better where conversance with technology is involved.

j. Immigrant Scientists, Engineers and Technicians

The average annual new openings of jobs on a national basis projected for the period 1977–1985 are approximately 17,000 for physical scientists and mathematicians, 73,000 for engineers and 59,000 for science and engineering technicians. The corresponding average annual replacements expected for these openings based on past experience in filling such jobs from available sources, as determined from U.S. Bureau of Labor Statistics, are only about 10,500, 40,000 and 16,000. An annual average shortfall of 6,500 scientists and mathematicians, 33,000 engineers and 43,000 technicians is expected for the same period.[6]

While it is projected that the U.S. educational establishment will graduate an annual average of 52,000 physical scientists and mathematicians at all degree levels, 67,000 engineers in all categories and 73,000 science and engineering technicians, which should be more than enough to satisfy the openings, the majority of U.S. graduates will elect not to enter their fields. They will go on to other endeavors for which science, mathematics, engineering or technical education seem valid preparations.

Some of the job openings will be filled by persons having nondirect but nonetheless pertinent educations—such as scientists or mathematicians working as engineers.

No doubt, the shortfalls will present opportunities to foreign scientists, mathematicians, engineers and technicians for jobs and immigration. Those from English-speaking countries will be readily integrated, but the majority of such immigrants will require continuing education to help them adapt to U.S. practices.[7]

Estimates of Nonacademic CE/S&E Audiences

The Bureau of Labor Statistics, U.S. Department of Labor, provides data that can be used to assess the numbers of individuals in the several occupations who might benefit from CE/S&E, but mainly on a national basis. Unfortunately, indications are that only a small fraction of the technical labor force is now committed to continuing education. An assessment nationwide remains to be made, but even in a high-technology locale such as Boston, Massachusetts, probably less than 3% of the eligible population currently participates in university-operated CE courses, and less than 10% of the eligible population participates in company-conducted programs. For these reasons, in planning most CE/S&E programs it is necessary to focus on a particular locale or region in assessing the probable audiences. Yet, even if such data were assembled, further speculation would be necessary to estimate the sizes of particular audiences as functions of their occupational status, needs and abilities to participate in CE/S&E at various levels.

Data taken from reference 6 are presented here to demonstrate the overall population, nationwide, that could conceivably participate in CE/S&E (hereafter called the eligible population). Then, data based on the Boston industrial complex is used to illustrate how various nonacademic CE/S&E audiences can be estimated for a given geographic location. Of course, some CE/S&E programs draw nationally or internationally, but the expense and short duration of such programs places them in a special category. They may augment, but do not constitute, CE/S&E on a continuing basis or regimen for supplementing learning on the job. It is important to recognize here that, however useful occasional attendance at a short course of several days' to several weeks' duration may be, such courses do not replace continuous lifelong learning essential to keep scientists, engineers and technicians updated, innovative and competitive. Moreover, the tuition, travel and living costs associated with such programs, in addition to salary and overhead paid during employee participation in short courses at national centers, precludes attendance by significant numbers of professional people Most industrial organizations allow their top contributors to attend a 1-week short course about once every 2 years

The National Scene (Figures Based on Estimates for 1977)

About 450,000 scientists, 1,200,000 engineers and 950,000 technicians are currently employed[6] In addition, about 70,000 mathematicians are employed in diverse capacities, some of which are applicable to industrial practices.

It is projected that by 1985, about 533,000 scientists, 1,500,000 engineers and 1,240,000 technicians will be employed. Additionally, 77,000 mathematicians are expected to be in professional practice.

The size of the potential market is large, but it would be highly optimistic to expect more than 20% of these people to actually participate in CE/S&E, at all levels, in the near future. Undoubtedly, with further advances of science and technology, plus Federal encouragement of CE/S&E and the possible adoption of certification procedures for registered engineers and some technicians, it is likely that 50% of the national eligible manpower force in science and technology will commit itself to CE/S&E as an ongoing career-long regimen by 1985.

On the basis of these assumptions, in addition to an assumed linear attenuation of audiences with age, the anticipated audiences at all levels, by age groups, are estimated here to be as follows:

Age Group	*Scientists*		*Engineers*		*Technicians*	
Years	1977	1985	1977	1985	1977	1985
22-28 (Entering Levels)	27,000	32,000	61,000	76,000	49,000	64,000
28-40 (Seasoned Levels)	42,000	49,000	97,000	120,000	76,000	100,000
40-50 (Midcareer Levels)	22,000	26,000	51,000	63,000	40,000	52,000
50-65 (Mature Levels)	12,500	15,000	29,000	36,000	23,000	30,000

Although the above table is based on participation by 20% of the eligible population in nonacademic CE/S&E, it is estimated that only about 10% of the current eligible population participates in all forms of non-academic CE/S&E. With government encouragement, participation should rise quickly to 20% for combined university-based and industry-based CE/S&E programs These figures do not include undergraduate and graduate students seeking academic credentials either on a full-time or on a part-time basis.

The Boston Complex

It seems important to indicate, at the outset, that the Greater Boston area has unique industries and educational institutions which constitute an unusual laboratory for CE/S&E in its several aspects. It can also provide a model for assessing needs and target audience in any locale.

Boston has numerous industrial organizations based on advanced technologies that are actually satellite operations of large companies headquartered elsewhere in the country, but their practices relative to CE/S&E on home grounds may differ radically from what they are in Boston. Fortunately, most of these companies usually have enlightened policies concerning continuing education, but they are also very discriminating with regard to costs and the quality of education. Thus, they prefer in-house programs if outside opportunities (university-based) are not available or favorable. Of course, Boston has its share of locally centered, sprawling companies with distant plants and facilities. Some of these companies are also generous and farsighted regarding educational benefits for employees.

Industry in the Greater Boston area ranges from light to medium heavy, and encompasses such things as textiles and textile machinery, shoes and shoe machinery, leather and wool processing, energy conversion, defense electronics, electro-optics, shipbuilding, scientific research, seafood processing, paper goods, sugar refining, coffee processing, meat and dairy foods production, fruit and vegetable processing, garment manufacturing, medical and dental instrumentation, aircraft and marine propulsion machinery, specialty rubber goods, printing and publishing, hydraulic and pneumatic equipment, industrial materials processing machinery and equipment, furniture, bedding, confectionery production, photographic equipment, electrical instruments, toy manufacturing, plastics, industrial chemicals, pumps, blowers and fans, furnaces and ovens, razor blades, data processing equipment and a multitude of sundry manufactured goods produced in seemingly countless small production plants operating on job-shop bases. In addition, regional offices of numerous distant industrial organizations are centered here to service their customers and plants in New England. Since many of these organizations are technically oriented, a significant group of scientific and engineering people are associated with their offices and constitute a substantial part of the local educational market.

Another factor that makes Boston different from many urban centers is the large number of leading educational institutions that provide courses and seminars as well as special programs in virtually all subjects, at all reasonable hours of the day and night, and at all levels. Consequently, it is possible for individuals to update or upgrade themselves in institutions such as Harvard, MIT, Northeastern, Tufts, Boston University and Boston College, among others, both at graduate and undergraduate levels.

Table IV provides an estimate of the current composition of most Greater Boston industries and the numbers of engineers employed by the largest of 200 industrial organizations within a 15-mile radius of downtown Boston. This table is based on the latest information (1974) available from the Greater Boston Chamber of Commerce. No provision in the collection or reporting of this data distinguished between scientists and engineers. Thus, the assumption is made that the data for engineers includes physical scientists.

More recent data (1975) furnished by the Massachusetts Division of Employment Security[7] shows that there are 249,688 professional and related technical workers in the Greater Boston area, but of these only 28,150 are listed as engineers and 20,653 are technicians (except health). On the assumptions that here the engineers do not include scientists and that the composition of the scientific, engineering and R&D technicians workforce is similar to the national profile, it is assumed that approximately 12,000 physical scientists, 28,000 engineers, and 20,500 technicians are employed in Greater Boston.

On the basis of these assumptions, the probable target audiences for nonacademic CE/S&E during 1977 and as projected to 1985 by age groupings for 20% participation and a linear-attenuation by age of the eligible populations are as follows:

These figures correlate fairly accurately with current estimates of participation for personnel in the Greater Boston area covering both company-conducted and university-based nonacademic CE/S&E. It is expected, however, that given added incentives and governmental encouragement, participation could rise to 50% of the eligible populations or 250% of the figures given above.

At present, approximately 1,200 professionals participate annually in the CE/S&E program at Northeastern University. Approximately 20% of the participants have Ph.D.'s, 60% have master's degrees, and 20% hold bachelor's degrees in the sciences or engineering.[8]

Age Group	*Scientists*		*Engineers*		*Technicians*	
Years	1977	1985	1977	1985	1977	1985
22-28 (Entering Levels)	600	700	1,500	1,800	1,000	1,300
28-40 (Seasoned Levels)	1,000	1,200	2,300	3,400	1,700	2,100
40-50 (Midcareer Levels)	500	600	1,100	1,600	800	1,000
50-65 (Mature Levels)	300	360	700	1,000	500	600

III. Characteristics of Productive Scientists, Engineers and Technicians; The Most Likely Candidates for Continuing Education

What then are the characteristics of productive scientists, engineers and technicians who are the most likely candidates for CE/S&E? First and foremost is their productivity. Whatever level of science or technology they work at, they are full of ideas for advancing or implementing new developments. Moreover, they are not stumped by obstacles in the realm of change, theory, materials, manpower, facilities or funds. They do the

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TABLE IV.—Composition and Employment—Greater Boston Industries

Product or Service Lines	*Total Employees Within 15-Mile Radius 200 Employers*	*Estimate of Engineers Working Within 15-Mile Radius*	*Within 25-Mile Radius Total Employees 500 Employers*
Rubber Goods	8,200	110	9,500
Chemicals	2,410	460	5,000
Optics	2,975	850	6,500
Office Equipment	1,600	40	2,800
Building Materials	5,800	520	8,000
Electronics—Communication	7,617	1,800	15,000
Electronics—Aerospace	28,405	7,000	40,000
Electronics—Industrial	15,648	1,600	22,000
Machine Parts	11,850	850	18,000
Garment Industry	7,960	20	15,000
Domestic Devices	500	15	900
Packaging Materials	500	30	1,200
Paper Goods	2,600	225	3,800
Leather Goods	5,600	50	14,500
Shipbuilding	6,300	150	7,500
Instrumentation	7,486	2,500	11,000
Electrical Machinery	5,500	510	6,000
Aircraft and Marine Propulsion	5,200	1,200	5,200
Automotive Parts and Assembly	8,450	175	14,600
Barbering Supplies	3,200	200	4,000
Biomedical Instrumentation	800	425	1,300
Energy Conversion	660	350	800
Computer Technology	10,500	3,100	6,000
Toys	650	35	800
Industrial and Product Research	3,675	2,100	8,500
Spirit Distillation	500	15	500
Military Planning	1,700	900	1,700
Photographic Equipment	6,000	1,200	7,500
Food Processing	650	30	1,600
Textiles	700	150	2,500
Printing and Publishing	7,500	40	11,000
Banking and Finance	12,070	10	13,000
Domestic and Industrial Insurance	18,900	260	20,000
Wholesale and Retail Trade	37,500	600	65,000
Transportation	11,000	40	16,000
Utilities	11,320	350	13,500
Telephone and Telegraph	10,000	700	18,000
Health and Hospital Services	17,000	125	29,000
Higher Education	38,000	3,000	46,000
Hotel and Recreation	5,400	60	12,000
Food Products and Services	15,000	10	40,000
Construction	6,500	850	26,000
	353,826	32,655	551,200

best they can, however trying the circumstances, and manage to further the work in progress. They tend to lose sight of time because of absorption in their work and dig hard for new knowledge and techniques that they feel are required to do the job right. Above all else, they communicate openly with their colleagues, share information and teach each other those things that must be transferred without undue concern for position or rank. In particular, the earmarks of diligent CE/S&E learners can be summarized as follows:[4]

1. Assume leadership roles on difficult projects and proposals.
2. Serve as spokesmen during presentations to important customers of complex proposals or reports.

3. Document creative contributions to advanced developments or research.
4. Publish papers in noteworthy professional journals.
5. Make knowledgeable contributions to business planning and marketing strategy.
6. Speak before technical societies, customers colleagues and management.
7. Participate in after-hours teaching of in-house courses or at a university.
8. Are frequently consulted by colleagues, other companies, vendors, customers or government agencies.
9. Participate in job-related continuing engineering studies as student, instructor or both.
10. Receive repeated job offers.

Equally important, it is necessary to understand the characteristics of professionals as learners when implementors of continuing education are formulating CE/S&E programs. If these characteristics are not recognized and acted upon by management as well as the administrators of continuing education, serious errors in program design and implementation will be made and the effectiveness of the program reduced.

The characteristics of the contributing scientist, engineer and technician as a learner are:

1. Possesses a body of knowledge and experiences to share and is often a generator of new knowledge.
2. Usually has depth in one or more disciplines and breadth in several areas of concern pertinent to work in progress.
3. Typically eager to obtain specific knowledge directly or peripherally related to his or her work.
4. Often untrained formally in the area of immediate vocational/specialty because work content is subject to frequent change or reorientation.
5. Frequently trained in discipline differing from area in which continuing education is undertaken.
6. Often capable of serving as instructor in course or workshop being attended.
7. Acquired considerable knowledge and deep understanding of difficult subject matter on the job and through related professional activities.
8. Severely limited in time for studies—generally cannot afford to take time from job. Frequently is required to travel at times that seriously interfere with CE/S&E. Allowances for absences from a program must be particularly liberal.
9. Needs time to digest, reflect upon and apply newly acquired knowledge to the job before ready for additional learning.
10. Preoccupied with pressures stemming from professional, family and community commitments.
11. Generally concerned with job security and competitive position rather than advanced degrees. Is seldom concerned with grades for course work, but is appreciative of modest recognition for efforts to remain updated.
12. Resents being forced into study programs aimed at the accumulation of credentials rather than immediately applicable knowledge.
13. Readily discouraged by course prerequisites, deadlines, attendance or promptness requirements, hurdles, quizzes, needling, special fees or fines for late registration, high-school atmosphere, etc.
14. Is sometimes prohibited to share knowledge with others to the fullest because of security or proprietary considerations.

IV. How Scientists, Engineers, Technicians, Teachers, Researchers and Academic vs. Industrial Employees Remain Current, Creative and Competitive

Probably the poorest advice that one can give regarding how to keep up with a fast-moving field is to drift with the stream. It doesn't work well. Besides, there are rapids, whirlpools, rocks and other impediments that hinder progress. Deliberate, often strenuous, efforts are required to steer a survivable course and make headway in a stream that rushes ahead and merges with other currents.

The key to keeping abreast of a fast-moving R&D field is significant participation in work progressing at the very cutting edge of the advance, but doing so requires much more than professional contribution.

First and foremost is the need to be knowledgeable in the theory and practices pertinent to the field so that new phenomena or problems can be recognized as they occur, but acquisition of such knowledge rarely occurs in schools. A sound background is essential. Much of it initially comes from academic preparation, but most of that background eventually is acquired on the job, particularly as the individual grows in competence by applying what is already known to achieve desired results and generating or otherwise obtaining such new knowledge as may be required to achieve those results.

An iceberg analogy,[9] given in Figure 3, illustrates how the initial charge of knowledge acquired in school melts away with time as the graduate seasons* and ultimately

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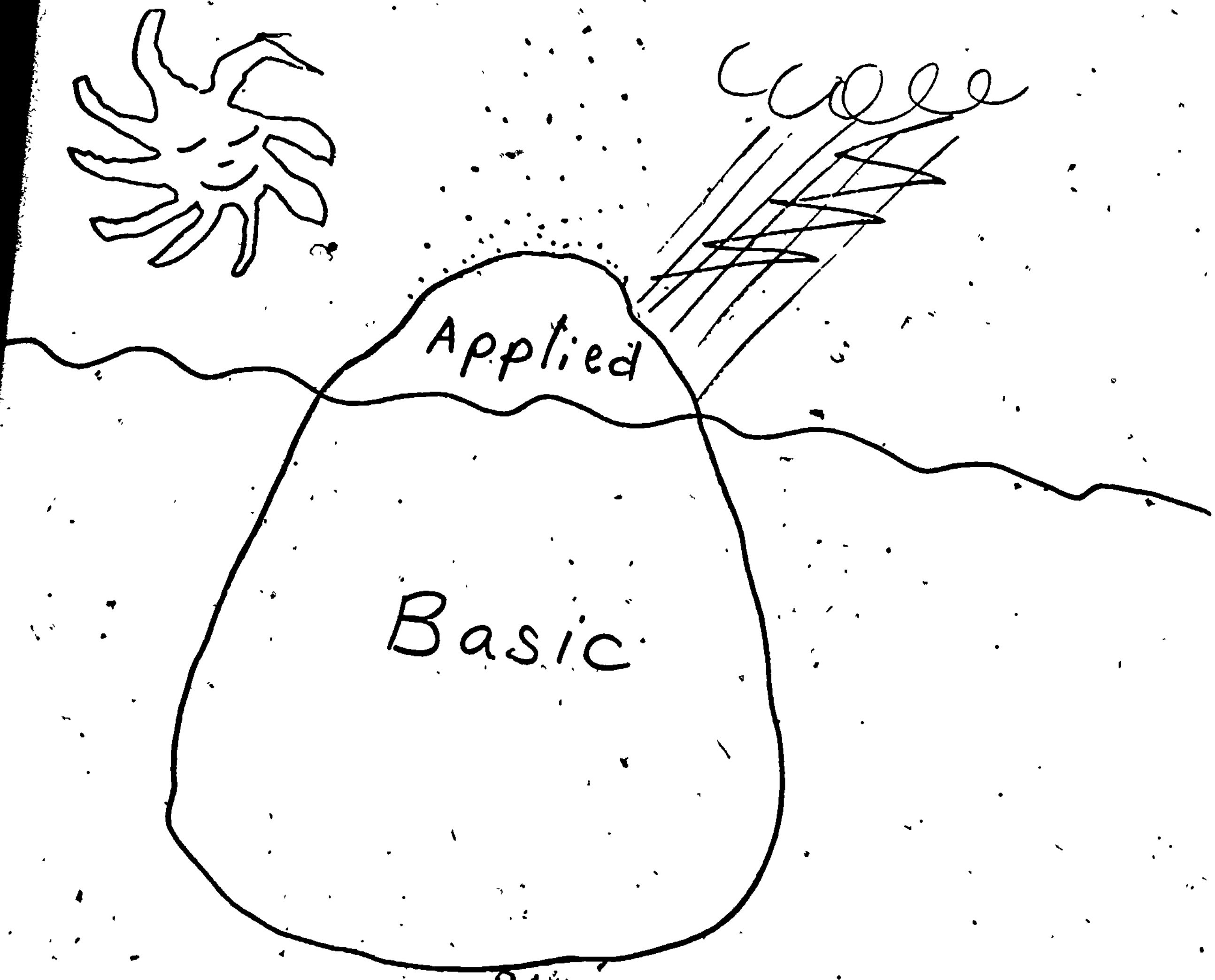
* Achieves a deeper understanding of differences between theory and practice, can cope effectively with practical deviations from the ideal in applications of scientific principles, and acquires discretion in design that takes into account constraints imposed by socio-economic, political, aesthetic, health and competitive technical factors.

Figure 3.—The Iceberg Analogy



is replaced by new knowledge acquired in the course of professional practice. The qualities of a professional's job, however, has much to do with the opportunities to accumulate new knowledge and transfer it to new work and to colleagues.

In this analogy, a sunny job that poses few difficulties leads to complacency. The top of the iceberg melts as the bottom deteriorates in the sea. Similarly, a stormy job preoccupies the professional with difficulties and "fire-drills" that afford little time for growth. The top also melts as the bottom attenuates. Only a challenging job, represented by snow, allows for the accumulation of mass, which in turn also increases the size of the submerged mass. The basic part of an individual's knowledge is obtained originally through formal education but may be augmented by new knowledge of a fundamental sort acquired on the job. Basic knowledge is enduring, yet becomes rusty with age unless burnished frequently through use. The applied component of an individual's knowledge is exposed to the elements and suffers the wear and tear of daily usage. It may change rapidly in content, tends to be interdisciplinary as well as speculative and obsolesces quickly, but it is the part of an individual's knowledge that pays off quickly, and its mass depends upon the underlying structure of basic knowledge that supports it. Addition to the submerged portion of knowledge, such as through graduate study, forces some of it up into the applied area, but usually at a rate inconsistent with the pace of technological change. Addition of applied knowledge forces more of the total mass to submerge, thereby adding such basic knowledge as is necessary to comprehend and apply new phenomena, techniques and materials. Continuing education that truly supplements on-the-job-gained knowledge and experiences operates primarily on the upper or applied portion of the knowledge iceberg. Its effect on the total mass, however, depends upon the quality of the CE/S&E program and the abilities of an individual to benefit therefrom. In time, accumulations of new knowledge on the exposed portions of one's iceberg may cause it to tumble into new career opportunities. Ultimately, with age, accumulations cease and the iceberg melts away.

Scientists, engineers and technicians in industry must strive for opportunities to work at the cutting edges of technological advances that are not always available, but they are limited in professional growth only by their own intellectual levels and diligence in keeping ahead. Although their jobs can introduce barriers to growth, they must exercise initiative to make the most of their opportunities and help make their jobs learning experiences not only for themselves, but for their colleagues and support personnel as well.

Professionals in academia (teachers) are often constrained by formal curricula that seldom grow at rates consistent with the technological advance. One reason for this slow growth is the need to teach fundamentals that become firmly established and change only as new knowledge is integrated into accepted theory. Unless the academician is an active participant in R&D at the frontiers of knowledge, either through government grants, cooperative programs with industry or consulting with industry or government at high levels, little or no new knowledge has an opportunity for prompt injection into academic curricula. Less than 20% of the nation's physical scientists and engineers in academia participate in such activities. For these reasons, most academic curricula are years behind the frontiers of knowledge, whether basic or advanced. For example, the theory and practice related to coherent radiation and its applications have existed for about 15 years, yet few science or engineering courses in academia cover the subject.

Constructive Action Required by Industry and Academia

With the foregoing in mind, here are some suggestions, to industry and educational organizations, for constructive action to encourage professional development of various target audiences through participation in CE/S&E:[10]

1. Responsive industries and educational organizations must take risks in developing and offering educational programs in which the new knowledge content is advanced, often speculative, frequently not yet committed to print, but sufficiently provocative and pragmatic to be of interest to a sufficient number of applied scientists and engineers so as to warrant an information exchange amongst them. The risks are in terms of investments of staff effort and funds to analyze the knowledge needs, search out resource people in the field, enlist their support to outline and develop a program, commit physical facilities, and promote the offering. Such programs, almost invariably, fail to pay their own way at the start, but eventually become more than self-supporting. A policy in industry or academia that all CE/S&E programs must pay their own ways from the outset precludes their implementation.
2. Search for and organize the required teaching staff from amongst persons in academia and professional practice who are sufficiently knowledgeable in the field, or in related peripheral areas, to serve as resource persons to professionals earning their livelihoods in the same field. Such faculty members must be capable of planning programs as well as stimulating and leading heated discussions, critiques and interactive problem-solving sessions amongst informed professionals and be sufficiently knowledgeable to help such groups over difficult or controversial points as they arise and seek expert assistance from other resource persons as required.

3. Continually survey their own community needs for new technology and determine the probable market for educational programs to fulfill such needs.
4. Assess technology and explore emergent technologies with a view toward preparing educational programs conducive to technology transfer and utilization consistent with societal needs and national priorities, but with a focus on their own community interests and practical extrapolations of such interests consistent with anticipated means of the community to excel in reducing related R&D to marketable products and services.
5. Seek out participants who can benefit professionally from CE/S&E in terms of enhanced performance on their jobs and technology utilization in their companies' products and services, transfer technology to colleagues and support personnel, as well as share with other participants their unique experiences and expertise.
6. Provide interactive teaching/learning opportunities for participants that draw upon their unique experiences and expertise, thereby achieving an important form of technology transfer.
7. Encourage the participation of local college faculty in continuing education, either as resource persons or students, and thereby provide means for transferring knowledge from academia to the professional fields of practice; but more importantly, facilitate the injection of new knowledge from professional practice into academia.

V. Indicators of Incipient Obsolescence Amongst Scientists, Engineers, Technicians, Teachers and Researchers

Employers, colleagues and students have their ways of assessing obsolescence amongst their employees, colleagues and teachers. Obsolescence, like competence, has a characteristic signature that is difficult to describe, but the news gets around fast. Employers can measure lack of innovation or productivity. Colleagues see in their associate a drop in familiarity with advanced aspects of their field. Students sense a professor's lack of conversance with advanced aspects of the subject being taught when they ask questions about a new development that they read about or saw on TV. When such things happen, it may be too late. Recovery is difficult; almost pointless.

What indicators are available to the individual, so that self-paced remedial action can be taken in time to prevent obsolescence?

As has already been mentioned, an early indicator is the inability of an individual to comprehend the advanced technical literature in one's own field. To make this assessment, however, the individual must read such literature. Unfortunately, few individuals who are slipping behind are concerned about reading of advances in their field and fail to detect their own inabilities to comprehend pertinent articles in the professional literature. For that reason alone, management should circulate technical literature relating to advanced aspects of their product lines and services so that its employees might assess their own slippages from the R&D cutting edge.

Another indicator of incipient obsolescence is a reduction in the acquisition of new knowledge and techniques relating to the work in progress. As innovation attenuates, work becomes routine. Products developed or improved by obsolescent individuals change very little as competition captures a larger share of the market.

Failure to participate in proposals for advanced R&D, because of personal avoidance or lack of an invitation, is a telling sign. Being left out of business meetings where bid/no-bid or make/buy decisions are made often demonstrates that one's associates no longer value a particular individual's judgment.

Lack of ideas for research or development on discretionary funds, infrequent or absence of patent activity, lack of publications—even travel reports, neglect of outside professional activities such as participation in society affairs, and the failure of colleagues to consult with an individual in the course of work are important, although subtle indicators, that one is no longer pulling an appropriate share of the load.

The annual review of an individual's performance by management should come to grips with incipient obsolescence where it exists and, with assistance from competent career counselors, remedial action should be taken.

The question arises: "Why do so few professionals, as a percentage of the total eligible population, participate in CE/S&E? Here are a few thoughts on the matter:[10]

1. Few truly-valid opportunities are offered for meeting deep-felt educational needs, particularly in terms of job-related knowledge.
2. Learning-on-the-job seems sufficient to many engineers because they are not compelled to stretch their competencies.
3. Feeling that competency or productivity does not really pay off. Politics plays too significant a role in many advancements.
4. Failure to involve them in interactive teaching/learning experiences where they are required to invest their own contributions to the discussions.

5. Universities indifferent to product service (meeting post-experience educational needs of their own graduates for competence retention and growth plus career reorientation).
6. Universities dodging opportunities to be change agents (by coupling their own students and curricula to societal needs and national priorities—many prefer ivory tower isolation from real-life issues, problems and pragmatic considerations).
7. Professionals are turned off by prevailing academic attitudes as to what constitutes quality education—prerequisites, credentials, credits, regular faculty, accredited curricula, exams, preset course sequences, inflexible course content.
8. Absence of programs dealing with advanced, speculative, highly applied and as yet unpublished subject matter.
9. Lack of instructor flexibility to swing with the needs and interests of a class. Usually offer off-the-shelf programs such as watered-down graduate and undergraduate courses.
10. Dogmatic expostulation of theory known to be out of date, impractical, questionable or wrong.
11. Avoidance of real problems of special interest to students on their jobs when presented by the participants.
12. Undue focus on analysis rather than design synthesis.
13. Lack of privacy on academic matters—in the extreme, the flow of classroom or course performance data to employers.
14. Tuition refunds tied to grades.

VI. Making Continued Learning-on-the-Job a Central Feature of Professional Practice

Because scientists, engineers, and technicians spend most of their alert time on their jobs, a prime objective of CE/S&E should be to help make each individual's job an important learning activity. Learning-on-the-job may be stimulated several ways, but CE/S&E focused on interactive solving of difficult problems confronting participants on the job fosters learning on that job as part of professional practice and encourages them to teach their colleagues and support personnel how to learn on their own jobs while transferring and utilizing technology in their work. Teaching others is a key to one's own learning. Therefore, it is the professional's and employer's joint responsibility to make each job a problem-centered adventure.

Most scientists, engineers and technicians learn anywhere between zero to 100% or more of what they need to know to keep doing what they are doing by doing it. Because the scientific and technological targets of their work are generally changing at unprecedented rates, those who learn less than 100% of what they need to know to keep doing what they are doing, are falling behind. Those who learn less than 100% require CE/S&E that supplements and further stimulates learning on the job.

Professionals who learn much more than what they need to know to keep doing what they are doing, and are able to serve as resource persons in teaching/learning processes with others, should be enlisted to participate in CE/S&E as teachers. They in turn will find that they learn as much or more from their students than the students learn from them and thereby enhance their own competences and reputations all the more.

In the interactive mode of CE/S&E, a group of learning-ready participants, from similar to diverse functions, are assembled to discuss a sequence of individual "barrier" problems presented by each of the participants at assigned times. The sessions are held once a week for periods ranging from 3 to 6 hours. In addition to the instructor who is competent in the general subject area, experts are invited to give short seminars on the particular aspects of the subject relating to a participant's job-related problem scheduled for that day.

After the guest seminar, the assigned participant presents his or her barrier problem. A brief discussion of the seminar and problem follow. The session is then opened for interactive problem solving during which time either the instructor or resource person serves to keep the discussions heated, focused on the subject, and help the class over rough spots as they develop.

Various suggestions and recommendations are made to the participant whose problem is discussed for application to problem solving on the job during the following week. The other participants have also acquired new knowledge that may be helpful in solving their own problems. Each participant whose problem was discussed is required to provide feedback from the job at the subsequent session.

Feedback from the jobs of all previously presented problems is called for at each session. If appropriate progress on a particular problem is not being made, the instructor and class focus on that problem and make additional suggestions for additional work to be reported on at the subsequent session.

In time, each problem is solved or better understood. New theory and practice are introduced at each session by the instructor, resource people and the participants themselves. Participants involve their colleagues and support personnel in the activity, which becomes a learning/teaching experience for each of them. Benefits to each participant become significant as the problem that they and their colleagues are working on become clarified and solved. Employers find that the process pays dividends not only in extending the professional competences of their personnel, but also that some of their company problems are solved.

VII. The Distinctive Role of Continuing Education as a Supplement to Learning on the Job

A variety of industry-based and university-based continuing education programs are offered across the country in the form of classes, seminars, workshops, short courses and semester-long courses, but most of these do not come to grips with the detailed work content of the participants nor do they carry over to the work environment.

To be truly effective in providing scientists, engineers and technicians with the new knowledge they need on a continuing basis, the distinctive role and objectives of CE/S&E must be as follows:[8]

1. *Provide opportunities for interfield and intrafield interdisciplinary knowledge dissemination and transfer* among all participants, but with a special focus on difficult problem solving that includes applicable theory and practice, design synthesis as well as design analysis. Design synthesis, the principal component of engineering practice is neglected in present day scientific and engineering education. Engineering technologists are being prepared in engineering design, but higher levels of achievement are required to handle the more sophisticated aspects of advanced R&D.
2. *Achieve the prompt transfer of new knowledge amongst its users* for problem solving in the development of new or better products and for enhancing services that meet societal needs. Some of this knowledge may be fundamental, although highly advanced and available only through interactive CE/S&E sessions. A measure of updating or refreshing of participants in prerequisite knowledge, as an integral part of interactive continuing education, may be necessary on occasion to increase the overall effectiveness of the learning process, but the focus of interactive CE/S&E must remain that of practical problem solving.
3. *Facilitate technology assessments on realistic and prompt bases.* Components of such assessments are short and long range technical goals, accurate appraisal of the current state of the art, and planned research and development necessary to close the gap between the current art and advanced R&D goals.
4. *Stimulate new technology utilization for societal benefits.* Such stimulation requires the determination of societal needs and a realistic assignment of priorities for meeting them. However constructive the societal benefits may appear to be, care should be taken to assess the societal and environmental impacts of new technology especially with reference to national priorities, timing, costs, cost-effectiveness, hazards, socio-economic dislocations and practical alternatives.
5. *Encourage further allocation of financial, materials and manpower resources to R&D* for the further advance of applied science and technology.
6. *Interest participants to study the pertinent literature* in their fields as well as become active in professional societies devoted to advancements of human welfare, science and technology.
7. *Afford means for injecting new knowledge from industry and professional practice into academia*; the primary means being to involve individuals from academia as resource persons or participants in interactive programs.
8. *Transfer new knowledge emanating from academia to industry* and the fields of professional practice. Currently, the probable U.S. percentage ratio of pertinent publications and "results" of R&D emanating from academia vs. industry is 14/68; with 3.5% of publications and "results" of R&D coming from other not-for-profit institutions and 15% coming from government laboratories. These figures are based on projected performance of research and development work, which should correlate strongly with new knowledge generation.
9. *Focus on supplementing on-the-job learning with new knowledge that is difficult for individuals to acquire on their jobs or through individual study.* Inputs from participants are required during CE/S&E to develop this focus.
10. *Provide prompt feedback from participants as to the applicability of new knowledge* acquired during the CE/S&E sessions to their jobs in terms of practicality, accuracy, timeliness and usefulness in solving difficult technical problems.
11. *Deal with current scientific and technical problems confronting participants on their jobs* with a view to providing them with knowledge relating to physical principles and phenomena, materials, production methodologies, environmental impact, functional performance evaluation, and the like, that may help them understand and solve their own technical problems over the long haul.
12. *Integrate concepts, factors and varied practical*

information from other disciplines that may serve to enhance the resolution by participants of their on-the-job problems as well as focus attention on the applicability of their products and services to other functions or fields.

13. *Explore the compatibility of each participant's products or services with applicable human factors, maintainability methods, costs as well as with competitive systems, products or services.*
14. *Help participants evaluate the socio-economic and environmental impacts of new technology,* products and services discussed during the learning sessions.
15. *Encourage industrial and business organizations to underwrite the costs of employee participation*, especially by having employees work on company problems.
16. *Provide measures for the evaluation of the program's effectiveness* as a means for knowledge transfer, technology assessment and the stimulation of applied science utilization in problem solving that leads to societal benefits.
17. *Provide reports or research-type data on the essential features of a particular interactive CE/S&E program* in sufficient detail to make their transferability to other typical areas and learning settings relatively simple and highly cost-effective.
18. *Present specific quantitative and qualitative measures for the evaluation of interactive CE/S&E cost-effectiveness.*

VIII. Characteristics of Effective CE/S&E for Persons in Every Category of the Target Audience with Particular Emphasis on Company Size, Individual Ages and Industrial Concentration or Dispersal

As scientists, engineers and technicians advance through their careers, they should acquire expanded backgrounds in terms of new knowledge and techniques as a consequence of their professional experiences. They must have a better understanding of how such functions as support services, manufacturing, marketing, finance as well as plant and community relations relate to their own efforts. Additionally, they should develop a broader view of their own field and how it relates to the work of people in other disciplines as it affects their own efforts.

In the course of this expanded background building, scientists, engineers and technicians should acquire impressive bodies of knowledge that they should share with their colleagues on the job and bring to CE/S&E sessions as means for exchanging new knowledge with other participants and benefiting from their experiences. At its highest levels, where it meets the educational needs of particularly innovative contributors to the technological advance, the characteristics of CE/S&E are:[10]

1. It is highly applied and job related; particularly focused on practical deviations from theory, interacting disciplines, and pertinent peripheral considerations.
2. Supplements learning on the job, especially where the subject matter is difficult, time consuming and seldom obtainable alone or on the job.
3. Essentially at graduate level or beyond, but rarely available in formal academic programs.
4. Generally non-academic credit; most participants already have their terminal degrees.
5. Caters to groups of professionals with mixed backgrounds and capabilities, but with common interests just as found on the job in business, industry and commerce.
6. Usually speculative and typically related to local business, commercial or industrial needs. In many instances the subject matter has not yet been substantiated by research or experimentation.
7. Sparsely documented; seldom is adequate information found even in the professional literature.
8. Interdisciplinary; involves several areas of knowledge.
9. Flexible format and requirements; the subject matter, level and setting may be varied to suit the abilities and immediate needs of the students without losing sight of longer range objectives.
10. Usually consists of round-table discussions or workshops rather than a lecture-recitation setting.
11. Instructors drawn mainly from the fields of professional practice rather than academia.
12. Instructors are generally catalysts, referees and resource persons, rather than teachers.
13. Most of the new knowledge involved is drawn from or contributed by the participants themselves.
14. Frequently requires supplemental enrichment in special theory or techniques. Instructors often provide such supplemental information as needed.
15. Apart from new knowledge acquisition and exchange, the prime objectives of continuing education are to help practitioners learn how inquiry can be made, to understand their individual present conditions and roles in society, remain updated as well as stretched in

competence and relate effectively to others in the performance of their work.

For recent graduates entering professional practice, the focus of CE/S&E should be on the theory and practice pertinent to their work, but aimed at closing the gap between their academic preparations and the specific knowledge requirements of their jobs.

In most instances, the subject matter will serve to augment the theory with which they come equipped and translate it into competences for creative contribution on the job. The actual content will be at graduate level, but well established as applicable to current practice. In essence, it will be state of the art material. Such educational programs can be taught by senior technical personnel or nearby college faculty for inplant courses, usually available in large companies who employ enough professional people to warrant giving inplant courses, or by faculty from local educational institutions where the companies are small and cannot afford to run programs inhouse.

IX. Relative Merits of Academic vs. Industrial Involvement in Continuing Education for Advanced Professions

As subject matter becomes increasingly difficult, the number of people capable of benefiting from a given CE/S&E course, workshop or seminar series is sharply reduced. Few industrial organizations have a sufficient number of professionals within a given geographic location to populate such programs on an inplant basis. In most instances, industrial organizations find it uneconomical to conduct inplant courses for less than 15 persons. Moreover, if a subject is speculative and proprietary, industries are reluctant to open inplant courses to qualified persons from other nearby industries however friendly.

For such reasons, most inplant courses are conducted in less taxing technical areas, particularly where there are enough employees locally to qualify for and benefit from the offering. Inplant programs tend to be quite general, routine, and at undergraduate levels. Only the largest industrial organizations, with significant numbers of advanced professionals within a given locale can provide such personnel with CE/S&E at appropriate levels on a continuing basis.

Academic institutions, on the other hand, provide a neutral ground for educational programs attended by personnel from several industrial organizations, some of which may be competitors. They have the freedom to seek the most qualified instructors in the area without concern for having an instructor from a particular company lecturing to participants from competitive organizations. Of course, it is a joint responsibility of the academic institution, instructors, and participants to safeguard proprietary and classified information. In fact, although some academic institutions have given hundreds of high technology CE/S&E courses each year for many years, and involved hundreds of instructors as well as thousands of students from industry, not a single complaint has been lodged against these institutions for compromising proprietary or classified information in their CE/S&E programs.

Industrial organizations are generally limited to participants from their own work forces and instructors from amongst their own professional personnel. On occasion, instructors are drawn from local educational institutions, but such resource people are typically unfamiliar with the practical aspects of advanced work in progress and are thereby confined to subject matter of general or basic content. Sometimes, industrial organizations bring in experts from consulting practice or academia to give seminars on specialized topics, but these special events are expensive and usually attended by large numbers of employees, most of whom lack sufficient depth in the subject to benefit materially.

Of course, industrial organizations have the flexibility to schedule inhouse educational programs to suit their own personnel and policies. Consequently, most inplant courses bearing directly on work in progress are given during regular working hours. They dismiss the costs of employees being away from their jobs during classes and generally arrange either to pay their inhouse instructors a nominal stipend or nothing. Parking and travel problems do not arise unless a large number of participants commute from other locations.

Inplant courses given by a nearby university, however, are usually part of the university's extension program and frequently carry academic credits. Participation in such courses is limited to students qualified by prerequisites. Here the objective is to accumulate academic credentials rather than new knowledge that is highly job related. Such credit courses, therefore, do not constitute a form of CE/S&E although in many places it is passed off as such.

Use of television and other media for large scale educational services to industrial personnel either at home, before and after hours, or inplant, raises the question whether such programs constitute extension education for academic credentials or are a form of CE/S&E. It can be either, but it is necessary to assess the benefits to the participants before a decision is made based on criteria selected. The principal advantages of such programs is that diverse audiences can be served over a large geographic area, travel-time is conserved, instructors from various sources can be used, and the timing is flexible enough to suit the needs of most participants. The principal disadvantage of these media programs is that the intimate relationships between resource people and other participants, so essential to educational interaction, simply do not exist.

The development of learning modules in specific technologies and their availability on a national scale through geographically dispersed reference centers will introduce an important new dimension in self-paced continuing education. Using a computerized index, the professional can order any available module on a particular topic. Through a system of programmed instruction, the learner can acquire new information and techniques useful in solving on the job problems at a variety of levels, but primarily where the data and methods pertaining to the subject are well established. The availability of resource people to back up the learning modules, on a 24 hour turn-around time basis, should serve to amplify the utilities of the scheme and extend this form of CE/S&E to professionals located in many areas, but especially to professionals isolated from other industries and academic institutions.

From the advanced professional's standpoint, however, it seems clear that university conducted programs afford greater opportunities for beneficial CE/S&E because universities can attract qualified participants from several local organizations and enlist the support of resource people from competitive industries without the usual constraints and inhibitions present in company-conducted programs. Even consortia of several local industries to conduct jointly sponsored programs suffer serious constraints in terms of subject content, level and timing. The cooperation of local universities in the planning or implementation of consortia programs would mitigate some of these constraints, but it seems virtually impossible for such consortia of industries to interest their local academic institutions.

X. Diverse Channels and Methodologies for Technology Transfer and Technology Utilization On the Job Where the Scientist or Engineer is a Teacher/Learner

Technology transfer is the process whereby a development in one field is applied to provide a similar or different function in another field. For example, radar used as a navigational aid at sea was applied to deep space exploration in astronomy. While the operating principles of radar and radio telescopes are similar, especially in the receiving modes, the hardware and instrumentation are physically quite different. In fact, in pondering the similarities, one develops new insights to the actual changes, costs and adaptations involved. Frequently, only a fragment of the original content, perhaps merely the basic principles remain intact. Most of the original hardware and much of the original software cannot be used because of differences in scale, composition, operating requirements and purpose.

Consider the diverse applications of lasers that require radical changes in equipment design, light pumping methodologies, materials, composition power supply, optics, and interface apparatus Lasers used for surveying are radically different in virtually every physical and operating aspect from lasers used for industrial welding, or in communications, medicine, navigation and photography. Each differing application requires substantial adaptation and special design to meet particular needs and environments. Similarly, gas turbines, originally developed for jet aircraft, have undergone considerable change for applications in such diverse areas as marine propulsion, central station power generation, locomotive propulsion, automotive applications and helicopter powering. Even differences in scale for similar applications, as, for instance in small, medium and jumbo aircraft propulsion, involve considerable variation in hardware, materials, maintenance, operating procedures, and pilot training. Computers, printing presses, food processors, construction equipment, sewing machinery, communication systems, and the like, each involve a virtual universe of highly differentiated hardware and methodologies, which, while based on identical basic technology in each case, account for diversities that make correlation with each other difficult indeed.

To effect such technology transfer and the utilization of new technology related to such transfers, scientists, engineers and their technicians need to exchange ideas and transmit techniques that would otherwise be kept from benefiting society. Some of this transfer occurs through business channels where formal arrangements are made to pay for services rendered. In other instances, scientists and engineers discover new techniques and product lines in the process of trying to duplicate existing developments. One of the most effective means for technology transfer and new technology utilization are CE/S&E programs in which new knowledge is exchanged amongst peers to the mutual advantages of those concerned as well as of society.

Yet, the greatest impediment to technology transfer and new technology utilization is the isolation of professional personnel from each other in many companies and their reserve in relating to other professionals from competitive organizations. Most professionals are generally pressed for time, faced with difficult targets, and burdened with administrative tasks even though they may not be part of management. In essence, professionals are required to manage their own work and supervise the efforts of support personnel. Preoccupation with such chores seldom permits an objective approach to problem solving. The scientist, engineer or technician must cope with the problem at hand in the best way possible, expeditiously. Industry seldom permits relaxed consideration of difficulties; every effort is a confrontation.

However, when professionals are required to apply new knowledge obtained during CE/S&E sessions and report back to a class or instructor as to how that new knowledge was applied in problem solving for purposes of critique, new insights are developed and learning on the job can be stimulated.

The professional may discover that in the process of applying newly acquired knowledge, a better understanding of the problem is obtained and that recommendations from an instructor or class are not applicable to the problem as now clarified. In fact, feedback to a class may introduce unique features that no one in the class had hitherto encountered on their jobs. Through the critique that follows such feedback, new suggestions may be presented. These ideas might now be applicable towards the solution of the clarified problem, but additional facts will surface that require further treatment.

Once progress is being made on a difficult problem, the interests of colleagues are stimulated. They in turn offer suggestions and are eager to determine whether their ideas are useful. In this process of cross-fertilization on the job, new knowledge is transferred and, in consequence thereof, new technology becomes utilized. Each professional then becomes a teacher/learner, and in the related technology transfer process contributes to the professional development of colleagues and support personnel.

Frequent meetings of such stimulated people, to consider each others' on-the-job problems, can be a most effective means not only for technology transfer and utilization, but also professional development and participation in CE/S&E for personnel at all levels in diverse functions. In such meetings, or follow-on CE/S&E courses, the participants (audiences) might be the entire project team assembled to solve the same problem, but from different perspective. The participants could be a group of scientists or engineers who plan to focus on a common problem or a set of differing problems. The group could also consist of personnel from diverse functions such as R&D, marketing, manufacturing, finance, and support services gathered to consider problems relating to different aspects of contractual effort or of product diversification. Participants could also represent unrelated activities or companies, but with common concerns who wish to focus on a set of similar problems of topical interest. With proper design of the sessions and sound implementation, substantial technology transfer might occur leading to new technology utilization. To effect such transfer and utilization, however, every participant must share new knowledge with the group as a teacher and be stimulated to absorb new knowledge from others as a learner.

XI. Sources of Appropriate Teacher Talent for CE/S&E

Instructors and resource persons for CE/S&E constitute a unique audience for continued education because they must keep well abreast of the fields in which they teach at levels and depths sufficient to satisfy the new knowledge needs of other professionals in those fields. Obviously, the first criterion for the selection of instructors and other resource people is expertise in their fields, but other factors are as important and must be met if their programs are to be effective.

Thus, principal criteria for the selection of teachers for CE/S&E are:

1. Expertise in fields.
2. Contributions to advances in the field.
3. Ability to teach professionals at appropriate levels.
4. Willingness to prepare subject matter, outlines and promotional descriptions of their programs.
5. Availability to meet classes as scheduled.
6. Cooperation with other instructors and resource persons.
7. Acceptance of constructive criticism for the further improvement of their programs and performance as teachers.

Table IV gives the percentage sources and degree distributions of instructors participating in the CE/S&E program conducted by Northeastern University over the period 1968–1974.[1] The ratio of 19% instructors drawn from academia to 81% from industrial practice correlates well with sources of R&D performed nationwide. Essentially the same ratio prevailed during the years 1975–1977. During 1966–68, Northeastern also conducted Project GAP, which was supported in part by Federal funds as a Special Merit Grant under the authority of the State Technical Services Act of 1965 administered by the U.S. Department of Commerce. This program was offered to then recent science and engineering graduates at the bachelors level working in local industry. The purpose of the project was to close the gap between their basic and increasingly liberal college preparations and practical knowledge requirements for creative performance on a job in any one of six key technical areas of special interest to local industry. These industries paid tuitions of $600 per year per participant in fulfillment of the cost-sharing requirement of the grant. Twenty-two instructors were enlisted for the project on the basis of meeting the criteria listed above. The numbers of instructors from specific industrial organizations were as follows:

1—Itek Corporation—Optics
2—A. D. Little, Inc.—Consulting
1—Baird-Atomic, Inc.—Electronics
1—Technical Operations Research—Electro-optics
5—Raytheon Company—Computer Technology
6—NASA—Space Electronics Research
1—AVCO-Everett—Biomedical Research
1—Massachusetts General Hospital—Biomedical Research

1—General Electric Company—Materials Development

2—National Research Corproation—Materials Research

1—Massachusetts Computer Associates—Computer Technology

1—GPS Instrument Company—Computer Technology

It is interesting to note here that none of the instructors were members of a college faculty. The important conclusion to be drawn is that the majority of teachers for CE/S&E must be drawn from industry and professional practice because that is where most of the new knowledge required by scientists, engineers and technicians to continue their innovative work is being generated.

Percentage distribution by activity, affiliation and field of resource persons (instructors) drawn locally (96%) and nationally (4%) to instruct in the CE/S&E program at Northeastern University over a six year period. During that time, the program's subject content had shifted with changes in the interests of participants in response to changes in knowledge needs required to propose on new R&D procurements and to execute the related work upon award of contracts. On an annual basis, the program offered about 125 different courses and involved about 100 different instructors. About 50% of the courses and instructors were entirely new each successive bi-annual term.

Table VI

	BS and MS Degrees	Doctorates	Totals
Academia			
Physical Sciences	1%	4%	5%
Engineering	2	5	7
Mathematics		1	1
Biological Sciences		4	4
Business		1	1
Other		1	1
	3%	16%	19%
Industrial			
Research	2	13	15
Engineering	15	11	26
Manufacturing	2		2
Management	6	2	8
Other	3	1	4
	28%	27%	55%
Special R & D Organizations			
NASA	2	5	7
Government Laboratories other than NASA	2	3	5
"Not-for-Profit" Academic Affiliates (Like MIT Instrumentation Lab.)	3	4	7
Private Concerns (like A.D. Little Co.)	2	2	4
	9%	14%	23%
Individual Consultants	2%	1%	3%
	42%	58%	100%

XII. Incentives for Life-long Commitments to CE/S&E for Target Audiences

Professional growth and development, consistent with the functional responsibilities of the scientist, engineer or technician on the job, as well as the individual's personal goals and career plan, are largely a matter of motivation to keep striving as far as the individual's energy and intellectual plane will carry. The motivated professional recognizes that CE/S&E is an essential ingredient for maintaining currency, creativity and productivity in a fast-moving field, but a variety of incentives are required from management, and perhaps from government, to make the effort seem worthwhile. When the climate is right, the professional becomes "self-actualized" to meet requirements.

Self-actualization—manifest by initiative, resourcefulness, intellectual independence and high performance on the job—must be the overriding purpose of motivation. The questions to which we should direct our attention is: Why, how and when should employers, managers, scientists, engineers, technicians, and their colleagues stimulate each other to become self-actuating and remain motivated? Self-actuated phenomena, stimulated or depressed by the working environment and achievements, reflect prevailing personnel policies and styles of management. Attention must be focused on management practices that seriously demotivate professionals because their counterproductive effects can be catastrophic from career development and employers' business growth or survival viewpoints.

Motivation takes much effort and time to build—just like a house, which can be destroyed in minutes when put to the torch. It is important for managers of professionals to realize that motivation comes slowly, but demotivation can occur in seconds. Moreover, as in building a house, the location, foundation and environment must be sound or little of value to the professionals or society will be achieved. It is virtually impossible to motivate professionals to the point of self-actualization while working for a company whose products or services are deliberately poor or have few social values, whose management is corrupt or preoccupied with political shenanigans, or whose personnel practices are abominable.

Physical scientists, engineers, and technicians wind the clockworks of industry. Without their innovative contributions operations eventually stop. Unfortunately, the time between their research or developments and sales of related products can be so long that many people fail to appreciate the high correlation between R&D efforts and a company's marketable products and services. For this reason alone, professionals need to be motivated, despite lack of appropriate recognition, so they will contribute to products and services that business sells and society needs.

How would you recognize a motivated scientist, engineer or technician? A number of direct and indirect indicators are available, but in interpreting them, it is important to be mindful of the particular individual's function and background. Here are some key earmarks of motivated professionals:[11]

1. Full of ideas relating not only to work in progress, but also bearing on many kinds of work and activities within the company, in vendors' organizations and at customers' facilities. Takes initiative in transferring these ideas into appropriate channels.
2. High performance on the job in terms of resourcefulness, creativity as well as the discharge of responsibilities promptly and within budget.
3. Open in relations with colleagues, support personnel and management. Works hard at maintaining good working relations on the job.
4. Rises above political intrigue even to the point of appearing to be unaware of its existence. Will deliberately avoid involvement in petty politics and intergroup squabbles.
5. Consulted frequently by colleagues for help and critique of their work. Offers help without expectations of return favors.
6. Maintains an up-to-date and detailed patent notebook and shows others by example how to use it.
7. Cooperates with legal and financial operations in protecting the company's intellectual property and maintaining appropriate financial records relating to work.
8. Refuses to fudge time change records, data and reports.
9. Has the same story for the customer and management, buyer and seller, supervisor and subordinate.
10. Carries a job through to completion and is particularly perseverant when the going gets rough.
11. Participates willingly in proposal activity even when deadlines are irrational.
12. Seems to have irregular work habits because of need to attend to many functional activities and interests; yet, puts in more than a day's work without expectations of rewards.
13. Performs difficult assignments as if by magic and within time limits that seem insufficient if not impossible.
14. Speaks mind—lets chips fall as they may, but is not necessarily insensitive to peoples' feelings. While circumspect, will tell management "like it is" when asked.
15. Avoids cliques because they do not seem necessary and are usually self serving.
16. Undertakes extremely difficult work, even when little is known in the subject area, and encourages the project team when bogged down by few ideas during a new R&D contract or proposal fog period.
17. Will consider all sides of an issue and come up with an independent judgment based on a methodical analysis of all known related factors and their relative merits.
18. Is difficult to dissuade from a position or decision, but will readily admit having been in error once such error is demonstrated.
19. Generously responsive to requests for help by others unable to cope with difficult work or adverse circumstances.
20. Pitches in to rectify someone else's botched up work and usually helps to bring that work to successful completion.
21. Keeps abreast of developments in own field and in contiguous areas of technology as well as other disciplines affecting work in progress.

What then, are the principal incentives that motivate scientists, engineers, and technicians to high performance, which will, hereafter, involve a life-long commitment to CE/S&E at the appropriate level and consistent with the individuals career goals? Here is a list of important incentives that management, with the support of government, can help provide:

1. Prompt support of exploratory work on innovative ideas. Creativity is fragile—ideas die fast if they are not nurtured promptly.
2. Customer contacts. Customers have a way of identifying key contributors, so management is wise where contacts are encouraged.
3. Financial support of continuing education, fully. CE/S&E represents an appreciable investment of personal time by the participant.
4. On the job training where it helps bridge the gap between present competence and job requirements.
5. Encouragement of professional society activities. Time off to participate, rather than payment of dues, is all important.
6. Challenging work assignments. Professionals will grow only if forced to stretch their competences to new heights.
7. Supportive colleagues. Friendly competition enhances growth, but backbiting is destructive.
8. Adequate clerical help. Managers do not save money by forcing professionals to scrounge around for clerical support.
9. Opportunities to publish and present papers. This outlet is particularly important to the individual and company. It should be encouraged and supported.
10. Open and congenial atmosphere.
11. Accurate and timely performance appraisals (al-

lowing professionals to contribute activity inputs adds to the completeness of appraisals).

12. Proper compensation. This factor may be the professional's ultimate measure of value to company if management makes a large issue of compensation.
13. Prompt attention to grievances.
14. Variety of work. Professionals at all levels desire to do several kinds of work at the same time.
15. Awareness of decisions affecting work when those decisions are made.
16. Participation in decisions affecting self. Professionals must have opportunities to correlate their own career goals and plans with company decisions relating to them alone.
17. Supportive managers.
18. Good library facilities.
19. Helpful administrative and security personnel.
20. Prompt reimbursement of expenses.
21. Appropriate fringe benefits.

Guidelines for Constructive Motivation

With the foregoing in mind, it should be evident that employers, managers and other employees must cooperate in implementing those policies and practices that motivate each other, and particularly the scientists, engineers and technicians who, as a group, seem to need it most. They need it most because as a group they are at the cutting edge of the company's advance. If they fail to achieve the company's technical objectives, the company fails. It is difficult to establish a priority order amongst the numerous factors and effects that favor motivation, but it probably doesn't matter since the priority order would doubtlessly vary with the individuals, jobs and their opportunities. Here is a list of guidelines, arranged in a rational order, that should contribute to the motivation of professionals in every CE/S&E target audience.[11]

1. Encourage appropriate contacts between professionals and customers, but provide training in customer relations and contractual commitments to help the professionals avoid getting the company into difficulties.
2. Build constructive stress into each job such as: pressure to get the work done right, on time and within budget. Difficult assignments in advanced R&D that are speculative or controversial stimulated intellectual strain conducive to professional growth.
3. Provide a measure of crossfunctional experience and interdisciplinary work that forces learning on every job.
4. Maintain an appropriate mismatch between job requirements and the immediate capacities of individuals to do their jobs, to force stretch through learning on-the-job and supplementary continuing education.
5. Allow professional jobs to grow in authority, responsibilities and accountability as their incumbents grow intellectually with their jobs.
6. Encourage learning on the job through open interactions between colleagues, professionals in other disciplines, consultants, managers and support personnel.
7. Scrupulously observe promises to employees and customers whatever the cost or however circumstances have changed.
8. Assure that salary reviews remain coupled to performance appraisals despite the feeling in some "informed quarters" that they should be separated. If managers want to motivate professionals they have to tell them why a salary increment was or was not approved.
9. Base promotions on performance rather than politics, academic credentials and promise. Assure that the criteria for promotion are understood and publicize each promotion in terms of the measures of performance that led to it.
10. Select personnel for difficult assignments on the basis of proven records of achievement and potential to grow into the new job rather than "will-of-the-wisp" political considerations that eliminate hard-working employees and force other people to carry the load.
11. Be diligent in discovering who is carrying the load on each job and provide appropriate incentives for the continuation of such effort.
12. If professionals are not performing well, find out why and take prompt corrective action to stimulate them to constructive effort by sympathetic discussion of the problems.
13. Never place proven contributors in positions subordinate to individuals with impressive academic credentials who have no track record or fail to live up to expectations.
14. Take immediate constructive action to correct management mistakes.
15. Never terminate highly respected personnel without good reason, especially at vesting time or when they professionally threaten inept managers.
16. Never fudge records, reports or time cards. All forms of falsification and the deliberate denial of terms to previous agreements, whether tacit or written, make management suspect on all issues.
17. Administer salary plans and schedules fairly.
18. Reject prejudicial treatment of individuals considering a change of employment.
19. Never give adverse references on past employees without their written permission to give a reference to a prospective employer. Apart from the illegalities, such chickens come home to roost.
20. Reject age, creed, religion and race biases in all business operations.

21. Re-employ previous employees if they qualify for an open job in competition with other candidates.
22. Do not take advantage of a tight employment market to force unpopular concessions from highly motivated scientists, engineers or technicians.

XIII. Demotivators of Involvement in CE/S&E

Scientists, engineers and technicians, in all target audiences work hard on their jobs and often contribute extra time to their work under the general heading of "casual overtime." Participation in CE/S&E adds additional time to the job, even if the formal sessions occur during working hours, considering time required for assignments, reading and other forms of preparation. Taking into account the typical family and community commitments of the professional, participation in CE/S&E represents a considerable investment in time and effort on the part of each individual and calls for a total package of incentives that have already been discussed.

Even if the incentives to participate in CE/S&E are both attractive and effective, a great deal of time and effort are required on the part of most individuals, to arrive at a decision to commit themselves. Yet, they can be discouraged from following through in a matter of seconds if the climate on the job is not conducive to professional development or the circumstances associated with implementation of a CE/S&E program are faulty.

Here are a series of demotivating factors on the job that impair a professional's contribution and seriously affect an individual's desire to participate in such activities as CE/S&E.

1. Red tape and undue paperwork to get work done by support services components (this is the most frustrating aspect of professional activity).
2. Financial services tail that waves the scientific or engineering dog.
3. Inaccurate, deliberately falsified or incomplete financial reports that forces professionals to keep their own financial records.
4. Lack of beneficial services because they are difficult to administer. (What are administrators needed for if not to administer difficulties?)
5. Extensive and time consuming approval chain to get things done.
6. Political infighting and intrigue (an energy sapping and time wasting sport).
7. Defensive letter writing with complaints usually originating in components that fail to do their job properly (half the time consumed in such correspondence exchange can often rectify complaints).
8. Aloof managers (why not, when they don't know what's going on).
9. Arbitrary decisions (usually wrong because the right decisions are difficult to make or formulate).
10. Inflexible operating practices that inhibit creativity.
11. Labor strife.
12. Pointless employee meetings and attitude surveys (nothing constructive seems to come from them).
13. Excessive administration and a flood of administrative memos.
14. Restrictions on the use of telephones.
15. Management by objectives that are obsolete at the outset or have little to do with the business.
16. Requests for reports that nobody reads.
17. "Fire drills" that achieve nothing.
18. Inordinate expectations of casual overtime.
19. Frequent turnover of personnel in all functions.
20. Unwarranted dismissals of respected personnel.
21. Poor physical facilities, lack of privacy, monitoring of telephone conversations, and parking harrassments.
22. Favoritism based on nepotism, politics or misguided notions of identifying leadership potential in inexperienced young people.

Even if these demotivators do not exist, it is difficult to keep professionals committed to CE/S&E if the following circumstances prevail in the CE/S&E program:

1. Poor instructor or resource personnel.
2. Marginal physical conditions in the educational facility.
3. Parking hassles for commuting participants.
4. Rigid prerequisite requirements that do not take into account pertinent knowledge acquired on the job.
5. Inordinate time requirements for preparation and assignments.
6. Inadequate text materials or notes supplied by the instructor.
7. Irrelevance of subject matter from the participant's standpoint.
8. Difficulties in registering for a course, workshop or seminar.
9. Inordinate amount of paperwork required to register for a CE/S&E program.
10. Lack of tolerance for absences from sessions due to illness, business travel or high priority commitments.
11. Inability to acquire information on ground covered during an absence.

12. Inordinately large classes that reduce opportunities of participants to interact appropriately with instructors or other participants.
13. Examinations or quizzes in non-credit programs.
14. Transmission of data on classroom or course performance (grades) to employers.
15. Lack of financial support for CE/S&E participation by employer.

One of the most serious impediments to participation in CE/S&E by professionals is the insistence by some managers or training administrators that the professionals are not simply occupying a seat in a CE/S&E program, but are actually benefiting from the experience. After a hard days work or extensive travel, a participant may on occasion doze during class. It seems ludicrous, however, for management to distrust the motives of professionals participating in CE/S&E to whom they pay high salaries and otherwise entrust the technical advance of the company.

XIV. A Comprehensive Systems Approach to Satisfying the Diverse Needs of the Total CE/S&E Audience Spectrum

The principal interdependent components of a national CE/S&E system are:

1. Sources of new knowledge and techniques.
2. Sources of state of the art knowledge and techniques applicable to R&D activities as well as routine industrial practices.
3. Discernible CE/S&E audiences.
4. Delivery methodologies.
5. Evaluation methods and feedback channels.
6. Implementing agencies.
7. Sponsoring organizations.

These components must be appropriately organized and integrated to optimize the benefits to all individuals and organizations involved. To assure economic feasibility as well as effective transfer of technology, the system operating parameters and constraints must be carefully formulated and implemented. Some of the parameters and constraints are as follows:

1. Maximum/minimum participant to faculty ratios.
2. Costs of instruction or subscription to system services.
3. Levels of technology transfer matched to target audiences.
4. Frequency of sessions or periods during which services are to be available.
5. Geographic range of operations.
6. Interconnections and relationships between cooperating operations at the same or different geographic locations.
7. Size of operations to meet needs of target audiences in given locations.
8. Specialization or service limits to meet needs of particular target audiences.
9. Investments and related limitations for producing instructional materials associated with the technology transfer processes selected.
10. Measurements for assessing benefits to the target audiences as well as of system operations.

For any given operation, a variety of factors must be established as follows:

1. Local or regional industrial mix.
2. Identification of local or regional target audiences.
3. Size of local or regional total eligible populations and probable percentages of participants attainable in the several target audiences.
4. New knowledge needs of the target audiences based on R&D as well as high-technology contractual work in progress.
5. Projections for anticipated proposal activities over the next two years in the target area.
6. Determination of probable requirements for courses, workshops, seminars, short courses, packaged programs, learning modules, electronic-media programs, etc.
7. Existence and anticipated offerings of competitive programs in the target area; particularly inhouse courses conducted by local or regional industries.
8. Enlistment of competent instructor talent and preliminary arrangements for instructional materials.
9. Scheduling of programs.
10. Development of promotional materials that present accurate descriptions of offerings, instructors, schedules, locations of programs, tuition and instructional materials.
11. Registration of participants.
12. Implementation of populated programs.
13. Collection of program evaluations from participants.
14. Feedback of program evaluations to instructors for appropriate action.

System Operating Detail

Little appreciation for systems concepts can be achieved without some understanding of operations. For that reason such detail is discussed here in guideline form. Experiences in conducting a university-based CE/S&E at various levels and for diverse audiences, as well as observing other company-conducted and university-based programs in different geographic locations around the country lead to a number of guidelines for satisfying the diverse needs of the total CE/S&E audience spectrum and are recommended as follows:

1. Participants should not be expected to devote more than one day per week or one evening per week to class attendance, although some will come twice a week. Enrollments will suffer seriously if most students cannot take more than one course they need during the same day or evening.
2. Keep accurate attendance records, but develop a liberal policy on absences. Never ask for excuses. Up to 25% absence from class may be unavoidable because of business travel, overtime work requirements (especially on proposals), and conflicting community commitments. Do not penalize participants with faulty attendance records who otherwise make earnest efforts to absorb the work and contribute to class discussion.
3. Lateness due to commuting difficulties is an incurable feature of continuing education. Strenuous efforts to correct late arrivals may eliminate both the problem and the program.
4. Audio-visual aids, as well as an operator, should be available on one or more weeks notice at a preset time. Instructors should be responsible for making their own arrangements through an assigned assistant. Taping of class discussions, however, is taboo.
5. Administrative help coming in contact with both the participants and instructors must be intelligent and cooperative. Some participants throw their weight around. Matters become very difficult when the staff also does so.
6. Classes must be kept to optimal sizes. Survey courses can be large, but in-depth courses and workshops should not have less than 10 or more than 25 participants. Seminars are very flexible—some can accommodate fifty students with ease.
7. Sequences of courses, require long-range commitments by participants. Do not start such series unless a market analysis demonstrates appropriate demand over the long haul. Offer individual courses that may represent a series, but do not promote them as a series.
8. Instructors truly worth their salt may be plagued by requirements for business travel—so they will be torn between their responsibilities to their jobs as well as their students. Provisions for making up missed sessions must be available and participants should be informed that the risk of some cancelled sessions is characteristic of CE/S&E. Of course, participants should be informed well in advance of such cancellations and make-up sessions, or phoned at work if a class must be postponed at short notice.
9. CE/S&E programs should be clearly related to local industrial and business needs and not competitive with other courses available to the target audiences.
10. Tuitions or CE/S&E should be comparable with those for graduate work or free to employees if conducted on an inplant basis.
11. CE/S&E should make the participants stretch in competences, and in no sense compromise level if the majority of the participants can cope with the work. Instructors, however, should have sufficient flexibility to adjust content and level consistent with the majority of the participants.
12. Auditors of classes should not be tolerated and be asked to register or leave when detected.
13. Instructors should be permitted to conduct classes as they see fit; within the framework of good taste and pedagogy.
14. Classes should not normally be visited to appraise instructor performance. Formal evaluative feedback about instructor performance at the end of a course should suffice. Informal reports by participants are inevitable and should be considered seriously. Word of mouth endorsement of a given course among participants is measurable in the subsequent popularity of a particular course or instructor.
15. Canceled classes should be made up at the convenience of the class.
16. A liberal policy for accommodating substitute lecturers recommended by a reliable instructor to avoid missing a class session should prevail. Participants welcome such substitutions. Moreover, substitutes are an excellent source for new instructor talent as well as new sources.
17. Handle criticism judiciously. Listen to participant's comments carefully and weigh them critically. Do not take precipitous action. Where criticism of an instructor is indicated, don't beat around the bush. Confront the instructor privately with the criticism and give the instructor an opportunity for corrective action. Replace recalcitrant instructors at once.
18. Confine most classes, workshops and seminars to the hours between 4:00 and 5:15 p.m., and only on Mondays through Thursdays. Schedule classes to suit the instructor's availability. The premium times are 5:00 to 7:00 p.m. and 7:15 to 9:15 p.m. These times make it possible for some participants to take two courses during a given evening and allows time for classrooms to empty and refill. The 7:15 to 9:15 period is most popular with students and instructors alike. Day-long courses should be conducted

between the hours of 9:00 a.m. to Noon and from 1:00 p.m. to 4:00 p.m.

19. Schedules of courses should correspond generally to the local high school calendar, or to that of an evening graduate school if such programs exist in the area. This arrangement helps participants with children in school to plan their vacations.
20. Some courses may be started at 4:00 p.m., to beat rush-hour traffic, but since most participants will be required to leave work about an hour in advance, such early courses should cater primarily to executive level people.
21. Students should not be expected to travel more than 30 minutes each way to class or fight heavy traffic. About 70% of the students will be drawn from a ten-mile radius. Few students will travel more than fifteen miles.
22. Adequate parking or public transportation should be available. Since few participants will leave a campus before the next shift arrives, twice the normal parking area for evening groups is required.
23. CE/S&E deserves premium space on campus or inplant. High school settings for such programs ought to be avoided, especially if equipped with juvenile furniture.
24. A good food facility should exist in the vicinity, preferably a cafeteria inplant or on campus serving meals at reasonable prices. Few high schools used for some CE/S&E courses have cafeterias that are open during evening hours.
25. Classrooms should be equipped with adult seating; adequate writing surface and blackboard space; be well illuminated and ventilated.
26. Grades for non-credit courses should not be given.
27. Cooperate with sponsoring organizations to help them determine the benefits obtained by their employees in CE/S&E programs, but under no circumstances provide recommendations for professional promotions of participants or career directions.

XV. Relationships of CE/S&E to Graduate Programs

With rare exceptions, it takes about ten to fifteen years for knowledge, percolating from R&D at the technological frontiers, to become part of formal graduate school curricula; although by then a better understanding of the principles involved are available. For example, few if any of the topical areas given in Table I, which deals with emergent technologies are currently covered by graduate courses. Topical areas given in Table II, which lists recently emerged technologies that have been in existence some 10 to 20 years are just beginning to be included in graduate curricula.

For this reason, advanced scientists, engineers and technicians working at the very cutting edge of the technological advance cannot look to graduate programs for fulfilling their needs for CE/S&E.

Even professionals working at a somewhat less advanced level whose efforts are largely that of product design rather than R&D, will require CE/S&E of a less fundamental nature than that offered by either undergraduate or graduate curricula in the sciences or engineering. Only graduate programs in engineering technology, of which there are very few, relate to the knowledge content of pertinence to designers on the job, but few of these people can afford to take such graduate work on an extensive basis.

Scientific and engineering curricula tend to be basic, as they should be, but also increasingly theoretical as well as liberal. Even though they cannot be all things to all people, academic institutions serve a variety of needs in their communities Yet, despite their growing diversity and commitment to services that hitherto have been well outside the province of academia, the first responsibility of graduate and undergraduate schools of science and engineering is still to prepare young people to become alert, informed and constructive members of society. Many academic institutions are unwilling to tamper with this traditional role for fear of diluting their efforts towards fulfilling this prime responsibility. This attitude prevents many academic institutions from responding to the continuing educational needs of the work-a-day world; even to the needs of their own graduates who have gone on to become contributors and executives in industry, business and the professions. The "ivory tower syndrome" prevails in much of academia and it seems almost hopeless to try to change the attitudes of institutions devoted to traditional disciplines and studies.

Fortunately, a few academic institutions whose focus is set on the needs of the community and on the future, rather than upon the needs of the faculty and the classical past, recognize that new knowledge does not grow on trees nor does most of it originate in academia these days. These institutions realize that professionals have become the principal new knowledge generators and that somehow this new knowledge must be injected into graduate and undergraduate curricula if regular academic programs are to be relevant to the needs of the students, society and the times.

What better way can there be for harvesting and distilling such new knowledge than by bringing together a group of knowledgeable contributors to advances in a particular field for a round-table learning experience and giving them an opportunity to share their knowledge and exchange their views concerning some new area of inquiry or intellectual activity? When such groups are assembled in the presence of instructors from academia (who are there primarily to serve as catalysts, referee the teaching/learning process, keep discussions focused on the subject, and help the group over rough spots as they develop or search out experts on some particularly sticky point should they be unable to do), they are in position to benefit far more than any one of the participants and bring back some of the new knowledge acquired in this process to their regular teaching activities.

Only academic institutions that have scientific or engineering schools will probably respond to the growing needs for CE/S&E, but there is no guarantee that those that should will do so. Wherever one of several academic institutions has already responded to such needs in its locale; industry, government and some local branches of professional societies have responded in kind by supporting the effort fiancially or through tuition refunds and promotional assistance. Industry and government can also solicit the services of their own outstanding contributors as resource persons or instructors in CE/S&E programs conducted by academic institutions.

Academic institutions, however, cannot sit back and expect industry or government to come to them with requests for CE/S&E programs. They must take the initiative in developing such programs that meet a variety of needs at all levels and for the several audiences that can benefit them. Academic institutions can also meet the specialized needs of local companies by designing workshops or courses that cater directly to their unique needs and conduct them as in-plant programs on a company's premises or alternatively offer uniquely tailored programs in special facilities or on campus.

Where academic institutions have not taken the initiative to provide needed CE/S&E programs, or have not been responsive to the needs of local industry, a vacuum will exist until filled sooner or later by enterprising professional societies, proprietary educational organizations, or other schemes using special technology transfer techniques.

Even where scientific and engineering schools are responsive to the CE/S&E needs of industry, their undergraduate programs will continue to concentrate on developing a broad foundation for future specialization, but because of continued growth of knowledge in the basic sciences, emphasis will be placed on knowledge compression through integrated studies in physics, chemistry, mathematics, communicative skills and the humanities. Some aspects of the engineering sciences such as applied mechanics, thermodynamics, communication theory, energy conversion and circuit theory will give students insights to the interrelationships of energy and materials in the performance of useful functions. While this pattern should provide an effective knowledge base, serious difficulties will arise from the growing abstractions in classroom considerations of practical applications of scientific principles. These abstractions stem mainly from unfamiliarity of some educators with current professional practices as well as a tendency of curricula to consolidate the burgeoning mass of subject matter into fewer courses. For example, several courses in electromechanical energy conversion now consolidate work previously given in several electrical power and machinery courses. Such consolidation is both necessary and desirable, but a new language, incomprehensible to most designers, builders, dealers and purchasers of electrical machinery has developed. Recent graduates who have had this kind of course will have to contend with a language barrier on top of a knowledge gap upon entering the industrial world.

Graduate work is now largely an extension of undergraduate education. Its aim is to develop depth in restricted areas of applied science. The principal objective is preparation for research. Gradute work under "personal direction," in which students were "apprenticed" to their professors, has become economically unfeasible. Many important values formerly derived from personal interactions between the professor and student have disappeared. While emphasis in graduate education will remain that of preparing people for research, it will not effectively fulfill the practical knowledge needs for advanced applied scientific or engineering work unless its orientation were substantially changed.

For these reasons, continuing education in science, engineering and technology must become the principal means not only for helping to keep alert professionals abreast of developments but also bridging the gaps that exist for each of the target audiences between theory and practice.

Of course, the younger people will be interested in the formal undergraduate and graduate programs because they are concerned with the accumulation of academic credentials. There is no reason, however, why recent undergraduate students cannot alternate their educations between graduate work and CE/S&E related to their entry jobs. In fact, with rising costs of formal education as well as the proliferation of both basic and applied new knowledge, most young people will be forced to hold down full-time jobs while they participate in part-time graduate work until they have obtained their terminal degrees.

For somewhat similar reasons, scientists, engineers and technicians may find it quite useful to participate in part-time graduate work where they wish to augment their academic credentials while simultaneously adding to their grasp of basic knowledge at higher levels.

This form of interplay between CE/S&E and formal academic credit bearing programs should be of benefit to all concerned including the educational institutions, but unless means of recognizing knowledge acquired on the job and through non-credit CE/S&E in lieu of formal prerequisites, the scale of such interplay will be severely limited.

XVI. Problem of Assessment of Needs and Markets

By all odds, the most difficult problem in the assessment of needs and markets for CE/S&E is the enlistment of a program director who has an expert understanding of the industrial mix in the target locale or region, who is competent in the education of professionals, and posesses the management skills necessary to plan and implement a CE/S&E program that meets preset objectives and is economically viable. Such individuals are scarce. Moreover, it is difficult to obtain these qualities through a combination of people because most programs operate at or below breakeven and cannot afford more than one qualified person.

Having acquired the essential director, it soon becomes evident that the keys to the assessments of knowledge needs and the size of the target market are:

1. Current R&D and high technology contractual work in progress
2. Anticipated proposal activities of local industry over the next two years.
3. The eligible population of scientists, engineers and technicians in the area.
4. Content and populations participating on ecompany conducted inhouse CE/S&E programs in the area.
5. Projections for changes in the employment of scientists, engineers and technicians over the next two years in the area.
6. Prevailing industrial policies concerning the financial support of, or tuition refunds for noncompany sponsored CE/S&E

Information as to the work in progress, and the numbers of scientists, engineers and technicians involved, can be determined by asking the appropriate executive officers of the principal high-technology companies in the area who are usually responsive when they understand the purpose for the inquiry. Other sources for such information are the local chambers of commerce, the State Departments of Labor or Employment Security, advertisements for technical personnel in the local Sunday papers, as well as the instructors and participants of ongoing CE/S&E programs.

Experiences accumulated over a fourteen year period shows that sources for information in assessing needs and probable participation levels, in order of descending reliability, are:

1. Instructors currently involed in the CE/S&E program.
2. Students (participants) currently involved in the CE/S&E program.
3. Regular college faculty having liaison relationships to progams (who also consult with local industry).
4. Remarks of professionals at social functions.
5. Engineering executives during plant visits.
6. Telephoned suggestions by professionals.
7. Classified advertisements for professional personnel.
8. Research departments of local chambers of commerce.
9. Research departments of State Departments of Labor or Employment Security.
10. Inquiries about specific topics by prospective participants (they often can indicate how many other people may be interested in a topic).
11. Advisory committee drawn from industry. (This group starts off consisting of engineering managers who then send their personnel people.)
12. Training and educational managers.
13. Announcements of CE/S&E programs from other local institutions.
14. Technical society surveys. (Most respondents to such surveys want relatively short spot courses at practically no cost usually attended by hundreds of people per session. They will not participate in CE/S&E programs catering to smaller numbers of students to enhance educational benefits, but at higher tuition fees.)

Continuous attention to articles in the professional journals and daily review of announcements of new contract awards or governmental procurement information in the local business press, the Wall Street Journal and the U S. Department of Commerce Daily are worthwhile efforts that round out the data base useful in assessing needs. CE/S&E offerings in the area and estimates of participation can be obtained from local industries and educational organizations. Such information is indicative of current needs and a clue to probable needs over the short haul. Local chapters of professional societies are usually cooperative in providing pertinent information or leads for the acquisition of useful data from reliable sources.

Once a particular CE/S&E program has been in operation for several years, and its relationships to other ongoing company-conducted and university-based programs have been established, it is a relatively simple matter to assess needs and markets that can be served. Considerable imagination, expertise and energy are required; however, to plan growth and serve unmet new knowledge needs and tap a larger portion of the eligible population.

With the foregoing in mind, the principal problems for assessing needs and markets can be summarized as follows:

1. Acquisition of a program director or other personnel who can collect, interpret and analyze the data necessary for accurate assessments.
2. Enlistment of sources for reliable data.
3. Sustained cooperation of local industry and public information sources.

4. Lack of adequate data relating to the breakdown of professionals in a given geographic locale. Scientists are not distinguished from engineers, nor are R&D technicians often distinguished from machinists, repairmen, draftsmen and other technical vocational-employees.

XVII. Comments Concerning Current and Projected Audiences for CE/S&E and Recommendations for Further Study or Active Intervention

It seems a foregone conclusion that, as the scientific advance accelerates and technology proliferates, every scientist, engineer and technician will have to cope with rapid change and gaps in knowledge that will interfere with their performance on the job. Even the generators of significant amounts of job-related new knowledge and techniques will find it advantageous to keep abreast of advances in their fields that do not immediately affect their work and attain conversance in disciplines that do

Where CE/S&E is properly matched to the needs of one or more audiences, an increasingly large number of participants should be expected to commit themselves to such supplementary studies It is necessary, however, to substantially raise the level of participation, from the present 10% of the eligible population on a national basis, if the nation is to retain its current pre-eminent position in science and technology

Perhaps it would be unduly optimistic to expect every scientist, engineer and technician to participate in CE/S&E, but a target number of 50% of the eligible population is a worthwhile goal. *Means to achieve this level of participation merit further study*

At present, the participating audiences consist primarily of the principal contributors to the scientific and technological advance. Why? No doubt, these are the people who need the most recent new knowledge so that they may continue to contribute at the cutting edges of technology and share in new business opportunities that call for expertise in the high technologies

Unfortunately, few CE/S&E offerings are matched to their new knowledge needs. For this reason, most members of these audiences are inadequately served and consequently do not participate.

Most so called CE/S&E offerings across the nation are watered down graduate courses offered on a non-credit basis. In other instances, participants are allowed to audit regular graduate courses at reduced tuition and on a non-credit basis for whatever benefits may accrue to them. By far the best courses offered primarily at lower technological levels are parts of company-conducted in-plant programs for employees.

Changes in the nation's pre-eminent posture can be expected as foreign countries develop their high technology industries and compete with U.S. products and services around the world. This is a compelling reason, indeed, for Federal intervention to keep the nation's technical manpower resources updated.

France has taken the initiative in recent years to provide an introduction to continuing education for its total workforce. All employers are required to provide up to 40 hours of sponsored continuing education to every worker. Employees are paid their regular salaries during the 40 hours off their jobs and take whatever coursework they wish, for which they must qualify at prescheduled times. The principal audiences, however, come from industry, particularly from those organizations owned or regulated by the state.

So far, there are virtually no programs for advanced professionals because they do not participate One explanation for their lack of enthusiasm is said to be a reluctance by French professionals to suggest that they may need updating or competencen enhancement. Moreover, French educational institutions are uncooperative and their faculties are aloof. French academia is characterized by an "ivory-tower syndrome" and can but grudgingly be introduced into this national effort.

It is anticipated, however, that trade associations, professional societies, large industries and public utilities will expand their program with further governmental subsidization and offer their programs not only to their own employees or members, but also to the general public.

Similar legislation in the U.S. might have a profound effect in bringing the needs for continuing education to every worker and employer. Moreover, with proper design and flexible implementation, such a scheme could stimulate a broad segment of the industrial community to participate.

Of course, 40 hours of CE/S&E is not enough, but in most cases it is far more than most people are getting. Such a job-related fringe benefit might start many employees off on a regimen of continuing education that requires but 2 to 4 hours per week on a continuing basis. Perhaps a program of 100 to 200 hours per year, paid for by employers but taken voluntarily, will bring about the changes in participation desired.

It is, therefore, recommended that a study of Federal stimulation of CE/S&E through legislation be undertaken to make such education a fringe benefit available to every technical worker. It seems appropriate that such CE/S&E could be established under the guidance of NSF

University-based research tends to be fundamental and seldom has immediate applicability to industrial R&D or engineering practice. Industrial sponsored research at universities seems more applicable to practice but usually covers aspects of work not particularly suited to the customer's own R&D operations. An increase in cooperative university-industry R&D, conducted at industrial facilities where the appropriate instrumentation and apparatus may exist, could serve to enhance benefits for more college faculty by not only broadening their understanding of industrial practices as distinguished from theory, but also prepare them for participation as instructors or resource persons in CE/S&E. NSF can have substantial influence in the amplification of such cooperative programs by suggesting R&D that meets societal needs as well as national priorities and serving in an advisory capacity to universities and industries in the implementation of such joint R&D.

It is, therefore, recommended that NSF undertake a study to encourage cooperative university-industrial R&D aimed not only at helping to meet national needs for new technology, but also the enhancement of faculty qualifications to serve as instructors or resource people in CE/S&E.

For the most part, universities regard continuing education as a marginal activity and treat its administrative staff or CE faculty as second class citizens In fact, some of the accrediting agencies frown on the use of full-time college faculty for continuing education programs and thereby reinforce the relegation of CE/S&E to secondary status. NSF can materially alter this situation by interventive action that will place a higher priority on CE/S&E at universities and change accreditation policies that currently preclude full-time faculty participation in continuing education. *It is, therefore, recommended that NSF study means to upgrade the status of CE/S&E at the nation's universities and foster the recognition of continuing education as a valid activity for qualified full-time faculty.*

Continuing education at most universities is considered primarily as an income producing activity rather than as a means for serving professionals, most of whom are their own graduates, with otherwise unavailable education opportunities. Federal subsidization of CE/S&E at universities on a cost-sharing basis could materially alter the attitudes of university administrators and faculty alike so that continuing education would be handled financially as one of their regular educational activities. *On this basis, it is recommended that NSF undertake a study of Federal subsidization of CE/S&E with a view towards establishing continuing education as financially sound and fully recognized part of higher education.*

Some educators and training administrators from industry as well as academia seem concerned about the quality of CE/S&E. As a consequence of this concern, a rather loose system of "Continuing Education Units" (CEU's) has been established as means for recognizing participation in continuing education and for rating courses. Experience has shown that CEU's are virtually meaningless for professionals with academic credentials and not truly acceptable to technicians seeking some forms of undergraduate credentials. During 1976, the Continuing Education Division of the American Society for Engineering Education issued a white paper that recommended the abandonment of CEU's for rating CE/S&E courses, workshops, seminars and short courses.

A majority of professionals would prefer to have no ratings or accreditations for non-academic CE/S&E programs because of the constraints that would be imposed. Most CE/S&e programs cater to participants with mixed academic backgrounds, but common interests in a subject area. They may differ in competences, yet much of their knowledge requisite to benefit from a particular course has been accumulated over years on the job. Thus, the imposition of credits that have no academic significance may eventually require prerequisites, grading and evaluations that could not only severely reduce participation, but also seriously cut into valuable time that participants can devote to CE/S&E.

Still, a strong feeling persists among some employers and educators that means short of testing students, freezing the contents of an offering, and giving grades or credits, should be developed for evaluating the merits of CE/S&E programs to assure that the related expense is warranted.

Several instruments for participant evaluation of CE/S&E courses, workshops and seminars are in use. Some of these instruments, which are usually filled in by able professionals at the completion of a program, are acceptable to employers. If an employee claims to find an offering beneficial, it usually satisfies the sponsor. Yet, fault is found with these instruments because they do not evaluate the performance of each participant. Some employers want a grade in programs that do not warrant grades.

Because this matter of CE/S&E course and participant performance evaluations seems to be a recurring problem, *it is recommended here that NSF undertake a study to determine means for evaluating non-academic CE/S&E offerings as well as participant performance therein without resorting to testing of participants and the imposition of inflexible constraints on CE/S&E implementation.*

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APPENDIX F

FACTORS AFFECTING THE RELATIONSHIP BETWEEN CONTINUING EDUCATION AND PERFORMANCE: A STATE-OF-THE-ART REVIEW

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This paper was one of six prepared in response to a request of the Science Education Directorate of the National Science Foundation as part of its consideration of current and possible future activities in continuing education in science and engineering. Any opinions, findings, conclusions or recommendations expressed herein are those of the author and do not necessarily reflect the views of the National Science Foundation.

FACTORS AFFECTING THE RELATIONSHIP BETWEEN CONTINUING EDUCATION AND PERFORMANCE: A STATE-OF-THE-ART REVIEW

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The general topic this paper will address is the relationship between participation in Continuing Education in Science and Engineering (CESE) and its effects on performance. This relationship will be explored with reference to how the educational mode and objectives as well as the characteristics of the individual, the work and the organization are related to the outcomes of CESE.

Accelerating expansion of scientific knowledge and rapid technological change have contributed to the widespread problem of obsolescence among scientists and engineers (Kaufman, 1974a, 1975b). The obsolescence of technical knowledge acquired while in college has been quantified in terms of its "half life" (Zelikoff, 1969). For example, the half-life for a 1955 engineering graduate was approximately eight years—that is, half of what was learned in 1955 was no longer applicable eight years later.

Industry and government have typically responded to the problem of obsolescence by providing CESE for updating their scientists and engineers. Indeed, the expansion of organizational allocations toward CESE activities appears to have paralleled the rapid growth of scientific and technical knowledge which has occurred since World War II (Torpey, 1964; Wheeler, 1968).

The Lack of Assessment

It would be expected that with the substantial investments being made in CESE, there would be some assessment of the benefits derived from it by scientists and engi[illegible]rs or their organizations. However, all indications [illegible]e that assessment of CESE is indeed rare. For example, in an NSF sponsored study of 17 R&D laboratories, it was revealed that "none of them report any systematic research or measure designed to determine the benefits of continuing education either to the laboratory or the individual" (Renck, 1969, p. 36).

However, it does appear that a minority of private companies do at least make an attempt to ~~carry~~ out some type of evaluation of CESE as the following survey of over 70 large corporations revealed:

> Attitude surveys, skills inventories, turnover analyses and degree and patent counts were identified as ways by which industry assessed the effectiveness and value of its sponsored continuing education: The most frequently used method of assessment was the attitude survey. Degree counts, skills inventories, turnover analyses, and patent counts followed in ranked order. However, more than 60 percent of the responding companies used no method for assessing either effec-

tiveness or value of their continuing education programs. Collection, analysis, and study of data about objectives, participants, or programs were lacking. This lack of measure and evaluation limited the understanding of means for combatting obsolescence because it restricted the available knowledge in this field (Wheeler, 1968, pp. 25–26).

As can be seen from the criteria used by those organizations that do evaluate CESE, job performance is conspicuous by its absence. In the NSF sponsored study on continuing education it was recommended "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" (Renck, 1969, pp 85–86). With such substantial organizational resources invested in CESE and with personnel researchers so concerned about the factors contributing to the performance of technical staff, it is truly remarkable that there is such a paucity of research relating CESE to performance. Possible reasons for this will be addressed later in this paper. Despite the lack of organizational assessment of CESE, there is a limited amount of relevant research that has been carried out primarily by university based investigators focusing on private industry. The results of this research will be integrated below in order to improve our understanding of CESE and its effects.

Most organizational support for formal CESE tends to be concentrated in two areas, namely, tuition refunds for university sponsored courses and sponsorship of in-house courses (Wheeler, 1968). Hence, this analysis will focus primarily on these two course modes.

UNIVERSITY SPONSORED COURSES

It has been found that completing an advanced degree is related to being more up-to-date (Purrucci and Rothman, 1969), achieving higher job performance (Dalton and Thompson, 1971) and attaining more rapid advancement (Renck, 1969). However, it is those who are most competent to begin with who are more likely to complete more advanced education (Kaufman, 1975a), and hence, the strong relationships between degree level and these criteria may be spurious. Furthermore, scientists and engineers who, after completing their baccalaureate, remained as full-time students pursuing a graduate degree would not be considered as participating in CESE. As used in this paper, CESE applies only to educational activities engaged in by those who have already begun working in their profession.

There is evidence (Kopelman, Thompson and Dalton, 1974) that R&D professionals who do return later in their career to complete a master's degree are lower in performance, compared to their colleagues who received their master's degree when they were in their early twenties—very likely before they began working full-time. However, even the R&D Professionals who completed a master's degree later in their career still tended to be higher in performance than those who did not go beyond their baccalaureate.

More convincing evidence that having an advanced degree does improve performance comes from a longitudinal study of R&D professionals (Kopelman, 1977). The study demonstrated that having a graduate degree was one of the most important factors related to performance improvement over a period of four years. But since the most competent R&D professionals are more apt to complete a graduate degree, their performance improvement may be more a consequence of their competence than their advanced education.

Although university-sponsored courses taken for credit were ranked by R&D scientists and engineers as the most important formal CESE mode for keeping up-to-date, participation in these courses were not related to advancement (Renck, 1969). Other research has also failed to demonstrate that the number of courses completed for credit is related to performance and in fact, R&D professionals who completed more accredited courses were found to have lower performance (Kopelman, et al., 1974). However this could be an artifact of those with the least education (e.g., those without a degree), who may be the poorer performers, enrolling in such courses.

Further complicating the relationship between CESE and performance are consistent findings that those who complete university-sponsored courses are perceived as less obsolescent, regardless of whether or not the courses are applied toward a graduate degree (Cenko, 1964; Rubin and Morgan, 1967). A possible implication of this is that participation in CESE may result in a positive "halo" effect in the performance ratings of some scientists and engineers. This would tend to bring into question the reliability and validity of performance ratings as criteria for CESE. Unfortunately, there are few alternatives criteria to performance ratings that are relevant to all scientists and engineers. Thus, a greater understanding of the relationship between CESE and performance appears to be dependent, in part, on the development of more reliable and valid criteria.

Individual Differences

It is clear that one of the major problems in attempting to determine the effects of CESE on performance, even in longitudinal research, is the need to remove the effects of individual differences on course participation. If this could be accomplished, it would permit an analysis of the contributions of CESE to performance while controlling for the effects of competence on course-taking.

There is one study that did take into account individual differences and their relationship to CESE (Kaufman, 1970). This study was longitudinal and followed up 110 engineers in three organizations who were administered a battery of tests by Educational Testing Service shortly after they were hired (Hemphill, 1963). Thus, there were competence scores available for base-line data. Performance ratings and CESE data covered a period of 14 years, divided into three periods, namely, the early career, the half-life period and mid-career.[1]

An analysis of the total sample, revealed that there was a small positive increase in the relationship between the number of university courses completed[2] and later job performance, so that by mid-career this relationship became significant (Kaufman, 1970). A new analysis of this data controlled for initial competence which was found to be significantly related to participation in graduate courses (Kaufman, 1972). When initial competence was controlled, the relationship between graduate course-taking and subsequent performance was reduced somewhat but was still significant during the mid-career period.

Work Environment

Since differences in work environment were found to be related to participation in graduate courses (Kaufman, 1975a), organizational characteristics may affect the relationship between graduate course-taking and performance. Hence, a comparative organizational analysis was carried out and the results are depicted in Table 1. As can be seen from this table, in organization A, whose work is exclusively in R&D, there is a strong relationship between the number of graduate courses taken and performance, at least up until mid-career. When initial competence is controlled for in organization A, the relationship between participation in graduate courses and performance is slightly reduced but still significant during every career period.

A completely different picture emerges in the other organizations. For example, in organization B, which was oriented toward highly applied development work, those who completed more courses tended to have lower performance early in their career regardless of competence. However, no relationship between graduate course-taking and subsequent performance in the half-life or mid-career periods was evident. In Organization C, whose activities were directed toward manufacturing, graduate course-taking was not significantly related to performance during any period.

Table 1.—Correlations Between Number of Graduate Courses Completed Early in Career and Job Performance Ratings During Three Career Periods

Organization and Technology	N	T_1 Early Career (Years 1-8)	T_2 Half-Life (Years 9-11)	T_3 Mid-Career (Years 12-14)
A. Basic R&D	37	.47**	.42**	.40*
B. Applied Development	35	-.29	.05	.06
C. Manufacturing	38	.14	-.02	.15
TOTAL	110	.15	.17	.21*

** $P<.01$
* $P<.05$

Thus, it appears that participating in graduate courses can have a positive effect on performance but only in certain work environments. An R&D environment may be more likely to encourage and reward graduate course-taking. But in those environments where such encouragement and rewards are limited or absent, such as in the organizations engaged in more applied work, graduate courses may not only have no impact on performance but also can even have a negative effect. In organization B, it may be that those who devoted more time to graduate courses were spending less time on their job assignments, a factor strongly related to performance ratings (Kopelman, 1977). Hence, it is possible that efforts at graduate course-taking may be penalized in some organizations, especially if it diverts time and energy from the individual's immediate job assignment. There is evidence that discouragement of participation in CESE, particularly by the immediate supervisor, occurs for this reason (Hunter, 1966; Kaufman, 1974a; Landis, 1969). Since supervisors typically are responsible for rating the performance of their subordinates, they have the power to reinforce or stifle CESE participation, regardless of company policy.

Evaluations by Universities

Although assessment of CESE in private industry has been quite limited, the situation is far worse in educational institutions, where few have any evaluation of CESE (Greenfield, 1969). One assessment carried out in a university setting was a survey of engineers participating in the University of Wisconsin-Extension continuing engineering education programs (Klus and Jones, 1975). This survey found that greater program participation was related to salary level, salary increases and promotions. Considering that no comparisons could be made with non-participants (i.e. there was no control group), and that the sample was very likely a select one to begin with, the findings are quite limited in their implications. Perhaps the only implication is that among engineers enrolling in university sponsored programs, those who are more competent have a higher participation rate. The

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[1] The early career was defined as the first eight years of work experience, the half-life was from nine to eleven years since the engineers received their degrees in the mid 1950's, and mid career began in the twelfth through the fourteenth year

[2] Almost all university courses were com[illegible] during the early career. A measure was developed which inclu[illegible]egree recipients as well as those who completed courses withou[illegible]ng a degree (see Kaufman, 1970).

survey did not reveal—and indeed could not since it was not longitudinal—what effect participation had on subsequent performance. Since it is the universities which are largely responsible for developing CESE programs, particularly at the graduate level, their laxity in assessing the effects of their own programs is even more blatant than that of industry.

Non-Credit Courses

The results of the University of Wisconsin-Extension study cited above, dealt primarily with non-credit programs, and there is considerable evidence that scientists and engineers feel that non-credit courses are important for keeping up-to-date (LeBold, Perrucci and Howland, 1966; Renck, 1969). Although those who are more competent apparently turn to non-credit courses (Klus and Jones, 1975, Kopelman, 1977), participation may be more likely for engineers who have only a baccalaureate (LeBold, et al., 1966; Renck, 1969). The limited evidence that does exist fails to show any relationship between non-credit course participation and performance. For example, a longitudinal study of R&D professionals revealed that there was virtually no change in performance related to the taking of non-credit courses (Kopelman, 1977). Non-credit courses are also offered by professional societies but despite being popular (Landis, 1970), their effects on performance are unknown. Although non-credit courses appear attractive for updating, their impact on performance improvement has yet to be demonstrated.

Educational Leave Programs

An NSF-sponsored study of CESE revealed that only 14 percent of R&D professionals participated in educational leaves of absence with pay (Renck, 1969) which is exactly the proportion of engineers who work in organizations where this educational option was available (LeBold, et al., 1966). However, such leaves are used much more by the "elite" R&D professionals, who tend to be the scientists, and by those working for the government (Renck, 1969). Surveys in private industry indicate that only the large high-technology corporations sponsor full-time fellowships for their employees and they are highly selective (O'meara, 1968).

The only indicator of program effectiveness has been a consistent report that participants had a much greater likelihood of remaining in the organization and provide longer length of service than non-participants (O'meara, 1968; Renck, 1969). This organizational commitment however, may be an artifact of the selection procedures used to determine who will participate.

Educational leave in the form of a sabbatical appears most applicable to the scientist or engineer at mid-career. Assessment of the effectiveness of sabbaticals are rare, and when they do occur a questionnaire survey of participants is the most popular evaluation tool (Slonaker, 1976). However, one exception to this methodology obtained before and after evaluations from individuals who acted as reference persons for program applicants (Slonaker, 1976). The methodology was considered effective, despite the lack of a control group. One important finding was that "a significant minority of participants experienced re-entry problems when they returned to the work place" (Slonaker, 1976; p. 8). These problems included being out of touch with the organizational network and underutilization of newly acquired knowledge and skills. Furthermore, anticipation of reentry problems has served to diminish interest in sabbatical programs (Miller, 1974).

It is clear that participation in educational leave programs have been quite limited and hence, evaluations have as well. However, any assessment of such programs, particularly for the mid-career professional, must take into account the very crucial reentry problem.

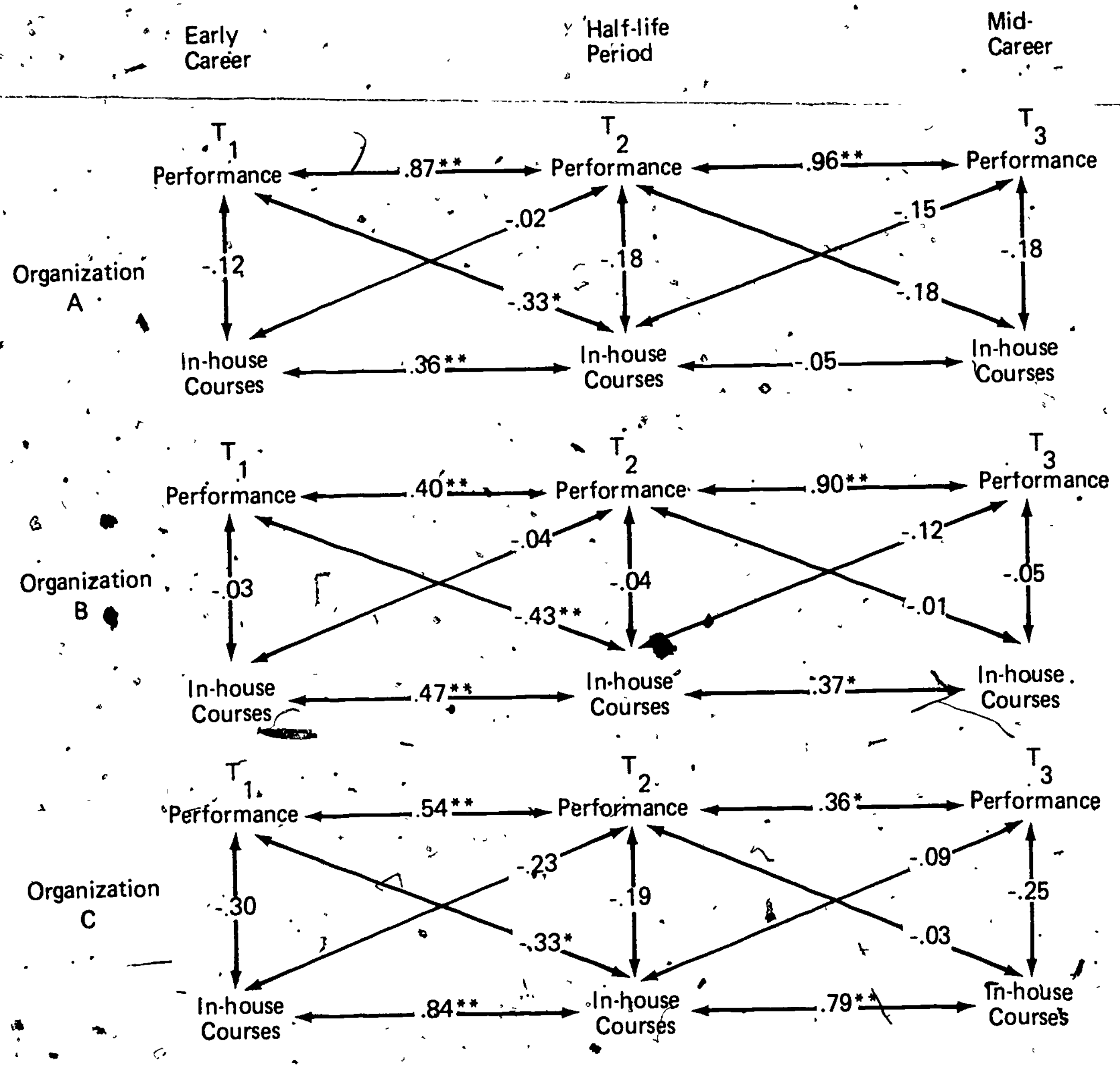
IN-HOUSE COURSES

As was already noted, there has been an extremely rapid growth in organizationally sponsored in-house CESE. However, as in the case of university sponsored courses, research studies that yield relevant data on the effects of in-house course participation on performance are rare.

About as many R&D professionals turn to in-house courses as are enrolled in accredited university coursework but 44 percent ranked the latter as first or second in importance for keeping them up-to-date compared to only 20 percent who selected the in-house courses. These results tend to be reflected in most of the research relating in-house courses to performance. For example, those who had the poorest performance tended to have taken the most in-house courses during the previous period (Kopelman, et al., 1974). However, there is consistent evidence that those who are least competent are attracted to such courses to begin with (Kaufman, 1975a; Renck, 1969). Hence, only a longitudinal study would be able to determine whether in-house courses have any effect. One such longitudinal study revealed that, indeed, it was the poorest performers who tended to take more in-house courses (Kaufman, 1970). However, such course-taking was not related to subsequent performance in mid-career as can be seen from the analysis in Figure 1. This was replicated in three organizations and the results were consistent for all—the poorest performers take more in-house courses but such course-taking does not lead to improved performance. These results hardly changed when competence was controlled for.

However, one interesting trend should be noted. The relationship between the number of in-house courses completed during the half-life period and subsequent performance turns positive, although still insignificant, after

Figure 1.—Cross-lagged Correlation Analysis for In-House Course Participation and Job Performance Ratings.



controlling for the negative correlation between early performance and course participation during the half-life period. This suggests that perhaps certain types of in-house courses are more effective than others but the impact of any one type is obfuscated by aggregating all in-house courses. There is evidence that in-house courses have differential effects. Performance decreased over a four-year period among R&D professionals who took in-house courses that were longer than 20 hours duration; those taking shorter courses improved their performance (Kopelman, 1977). It was suggested that this difference may be more a reflection of the objectives of the participants rather than of the courses themselves. Those taking long courses may be doing so to remedy a general deficiency in their knowledge and skills whereas the shorter courses may be taken to acquire specific skills that can be readily applied to the job.

The implications of the above results are not only that it is necessary to evaluate courses by mode but also by the objectives of participants. For example, those who enroll in the longer in-house courses may have career-oriented objectives that would not be reflected in immediate improvement of performance but rather in long-term career growth. Hence, the need for longitudinal studies to investigate the impact of CESE on the careers of scientists and engineers is quite clear.

CESE AND TURNOVER

Although turnover of personnel is not a direct measure of performance, it may be an important criterion of CESE effectiveness for at least two reasons. First of all high turnover is an index of poor job satisfaction which may affect performance. Secondly an organization's investment in developing its scientists and engineers is completely lost if they leave.

As we already noted, there is evidence that participation in educational leave programs is related to longer subsequent service and the same was found to be true for R&D personnel who were supported by receiving reduced-time at work in order to continue their education (Renck, 1969). A survey of company tuition-aid plans found some firms reporting "that an employee's participation in their plans improves their chances of retaining his services" (O'meara, 1970, p. 109).

However, an unpublished study carried out by the author in one company found that engineers who took advantage of the tuition-aid program to complete their masters degree did initially tend to stay longer with the company, but ultimately their turnover rate was higher than for non-participants. It is possible that length of service is increased in the short-run because of a several year commitment to complete a master's degree. However, if following completion of the degree the prospects for advancement or more challenging work are limited in the company, the individual may look elsewhere for such growth. In fact, a study of in-house training revealed that those who left their companies after completion of the training did so because their advancement possibilities and job assignments did not work out as expected (Habbe, 1963). Hence, support for CESE may stimulate turnover in the long run, particularly when organizational rewards for participation are not forthcoming. However, if the organization does not provide adequate support for CESE, the most competent are likely to leave in order to continue their education (Hemphill, 1963). It is clear that more research is needed to determine the impact of CESE on turnover, particularly the role played by the organizational reward system.

CESE AND UNEMPLOYMENT

Involuntary turnover in the form of layoffs have periodically plagued scientists and engineers but there is consistent evidence that participation in CESE may enhance job security at such times (Kaufman, forthcoming). A study of 125 engineers laid-off by a large division of a major corporation revealed "one interesting constant among all—not one had taken any form of extracurricular education in the past six years" (Davis and Koerper, 1965, p. 14). Perhaps the most clear-cut evidence comes from a study of layoffs of R&D professionals from eight firms, where it was found that those with advanced education, particularly an M.S. degree, had the least likelihood of losing their jobs (Thompson, 1972).

Not only does CESE appear to enhance job security, but even when job loss does occur, having advanced education, especially at the masters level, has consistency been found to enhance reemployment success (Kaufman, forthcoming). However, little research has been carried out to determine whether CESE subsequent to layoffs has any impact on reemployment success. Although the issue of CESE and in particular retraining, for scientists and engineers who cannot find work in their field, is beyond the scope of this paper, it is a crucial problem that will demand more attention as the "Ph.D. glut" becomes more serious and an increasing number of science and engineering graduates settle for underemployment.

THE ROLE OF NSF IN THE ASSESSMENT OF CESE

The research that has been carried out relevant to the assessment of CESE has raised more questions than it has answered. Nevertheless, it is these unanswered questions that have stimulated the following evaluations and suggestions regarding the role of NSF vis-a-vis the assessment of CESE:

1. NSF Support for CESE Assessment

Employers and universities are generally not involved in the assessment of their CESE programs despite their considerable allocations of resources to develop and maintain them. This lack of assessment of CESE may be a case of apathy or lack of interest as has been suggested by some (Renck, 1969; Smith, 1973). Or perhaps assessment would be too threatening to the vested interests of many training and development directors and university administrators. Although these are plausible explanations, perhaps the most important barrier is that assessment of CESE not only requires the investment of resources but also expert knowledge of evaluation research. Some organizations involved heavily with CESE have both but others may not. *One possible approach that NSF could take to stimulate assessment is to require an evaluation of the effectiveness of NSF funded CESE programs.* By making such assessments mandatory, it will be possible for the first time to evaluate the effectiveness of CESE on a wide scale *NSF could also allocate research funds specifically earmarked for assessment of CESE.* This could complement mandatory assessments but would place greater emphasis on adequate research design including the use of control groups

2. Priority to Longitudinal Evaluations of CESE

It is clear that in order to study CESE adequately, longitudinal research is necessary. In fact, longitudinal evaluations have recently been identified as one of the three most pressing research needs in continuing engineering education (Griffith, 1976) Not only is it desirable to be able to determine what the immediate effects of CESE are in terms of performance, but also what type of impact it has on the individual's career Different types of CESE may be more effective for certain career stages than for others and only longitudinal types of research would be able to determine this. *By giving priority to longitudinal studies, NSF will thereby encourage a long-neglected but much needed area of research However, meaningful results will be forthcoming only by NSF commitment to projects of adequate duration.*

3. Development of Criteria for CESE Evaluation

It is clear that individual objectives in CESE participation differ and any evaluation research must take into account these objectives and the degree to which they have been attained CESE by objectives could be one approach to develop criteria by which to measure course effectiveness Evaluations of this type using behavioral and course-content objectives have been reported to be quite successful for assessing in-house programs (Cantwell, 1976)[3] Evaluation criteria could also involve return on investment (ROI) or cost benefit analyses. However, experience in using an ROI approach shows that when the evaluation instruments are too costly in terms of time or difficulty in collecting the data, even organizations that were initially willing to cooperate in the evaluation of CESE become discouraged and are reluctant to continue (Morris, 1976, Morris, 1977)[4] Therefore, if the evaluation instruments are to be very elaborate, commitment to their use by participating organizations must be ascertained prior to NSF funding One alternative is to use a less elaborate technique for assessment It is quite possible that using a relatively simple approach in assessment may be almost as effective and more efficient than one which is complex However, it is also clear that using existing performance ratings have a limited usefulness since they may be measuring only one aspect of CESE impact and are more relevant for certain objectives than for others It is clear that much closer attention must be paid to the criteria used for evaluation They should be reliable, valid and acceptable to users The importance of acceptability cannot be overstressed since even the most reliable and valid measures become totally useless if organizations are reluctant to use them *The development of such criteria for CESE evaluation should be included as one aspect of NSF sponsored research in CESE.*

4. Require Base-line Measures of Individual Differences

Since it has been amply demonstrated that those who enroll in university sponsored courses are quite different from in-house course participants (Kaufman, 1974b; Kaufman, 1975a), any assessments of CESE must not only evaluate the impact on different types of professionals (e.g., scientists versus engineers, younger versus older, etc) but also should take into account base-line measures of individual differences Although controlling for competence using test scores did not make a great difference, using prior performance appears to hold much promise as one way to obtain base-line measures *Any CESE evaluation research sponsored by NSF should require specification of appropriate base-line measures for individiaul differences.*

5. Assure Generalizability of Results

One of the major problems evident in the research reported in this paper is the generalizability of the results. Most available research of CESE has aggregated all engineers or, even worse, scientists and engineers Since engineers in different functions and scientists in different fields are likely to have different updating needs (Mali, 1969, Ritti, 1968), it is difficult to generalize about CESE in specific fields from studies that have aggregated their samples. *Therefore, it would be desirable that CESE research sponsored by NSF specify the populations of scientists or engineers to which the results would be applicable* As was clearly demonstrated, the impact of graduate courses was quite different in each organization but that of in-house courses was replicated in all This points out the need for replication in order to assure generalizability of results. *Hence, CESE research sponsored by NSF should require designs that will permit replication.*

6. Assessments of Work Environment

The factor that had the greatest impact on the relationship between graduate course-taking and performance was the organization. This corroborates the findings of other research which has found that the work environment and organizational climate are crucial factors in

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[3] Also based on discussions with John A. Cantwell of Sandia Corporation, Albuquerque, New Mexico

[4] This conclusion is also based on discussions with Albert Morris of Genesys Systems Inc. Palo Alto, California

stimulating and rewarding CESE (Kaufman, 1975a; Margulies and Raia, 1967). Over a decade ago researchers made the following plea concerning the crucial role of organizational climate in CESE assessment:

> The development of adequate procedures to assess the effectiveness of formal programs in terms of increased utilization of the organization's and the nation's manpower resources is a pressing need. If the climate variables are in fact crucial in the learning process, then a means of identifying them and assessing their impact on ameliorating the problem of growing technical obsolescence should be a major concern (Margulies and Raia, 1967, p. 48).

Apparently this plea has gone unheeded but it need not continue to be. *An assessment of organizational characteristics that affect the impact of CESE should be one of the areas of research supported by NSF.* In fact, the redesign of the work environment appears to hold the most promise in enhancing professional development while at the same time helping to maintain organizational vitality (Kaufman, 1974a).

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APPENDIX G

NATIONAL SCIENCE FOUNDATION DIRECTORATE FOR SCIENCE EDUCATION

Interim Report: Continuing Education in Science and Engineering

February 28, 1977

PREFACE

This report responds to the requirement, of the explanatory statement of the House-Senate Conference Committee related to the National Science Foundation Authorization Act of 1977, for a report on continuing education in science and engineering including.

a. recommendations for implementation in FY 1978,
b. analysis of information on the employment and availability of scientific, engineering, and technical manpower;
c. an assessment of the extent to which a federally-supported continuing education program could alleviate unemployment and underemployment among scientists and engineers and lead to the greater application of their skills to the solution of problems the nation is facing in areas of civilian science and technology.

This report was prepared by the staff of the Office of Program Integration of the Science Education Directorate. It is based on a review of the literature, input received from other NSF staff members. and input received from a public meeting of national experts on the problems of continuing education held at the National Science Foundation on December 13, 1976. A summary of the meeting is appended to this report along with a list of participants and observers. The National Science Foundation is grateful for the contributions of all these individuals. We are also indebted to Gene Dalton, Utah State University, Samuel Dubin, Pennsylvania State University; Richard Freeman, Harvard University, and Finis Welch, Rand Corporation, for informal comments made during the preparation of this report. The National Science Foundation is, however, solely responsible for any errors, findings, and interpretations.

We intend to conduct additional studies which we will be discussing with congressional staff.

EXECUTIVE SUMMARY

The need for continuing education in science and engineering stems from professional or technical obsolescence—the outdating of technical knowledge and resultant loss of job skills among scientists and engineers. Obsolescence is caused primarily by the rapid growth of knowledge and appears to be related to aging. There is evidence that on the average individual performance among technically-trained personnel peaks before age 40 and declines steadily thereafter. There is, however, great variability within age groups.

The obsolescence phenomenon is complicated by organizational, personal, and occupational factors. Job assignment, opportunities for interaction with stimulating colleagues, organizational reward systems, and individual motivation are all significant factors related to obsolescence of scientists and engineers.

Because of the obsolescence phenomenon, maintenance of the quality of the stock of human resources in science and engineering may be a significant problem.

Continuing education is frequently prescribed as the solution to the problem of maintenance of quality of technical personnel. It takes many forms ranging from informal activities in the work place to formal courses in universities.

Continuing education is a widespread practice. A recent survey showed that almost 40 percent of a national sample of scientists and engineers took part in supplementary training programs during the two years immediately preceding the survey. Almost half of that supplementary training was of the on-the-job type. Because of the great variation in the nature and scope of continuing education, the investment in it is hard to measure. However, one estimate is that business and industry spend $17 billion annually on continuing education of all types.

Assessments of the effectiveness of continuing education are mixed. In particular, courses alone do not appear to be an effective remedy for the problems of aging and obsolescence. This is in part traceable to the organizational, demographic and personal factors cited earlier.

Given this background, the basis for the program plan presented for FY 1978 is established by roughly measuring general program strategies for continuing education open to NSF (support for individuals, support for institutions, research, and development) against four criteria for program design (significance, NSF role, feasibility/readiness, and cost effectiveness) The argument for an NSF role in continuing education for the academic sector seems clear based on the four criteria, which leads to programs for college and high school teachers, and for support of incentives for colleges and universities to improve their organizational capabilities for maintaining the quality of their faculties.

The Federal role in supporting continuing education for industry is warranted when three conditions hold:

1. Individual workers, firms or industries cannot capture all the benefits from investments in continuing education or training
2. There is a reasonable probability that Federal programs will be effective
3. The costs of the Federal programs bear a reasonable relation to the expected social benefits.

Our analysis indicates that it is not known whether the conditions hold. Accordingly, our program plan for continuing education in industry emphasizes research and development In this way, we expect to clarify the extent to which the conditions hold, what the needs are, and to explore alternatives.

We find that unemployment rates for scientists and engineers have been significantly less than the rate for the total labor force. While estimates vary somewhat, a recent estimate shows that less than 1 percent of doctorate scientists and engineers are unemployed. When unemployment rates are compared with supply and utilization projections a question does arise about possible underemployment—underutilization of skills—of scientists and engineers There is evidence "credentialing"—increasing education prerequisites for jobs—is occurring. However, it is not clear to what extent upgrading—changing the nature and content of jobs to be commensurate with the prerequisite training—is occurring. Thus, it is not clear whether there is a problem of underemployment

On the basis of previous experience, especially with retraining and career redirection of unemployed aerospace workers in the early 1970's, it does not appear that continuing education is effective in dealing with unemployment/underemployment unless there is assurance that such training will lead to reemployment or assurance that society will support new kinds of employment opportunities

The Problem

The need for continuing education in science and engineering stems from professional or technical obsolescence, which we define as the degree to which professionals lack up-to-date knolwedge or skills necessary to maintain effective performance in their work roles.[1] Studies[2,3] trace the root cause of the problem to the growth of knowledge and information. One reason why the obsolescence phenomenon is becoming of greater interest today is that the rate of knowledge growth is accelerating. One estimate[4] shows that it took 20 years for the technical information the chemical engineering class of 1935 received in college to become obsolete. But the technical information the class of 1960 received took only five years to do the same. According to this estimate, the information received by the class of 1970 is already obsolete.

The rate of obsolescence among professionals appears to be related to aging as well as to knowledge growth. A recent study[5] of 2500 engineers in six technology-based companies found that individual performance among technically trained personnel peaks at an early age and declines steadily thereafter. While the general phenomenon is not new (and of course does not affect everyone), the age at which this is happening is falling.

The obsolescence phenomenon is complicated by organizational, personal, and occupational factors. On the organizational side, dull jobs, isolation from stimulating colleagues, and a poor reward system can all stifle vitality among professionals [6] A poor organizational climate reduces motivation to maintain an appropriate skill level

The social costs of obsolescence are high Either the organization stagnates or individuals must be replaced prematurely at a personal cost and the loss of their and society's investment in their training. In academic institutions, the effect of obsolescence may be multiplied because students are inadequately prepared. The indications, discussed below, that the educational system is entering a "steady state" will exacerbate the problem by slowing down the replacement of personnel

What follows is a discussion of supply and utilization projections of science and engineering doctorate holders, and the characteristics of all U.S. scientists and engineers This discussion leads to generalizations with which we end this section During most of the decade of the 1960's both supply and utilization of science and engineering talent were growing sharply. Toward the end of the 1960's, we began to see signs of oversupply Recent projections made by the National Science Foundation[7] indicate that between 375,000 and 400,000 sci-

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[1] H G Kaufman. *Obsolescence and Professional Career Development*

[2] Ibid

[3] S S Dubin (ed). *Professional Obsolescence*. Lexington Books. D C Heath and Company. Boston. 1971

[4] Kaufman. op cit

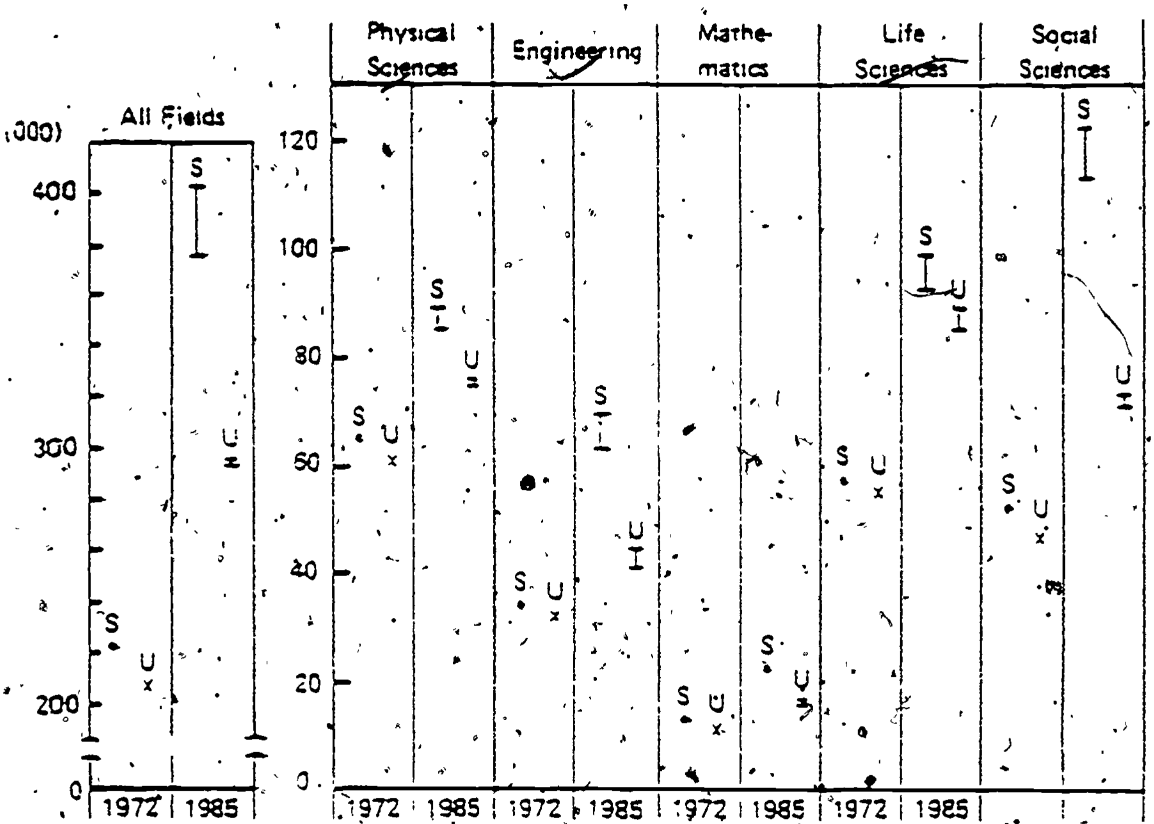
[5] G W Dalton and P H Thompson. *Accelerating Obsolescence of Older Engineers*. Harvard. Business Review. Vol 40 (1971). pp 57-67

[6] Kaufman. op cit

[7] *Projections of Science and Engineering Doctorate Supply and Utilization*. 1980 and 1985. NSF 75-301. National Science Foundation. 1975

Figure 1.—1975 Manpower Projections

SUPPLY AND UTILIZATION RANGES OF SCIENCE/ENGINEERING DOCTORATES. 1972 AND 1985



NOTE Vertical bars indicate range between probable and static model values of supply and utilization.
SOURCE: National Science Foundation.

ence and engineering doctorates would be available to the U.S. economy in 1985, compared to about 295,000 available positions in science and engineering-related activities. These projections are shown graphically in Figure 1. Recent projections of the Bureau of Labor Statistics[8] estimate that 13.1 million college graduates will enter the labor market between 1974 and 1985 while there will be only 12.1 million job openings requiring a college degree over that period. The latter includes an estimated 18% of the openings coming from increasing educational prerequisites for jobs not formerly requiring a college degree.

In comparison to previous studies, current ones show that the oversupply is increasing. The same picture of oversupply emerges from other studies:[9] academic careers for new Ph.D. holders will be difficult to obtain.

Figure 2 displays characteristics of all U.S. scientists and engineers in 1974, not just doctorate holders. This is based on an NSF study[10] which shows that the total population of scientists and engineers in the United States in the spring of 1974 was estimated to be 1,970,000; 900,000 scientists and 1,070,000 engineers. Although the population of scientists in 1974 was nearly equal that of engineers, their representation in the S/E labor force was considerably smaller; about 94 percent of all engineers as compared with less than 75 percent of all scientists. As a result, the S/E labor force, which numbered 1,680,000, consisted of 3 engineers for every 2 scientists. The reduction in the proportion of scientists in the S/E labor force as compared with that of engineers can be attributed to a number of factors including (1) the larger proportion of scientists who defer entrance into the labor force while pursuing postgraduate studies, (2) a greater acceptance of the bachelor's degree in engineer-

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[8] *Occupational Projections and Training Data*. BLS Bulletin 1918. U.S. Department of Labor, Bureau of Labor Statistics, 1976.

[9] R. Radner et al, Demand and Supply in U S Higher Education, a report prepared for the Carnegie Commission on Higher Education (New York: McGraw-Hill, 1975).

[10] Science Resources Studies Highlights, NSF 76-312, National Science Foundation, 1976.

Figure 2.—Characteristics of U.S. Scientists and Engineers: 1974 (in thousands)

Characteristics	*Total*	*Scientsits*	*Engineers*
Total	1,973	901	1,072
Sex:			
Men	1.788	724	1.064
Women	185	178	8
Race:			
White/Caucasian	1,886	852	1,034
Black/Negro	32	23	9
American-Indian	2	2	-
Oriental	37	17	20
Other	17	9	8
Age.			
24 and under	244	174	70
25 - 29	369	206	163
30 - 34	255	121	134
35 - 39	246	100	145
40 - 44	227	86	141
45 - 49	218	73	145
50 - 54	176	59	118
55 - 59	110	38	72
60 - 64	72	25	47
65 - 69	38	13	25
70 and over	18	7	12
Highest degree			
Doctorate	274	231	43
Master's	393	188	205
Bachelor's	1.255	474	781
Associate	14	-	14
Other degree	12	9	3
No degree	25	-	25
Employment status			
Labor force	1.678	669	1.009
Employed	1.662	663	999
Unemployed	16	6	10
Outside labor force	295	232	63

NOTE Detail may not add to totals because of rounding

SOURCE National Science Foundation.

ing as the professional qualification for engineers than is the case for a similar degree in science, and (3) the large number of women in the total population of scientists (over 22 times that of women engineers) who elect not to enter the labor force either because of fewer job opportunities or to pursue homemaking careers

In 1974 the distribution of scientists, by age, was considerably different from that of engineers. The proportion of scientists under 30 years of age, for example, was almost twice that of engineers. From age 30 the proportion of scientists in each successively older age group declined steadily. Engineers, on the other hand, displayed a dissimilar age profile The proportion of engineers in age groups from 25–29 to 45–49 is relatively constant. This difference may be accounted for, in part, by the greater stability in the supply of engineers versus that of scientists over the past two decades and possibly in part by less movement to occupations outside their general field by engineers.

Scientists and engineers also show substantial differences with respect to educational attainment. The proportion of scientists with graduate degrees, for example, was twice that of engineers. A very large fraction of this difference was accounted for by those individuals who obtained the Ph.D. Thus, while about one-fifth of both scientists and engineers held the master's degree, more than 1 scientist in 4 had earned the Ph.D. as contrasted with about 1 in 20 among engineers...

The age distribution of engineers indicates that obsolescence may be a concern for that group. While the age distribution for scientists look better, the proportion of doctorate holders in that group and a finer-grained breakdown of supply-utilization projections indicate that colleges and universities will face problems of aging faculties in the future.

In summary, the phenomenon of obsolescence caused by knowledge growth and intensified by organizational, demographic and supply-demand factors has created a significant problem: the maintenance of the quality of the stock of human resources in science and engineering. The separate problem of unemployment and underemployment is discussed more fully in a later section of this report.

Continuing Education

Continuing education is frequently prescribed as a solution to the problem of maintaining the quality of performance of scientists and engineers. In this section we consider various aspects of continuing education including target audiences and the nature and extent of continuing education. We conclude with a discussion of some problems and a rough application of some criteria to possible program strategies. This establishes the rationale on which our program plan for continuing education is based.

For the purposes of this report "continuing education" is defined more narrowly than the popularly held concept. Because we are concerned with the knowledge-intensive occupations of science and engineering, our discussion will be limited primarily to the post-baccalaureate level.

The entire target group is readily separated into two major components: those employed in academic institutions, and those employed by nonacademic (primarily industrial) organizations. Within academia, the organizational structure of institutions of higher education makes it relatively simple to distinguish between "scientists" and "engineers." And even though there are many, in both categories who are engaged in both teaching and research, one might consider "teachers" and "researchers" separately. From the point of view of continuing education, however, it is customary to separate those employed in large, research-oriented, graduate-degree-

Figure 3.—Number of the 1970 science and engineering labor force, by supplementary training received: 1972 and 1973

Type of Training	Year of Training 1972	 1973
Total	1,080,000	1,080,000
With supplementary training	397,000	406,000
On-the-job	187,000	194,000
Military applied to civilian	9,000	9,000
Extension/Correspondence	41,000	42,000
Employer training	166,000	180,000
Adult education	45,000	45,000
Other training	90,000	81,000
No supplementary training	472,000	489,000
No report	210,000	184,000

NOTE: Detail does not add to total because of multiple responses and rounding

SOURCE: National Science Foundation.

granting institutions from those in two-year or four-year institutions where there is less (or no) emphasis on research and more (or all) emphasis on teaching. A subcategory within academia comprises elementary and secondary school teachers of science.

In the nonacademic sector, the situation is different. Here there tends to be no clear line of demarcation between scientists and engineers. It is, however, useful to recognize certain other differences: differences between "large" and "small" companies, the position of "high" and "low" technology employers (or employees), and the differing needs of those located in urban areas where there are likely to be concentrations of academic institutions from those in other areas. The continuing education needs of these groups and the mechanisms required to respond to the needs are by no means the same.

Even a cursory examination of practices in continuing education shows that it takes many forms. It can be training offered in the work place or in universities. It can be part-time or full time, formal or informal. Professional organizations offer numerous workshops, seminars, and courses for their members—usually in conjunction with scheduled meetings. Community colleges also offer continuing education courses for scientists and engineers, typically in cooperation with a local professional society or company. One estimate[11] is that business and industry spend $17 billion annually on continuing education.

A recent NSF survey[12] showed that almost 40 percent of the national sample of scientists and engineers took part in supplementary training programs during 1972 and 1973. Of those receiving supplementary training about 48 percent reported it to be of the on-the-job type and over 40 percent enrolled in courses at employer's training facilities. Extension or correspondence courses and courses at adult educational centers were undertaken by about 20 percent of those receiving supplementary training. These marked preferences show that on-the-job training appears to be the most effective way to get continuing education. The relative participation in the various types of supplementary training remained almost constant over the 2-year period. These data are displayed in Figure 3.

Our plan for continuing education takes into account four elements: content, delivery, impact, and persistence. Content and delivery are primarily input considerations while impact and persistence are significant problems in relation to effects of outputs. Content is the easiest problem to solve because universities and private educational materials firms are currently able to develop courses and curricula. Mode of delivery is also a relatively easy problem although there may be some trouble in matching modes and specific needs. This trouble arises in part from the impact and persistence problems as will be discussed below.

With regard to impact, there is evidence[13] that the usefulness of university courses for updating all profes-

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[11] Kaufman, op cit.

[12] Science Resources Studies Highlights, NSF 75–317. National Science Foundation, Washington, D C . 1975

[13] H. G. Kaufman, "A Comparative Analysis of University Versus In-Company Continuing Education for Engineers," in *Maintaining Professional and Technical Competence of the Older Engineer*, American Society of Engineering Education Conference Report, 1973.

sionals may be limited because they are avoided by those who could profit the most. Moreover, many organizations do not provide the climate that would encourage their professionals to continue their education, even if they are self-motivated.[14] One study of 2,500 engineers in six companies found that there was no correlation between performance rankings of engineers and continuing education courses taken.[15] Moreover, the seriousness of a company's obsolescence problem was not related to the number of dollars spent on providing continuing education.

The problem of persistence of continuing education is related to organizational factors. Organizations are more prone to accept and exploit an individual's independent efforts at renewal and growth than they are to encourage and guide such efforts.[16] Such encouragement as there is is often sporadic and ambiguous. This is true for academic institutions[17] as well as for industrial organizations. In fact, many writers believe that the work environment plays *the* crucial role in determining the degree to which obsolescence occurs with increasing age.[18] This belief is reflected in the recommendations[19] for obsolescence deterrence measures in both academia and industry.

There are four strategies that NSF might consider in approaching continuing education: support for individuals (fellowships, short courses), support for institutions, research and development. Each strategy can in turn be considered in relation to either academic or industrial personnel, giving a total of eight categories. The easiest is providing opportunities of varying duration for self-motivated individuals to participate in education programs. We have the most experience with this type of activity and, in dollar terms, it is the largest part of our program plan. It is easier to justify such support for college and university faculty members than for scientists and engineers in private industry. This is argued in the next section of the paper.

A number of large companies (e.g., Xerox, General Electric, Bell Laboratories) with ample resources to retrain their own employees have developed rather sophisticated approaches to the obsolescence problem including establishment of their own schools and cooperative programs with universities. Such organizations do not need the help of the Federal Government.

Because small and medium-sized industrial organizations cannot easily develop schools of their own, it is believed that they might benefit from local or regional cooperative efforts with colleges and universities. We might consider providing incentives for such organizations to develop obsolescence deterrence programs including university-industry cooperation as a component. Greater and firmer commitment from local corporations is a necessary precondition to more effective university-industry cooperation. On the other hand, the initiative can come from either side; industry often needs to be convinced that such plans are indeed feasible.

Finally, given the "steady state" that academia is entering, it may be desirable to provide incentives for colleges and universities to develop internal systems for faculty development rather than rely exclusively on individual striving for recognition to motivate self-development. College and university faculty might also benefit from opportunities to learn more about the needs of industry and preparing students for non-academic careers.

In attempting to determine an appropriate mix and level of strategies or programs, the Science Education Directorate of NSF applies a number of criteria including the following ones.

1. Significance to science education.
2. NSF role: Whether the need is one which should be met by the public sector, whether there is a comparative advantage in meeting this need at the Federal level, and whether NSF is the appropriate Federal agency to undertake the effort.
3. Feasibility and Readiness: Whether the government has the resources to meet the need and whether the technology, knowledge, finances, or personnel resources are available in the field.
4. Cost-effectiveness: Whether the prospective benefits of meeting an identified need are significant in relation to the costs of the resources required.

What follows is a rough application of these criteria to the aforementioned strategies. The discussion is summarized in Figure 4.

Significance

The significance or need criterion can probably be said to be met, in general, for all the strategies on the basis of the discussion in the preceding section of this report.

NSF Role

The Federal Government is a principal monitor and a major user of the output from the knowledge sector. There is a natural Federal concern about maintaining and upgrading the skills of scientists and engineers. The NSF has a long tradition of continuing education support for the academic part of the knowledge sector. Currentness in research and educational skills is one of the basic prerequisites of knowledge generation. Clearly, the Federal Government and society as a whole capture some of the benefits of this currentness, and some of the costs should therefore be paid for by the Federal Government.

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[14] Kaufman, *Obsolescence and Professional Development*, p. 13[illegible]

[15] Dalton and Thompson, op cit

[16] W R Dell, *Obsolescence as a Problem of Personal Initiative*, in S S Dubin (ed), op cit

[17] A W Astin, et al, *Faculty Development in a Time of Retrenchment*, Change Magazine, New Rochelle, New York, 1974

[18] Kaufman, *Obsolescence and Professional Development*

[19] A. W Astin, et al, op. cit., Kaufman, op cit, Dubin, op cit.

Figure 4.—Rough Measures of Strategies Against Criteria

	Significance	*NSF Role*	*Feasibility/ Readiness*	*Cost/ Effectiveness*
Academic				
Individuals	Established	Established	Established	Bounds program size due to impact and persistence problems
Institutions	Established	Established	Established.	Bounds program size due to impact & persis. probs.
Research	Established	Established	Bound by existing capabilities	Established
Development	Established	Established	Bound by Research Base	Established
Industry				
Individuals	Established	Not Established	Not Established	Not Established
Institutions	Established	Not Established	Not Established	Not Established
Research	Established	Established	Bound by existing capabilities	Established
Development	Established	Established	Bound by Research Base	Established

The business and industry part of the knowledge sector have perhaps been more sensitive to the need to maintain productivity and avoid obsolescence. Business and industrial organizations have clearer market signals about potentially declining performance than do academic organizations. Industrial training programs and institutes proliferate. The Xerox program based at a campus in Leesburg, Virginia, is one example. Maintenance of quality of the work force is part of the cost of doing business. Therefore the Federal role in supporting continuing education for industry is limited to quite special circumstances. Such programs would be warranted in general when the following three conditions hold:

1. Individual workers, firms or industries cannot capture all the benefits from investments in continuing education or training.
2. There is a reasonable probability that Federal programs will be effective.
3. The costs of the Federal programs bear a reasonable relation to the expected social benfits.

We do not know firmly whether these conditions hold. Interviews with individual leaders for Science at the Bicentennial suggest that we should begin to assess the need for some additional Federal activity. NSF's December 1976 report on NSF-industry relations suggests exchange programs between universities and industry as a mechanism of information transfer. Clearly, there are effects on skill levels and obsolescence as well. The program plan presented below calls for research in this area and for experiments in university-industry cooperation specifically oriented toward continuing education.

Feasibility/Readiness

We believe that the feasibility/readiness criterion is met for provision of continuing education opportunities through fellowship and short courses for college and high school teachers and for instructional support of colleges and universities to provide incentives for those institutions to improve their organizational capabilities for maintaining the quality of their faculties. We have had a great deal of experience with these programs and believe we know how to operate them efficiently. However, cost-effectiveness considerations, discussed below, argue for reasonable dollar limits on such programs.

For reasons discussed earlier, the feasibility and readiness criterion is not adequately met to justify NSF support for delivery of continuing education to scientists and engineers in industry. This is so because the dynamics of the problem—particularly the organizational climate aspect—are not well understood.

Cost-Effectiveness

In the earlier discussion of impact of continuing education, it was indicated that there is reason to believe that the usefulness of university courses for updating faculties may be limited because they are avoided by those who can profit the most. This sort of consideration combined with the persistence problem discussed earlier leads to bounds on program sizes as indicated in Figure 4. These same problems do call for research and development to identify new strategies for continuing education of academic personnel rather than expansion or reinstatement of old strategies.

These considerations result in the posture reflected in our program plan. It calls for moderate support for continuing education of individuals and institutions in the academic setting. It also calls for research to improve the knowledge base and for development to test experimental strategies. We believe this posture is consistent with our analysis of the problem, input from consultants, and the recommendations of the workshop of eight experts we convened in December, 1976.

Program Plan

The program plan and budget for continuing education is shown in the following table. Essentially the Directorate proposes to spend $10.5M* in 1978 on continuing education of all types. This is about 14 percent of the total proposed budget for the Directorate.

For academic scientists and engineers, we judge that the continuing education needs of faculty in research-oriented, graduate degree-granting institutions are considerably less acute than the needs of those in the two- and four-year colleges. Scientists in the former have extensive opportunities for intellectual growth: research conferences, departmental seminars, and large libraries are readily available. Teachers in two- and four-year colleges, however, face more difficulties. They usually have considerably heavier teaching loads and consequently far less free time. They lack opportunities to go to professional meetings, and have a much smaller cohort of colleagues with related interests. The faculty in this setting need help in updating their information base, and in keeping their courses and students in tune with modern developments. Our program plan deals with this college teacher problem directly in several ways.

The college faculty short courses expose college faculty to new knowledge in an intensive way. Fourteen regional centers identify important science topics. With the assistance of the AAAS, first rank scientific talent give three-day courses at the regional centers. This program is of particular value to faculty from 2- and 4-year colleges which do not have active research programs on their campuses. The funds requested would permit 40 short courses for approximately 3,500 college teachers during the academic year 1978–1979.

In FY 1977, we combined the National Needs Faculty Fellowships Program and the Faculty Research Participation Program into the Science Faculty Professional Development Program. Both of the old programs were designed to do the same job—continue the education of college faculty. In the first, the participants spent up to a year in academic institutions. In the second they spent a short time in industry to help them prepare students for industrial careers. In the combined program faculty may choose either academia or industry for up to 12 months. This year we have 1100 proposals with about 10 percent of the applicants wanting to go to industry and 15 percent to government and other nonprofit laboratories.[20]

Continuing Education in Science and Engineering
Obligations by Program Subelement

Program Subelement	*Actual FY 1976*	*Budget Request FY 1977*	*Current Plan FY 1977*	*Estimate FY 1978*	*Difference FY 1978/77*
College Faculty Short Courses	$894,450	800,000	980,000	1,000,000	20,000
Science Faculty Professional Development	2,562,660	2,200,000	2,200,000	2,500,000	300,000
Resources Improvement (CAUSE)	1,000,000	1,000,000	1,100,000	1,450,000	350,000
Research and Development in Continuing Education for Scientists and Engineers	221,146	1,000,000	1,200,000	1,500,000	300,000
Total	$4,678,256	5,000,000	5,480,000	6,450,000*	970,000

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* $4.0M, not shown in the table, is designated for Pre College Teacher Development

[20] We are engaged in other activities directed at the maintenance-of-quality problem that are not continuing education per se, and so are not included in the foregoing budget. These include the Local Course Improvement program, Career Facilitation Projects for Women, and National Needs Postdoctoral Fellowships. Local Course Improvement provides small (up to $25,000) grants to individual college and university teachers to permit them to produce specific changes in their undergraduate science instructional courses and programs. While the primary objective is production of improved instruction for undergraduate students, this type of activity by faculty members is believed to be a significant factor in the maintenance of their technical currentness and professional vitality

Women's Science Career Facilitation projects are carried out by colleges and universities. Participants in the projects are women who have received their last degree between 2 and 15 years earlier. The objective is to facilitate their entry or reentry into science careers or graduate programs.

National Needs Post-doctoral Fellowships provide for up to one year of research or advanced study to scientists and engineers who have received their doctorates within the last five years. Such experience for recent doctorate scientists and engineers has in the past been considered more a part of [illegible] initial training than continuing education. However, by providing incentives for these individuals to move into emerging science and engineering fields related to national needs, it is believed that a contribution is made to the overall maintenance of the quality and diversity of the national stock of human resources in science and engineering. The budget for these activities is 5.8 million dollars.

The programs discussed so far are designed to provide individual scientists and engineers with services to prevent obsolescence. Some of our institutional support programs, in addition, contain continuing education elements. Experience with the CAUSE Program shows that some of the funds are used for revitalization of the existing faculty. We estimate that approximately 10 percent of the funds available in the program are used for this purpose.

We now turn to the issue of continuing education support to help prevent professional obsolescence among scientists and engineers in industry. In an earlier section of this report it was argued that it is not known at present whether NSF-supported programs to deliver educational services to scientists and engineers in industry are warranted or would be effective. Accordingly, our plan is to conduct research and development in FY 1978 to pin down requirements, if any, and to explore and better define alternatives. Given the complexities of the situation, we believe that new approaches to research are called for. In this regard, the following quotation[21] is instructive.

> "Studies on professional obsolescence cover mainly perceived needs of professionals (questionnaire studies), manpower planning models (axiomatic), extrapolation and forecasting of technological change, and time series of vocational interest. The need for the future will be, in my opinion, studies on the process of professional obsolescence within organizations, and in our organizational society, the impact of this process on society. Field studies are required which link models, perceptions and technological requirements with behavior."

Among the research problems to be addressed are identification of specific knowledge and skills needed by particular kinds of industrial scientists and engineers, variations in obsolescence rates by field, the role of organizational climate and motivation in maintenance of vitality, and the relationship of continuing education to job performance. As indicated by the above quotation, we have found that surveys are not particularly useful for studies of organizational climate. We are considering field studies to provide an integrated picture of context, motivation, and technical need.

In development, we plan to experiment with local or regional college-industry collaboration efforts. These efforts will improve our understanding of how best to provide institutional programs needed by industrial personnel. The experiments should generate a framework for faculty involvement in industrial problems. Such an approach is consistent with the recommendations contained in NSF's recent report on research in industry.

The program plan for FY 1978 presented above will build on past and present activities in regard to continuing education. Our research and development components are worthy of special note. The recently published solicitation for Research in Science Education (RISE) and guide for Development in Science Education (DISE) both include continuing education as a target category. Proposals in response to these announcements will arrive in April, 1977. We plan a content analysis of these proposals and will consider further action at that time, possibly including Program Solicitations in Continuing Education.

Unemployment/Underemployment and Continuing Education

In an earlier section, continuing education was discussed in terms of its possible value in overcoming or preventing obsolescence. In this section, we consider the potential impact of Federally-supported programs of continuing education for unemployed or underemployed scientists and engineers.

The rationale for continuing education in this sense generally stems from the measured unemployment rates and the estimated causes for unemployment. If unemployment rates are relatively low and are thought to be derived more from the lack of demand rather than structural sources, as seems to be the case now for scientists and engineers, then retraining programs are inappropriate.

Unemployment data from the Bureau of Labor Statistics indicate that over the past decade the rates for engineers have been varied between 1/12 to 1/2 the unemployment rates of all workers. While it is true that the rates for engineers have increased lately to 3.2 percent, it is still significantly less than half the rate for the total labor force (Figure 5). The unemployment rate for scient[illegible] is less than 2 percent.

It was pointed out earlier in this report that in 1985 perhaps as many as 100,000 doctoral scientists and engineers in the U.S. economy will have difficulty finding jobs normally considered suitable to their training. It is not expected that many of these people will be unemployed. In fact, most analysts believe that advanced training and degrees give individuals an edge in the overall job market, and the unemployment rates cited above tend to reinforce this. Between 1973 and 1975, the number of employed doctoral scientists and engineers increased by 16 percent. The most significant change in the employment pattern occurred in industry, where the number employed grew from 50,000 to 66,000, an increase of 32 percent.[22]

There are indications that "credentialling"—increasing educational prerequisites for jobs—is occurring at all levels.[23] Whether the jobs themselves are

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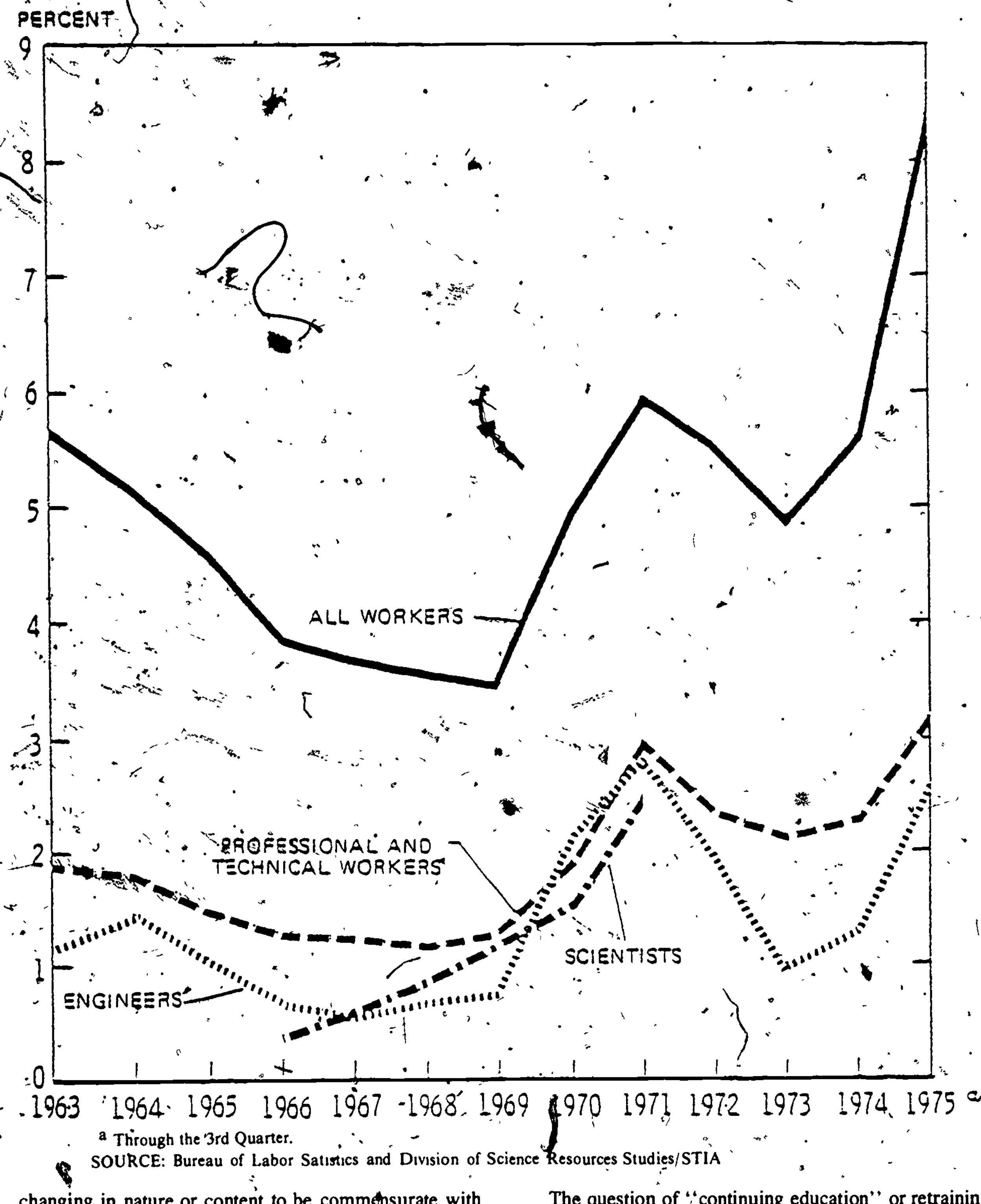
[21] P. Hesseling, "Factors in the Organization Climate Which Stimulate Innovation in Professional Knowledge and Skills," in S. S. Dubin (ed.) *Professional Obsolescence*

[22] Science Resources Studies Highlights, NSF 76-326, National Science Foundation, 1976

[23] M. C. Carey, *Revised Occupational Projections to 1985*, Monthly Labor Review, 1976, pp. 10–22

Figure 5.—Unemployment Rates, 1963–75



[a] Through the 3rd Quarter.

SOURCE: Bureau of Labor Satistics and Division of Science Resources Studies/STIA

changing in nature or content to be commensurate with the prerequisite training (educational upgrading) or whether underutilization of skills is the case is difficult to assess. NSF has a study in process dealing with this problem. We expect to have the results this fall.

The question of "continuing education" or retraining of unemployed or underemployed scientific and technical personnel for obtaining new jobs unrelated to their prior employment is a complex one. As is shown by previous experience, retraining and transferability are not simple phenomena; many factors are involved. Basic to any retraining program are the obvious requirements that: (1) job openings be available, which in turn requires a healthy and growing economy, and (2) prospective employers have a positive and constructive attitude towards rehiring personnel from different areas or specialties.

A report prepared for the National Science Foundation in 1975, summarizes some of the "special career redirection efforts" on behalf of unemployed aerospace workers in the following way:[24]

> "In the late 1960s and early 1970s, reductions in government aerospace procurement resulted in substantial layoffs of skilled blue-collar and white-collar employees. Unemployment among engineers went from 0.3 percent in 1967 to 3.0 percent in 1971. About 60,000 engineers were then out of work One response was the establishment of programs to refit new lines of work. Many of the programs were conducted under the auspices of the Technology Mobilization and Reemployment Program, U.S Department of Labor, which included counselling and information, relocation assistance, and retraining The Labor Department claims that 25,000 persons had been moved into new jobs through these programs by the end of 1972. The experience therefore offers an interesting opportunity to appraise the success of schemes for helping involuntary career changers, many of whom fall within the mid-life years. We derived the following lessons from this experience.
>
> - With few exceptions, the programs were mediocre in overall performance.
> - The quality of the training itself was low on the average. It was sometimes assumed that the clients required little in the way of new technical skills because aerospace industry skills were directly transferable to other industries and to public sector projects.
> - There was insufficient attention to imparting labor market knowledge and job-searching skills. Private employment agencies chose not to provide these services because they were unable to capture the private returns to these activities; and public employment agencies generally did not provide them, public agencies traditionally serve a less-educated clientele with qualitatively different job-search requirements from those of unemployed aerospace professionals.
> - Employers in target fields were particularly resistant to hiring seniors whom they viewed as technically obsolete, inflexible as to salary and job conditions, and undependable in the sense that they were deemed likely to try to return to aerospace should the market pick up.
> - Those programs that were judged successful tended to devote considerable efort to acquainting the job hunter with the reality of his prospects and to giving him an accurate understanding of what he might expect in terms of pay, status, and location, in his alternative opportunities.
> - Successful programs also tended to devote considerable effort to job finding and job placement for their clients; they did not concentrate solely on imparting new technical skills."

The following citation from the *Manpower Report of the President*, 1972, underscores Pascal's findings:

> "The feasibility of employing former aerospace engineers and scientists in professional jobs in state and local government agencies is being tested in a second program, begun in early 1971 and conducted by the National League of Cities and the U.S. Conference of Mayors with support from the Departments of Labor and Housing and Urban Development. The nearly 400 participants chosen from a vastly larger number of applicants (7,000) have received 4 weeks of intensive orientation in local government problems and processes at either the University of California at Berkeley or the Massachusetts Institute of Technology. Efforts to find appropriate job opportunities for the participants have run into problems, however—reluctance to relocate, the difficulty of explaining to both participants and employers the idea of transferability of skills, and, above all, local governments' frequent lack of funds for hiring additional personnel."

In 1972–73, in a special NSF-sponsored study of the impact of Federal pollution control and abatement expenditures on manpower, the Bureau of Labor Statistics examined the extent of skill transferability among fields of work for scientists and engineers, and specifically for ex-employees in aerospace and defense activities moving into professional jobs in pollution control and abatement. The following highlights the findings on this subject:

> "In the aerospace and defense industries, respondents indicated that a fair number of skills were transferable, but they saw little incentive to hiring ex-aerospace or defense oriented workers since they were not having problems in meeting their manpower requirements. Only in an expanding economy where potential or real manpower shortages exerted pressure on the employer, did skill transferability really enter the picture Furthermore, as far as the employer was concerned, technology bore a datemark, so there was not only a question of transferring a skill, but of updating a basic training.
>
> "However, many employers raised serious questions

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[24] A H Pascal, Evaluation of Policy Related Research on Programs for Mid-Life Career Redirection Vol I—Executive Summary, R-1582/1—NSF.

as to where, and how much, one could 'retrain.' Generally, retraining was more applicable, and easier, for engineers than for scientists, and in certain specialties. But, in no case was this a matter of simple brush-up or a few weeks', or months', work. In most cases it meant going back to college and getting a graduate degree in another specialty—a matter of 1 to 2 years work plus a substantial capital outlay in addition to the earnings foregone in the interim

"Skill transferability does exist, but to be overly optimistic on the prospects of quick retraining and absorption of professionals into new jobs of comparable level in the labor market is unrealistic It may appear negative to minimize the number of openings that may exist for the retrained professional, but it is unrealistic to encourage individuals to take up retraining at considerable cost and effort and still not be able to find suitable employment."

Finally, it may be useful to cite the conclusions of several studies carried out in the 1960's addressed to the question of obsolescence and retraining. In one study[25] of about 36 large companies where tuition refund programs existed, it was found that "most engineers and scientists were working towards master's degrees or were in noncredit university programs designed to update their knowledge and skills. Such efforts, however, do not affect the order of layoffs. While continuing education may affect internal promotions, *there is no evidence from the R&D studies that it aids reemployment.*" Two separate studies[26] of displaced professionals, both concluded that "on-the-job (OJT) training is considered by engineers and researchers to be the most useful form for retraining and transfer . . . followed by formal courses during working hours at the plant site."

To conclude, continuing education for the purposes of dealing with unemployment/underemployment does not appear to be effective. This was one of the conditions we listed for Federal programs for industry. Support of retraining projects for unemployed scientific and technical personnel appears meaningful only where there is an assurance that such training will lead to reemployment and particularly when there is assurance that society will support new kinds of employment opportunities for scientists and engineers.

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[25] Norgren, Paul H. *Obsolescence and Updating of Engineers' and Scientists' Skills*, Columbia University Seminar on Technology and Social Change. November 1961

[26] Mooney, Joseph D. Displaced Engineers and Scientists: *An Analysis of the Labor Market Adjustment of Professional Personnel*, Cambridge, Massachusetts. MIT, 1965

Rittenhouse, Carl, *The Transferability and Retraining of Defense Engineers*. Washington U.S Arms Control and Disarmament Agency, November 1967

Public Meeting on Problems in Continuing Education Held at the National Science Foundation Science Education Directorate December 13, 1976

Summary:

I. A. Fellowships for Non-Academic Personnel

There was general opposition to Fellowships for industrial workers except perhaps for local government, or small firm employees. The discussants felt that an unrestricted program would not reach those who could benefit most: They also suggested that an annual competition was too slow, and that quick response was necessary to meet specific individual needs.

B. Faculty Fellowships

Major universities offer continuing education activities as part of their normal program of faculty seminars, conferences, and routine interaction among a critical mass of talented colleagues. Faculty in non-research oriented universities and colleges have heavier teaching loads and fewer professional opportunities. They have greater needs and fewer opportunities to update or upgrade their knowledge. The consultants felt that the industrial option of the Faculty Professional Development program would not be used by those who could best profit from it.

C. College Faculty Obsolescence

The panel supported an expanded scope of the short course program to include non-academic topics and participants.

II. MOTIVATION, OBSTACLES TO PARTICIPATION: Many individuals do not believe that continuing education provides a return commensurate with their personal investment. Neither self-satisfaction nor employer recognition are guaranteed; even in companies that give nominal support to such activities. Young employees participate disproportionately, indicating that veteran employees stop lookng beyond the boundaries of the corporation for growth opportunities. Problems of logistics, credit, targeting of courses or programs, organizational climate and organizational payoff were also identified as barriers.

III. MATERIALS DEVELOPMENT: The group seemed to oppose this in favor of courses oriented to local needs. They felt adequate materials were available. They did note problems of dissemination, and especially of matching the needs of employers, employees and local resources.

IV. PROGRAM DESIGN AND FURTHER STUDY: The participants called for needs assessment, evaluation of existing programs, and studies of the disincentives and barriers to continuing education. They also emphasized the persistent (but not universal) problem of the mismatch between academic training and industrial needs.

PUBLIC MEETING ON PROBLEMS IN CONTINUING EDUCATION FOR SCIENTISTS AND ENGINEERS, 12/13/76

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APPENDIX H

TENTATIVE AGENDA (REVISED)

Purpose

- To obtain recommendations leading to a program plan for continuing education in science and engineering relevant to those employed in post-secondary academic institutions and in non-academic (primarily industrial) organizations.
- To produce analytic back-up to justify the plan in terms of needs or problems addressed by the plan, the NSF role, and alternatives available.

Friday Morning. Comments on the Six Commissioned Papers.

This session is intended to orient the participants to the business at hand and to provide authors and NSF with some idea of additions, deletions and changes that might be needed with regard to the considerations raised in the papers.

Each author is asked to present a five-minute summary of his paper, following which there will be discussion of that paper in order to obtain (a) clarification of each paper, (b) extent of agreement or disagreement regarding the perspective and content of each paper, (c) identification of perspectives or problems not encompassed by the set of papers.

Friday Afternoon: Implications of the Recommendations in the Papers.

This session is intended to sort out the recommendations in the papers with reference to what they imply about needs and problems on the one hand and program options (in terms of costs, payoffs, etc.) on the other. Participants will be organized into three small groups for the first half of the session with each small group reporting to the group as a whole during the second half of the session.

This session will be oriented to the second purpose listed above—specifically, the identification and ranking of problems requiring study or action. A list of the recommendations (in abbreviated form) will be circulated. This list is intended to be suggestive only and not restrictive. The three groups will enumerate the problems in continuing education being attacked by the recommendations on the list, as well as others the participants consider important. (Note: Participants are asked *not* to consider problems that may arise in *carrying out* the recommendations as this will come out of the Saturday morning discussion.) After a break, the participants will reconvene at 3:30 to consider as a whole the three problem lists and consolidate them. The output from this session is expected to be the participants' views on what are the pressing national problems in continuing education in science and engineering.

Before recessing for the day on Friday, a list of possible options for programs, clusters of activities, and projects will be distributed as a basis for Saturday morning's discussion.

Saturday Morning: Possible Program Responses and Priorities.

This session is intended to produce recommendations leading to NSF program responses including priorities.

The Saturday morning session is expected to generate a set of specific recommendations including projects, clusters of activities, and programs.

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Mrs. Sharon Gormley
Ms. Mary Kohlerman
Dr. John Maccini
Dr. Lyle Phillips
Dr. Terence Porter
Mrs Mary Rivkin

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* Unable to attend

Proposal for Establishing a Commission on Continuing Education for Engineers and Scientists

Preamble

Continuing Education* is a very timely subject:

1. societal values/priorities are moving slowly but surely toward realization of life-long learning;
2. the theoretical and empirical bases for continuing education are being developed in related areas such as life and career planning, and understanding the complex process of professional growth and development for individuals (there is much, of course, we don't know);
3. there is high interest and growing support of continuing education from employers.
4. legislative attention is growing (e.g., Kennedy Bill, Mondale Bill, etc.);
5. professional societies, universities, entrepreneurs and other such purveyors of continuing education are trying to serve continuing education needs;
6. and you could name other such indicators of timeliness.

There seems to be, however, at least one important missing element as we look to the future impact of continuing education on our society.

I would guess that the National Science Foundation is sensing that missing element, namely a comprehensive, integrated national approach to continuing education that will encourage, guide and support the wide variety of individuals and organizations which have an important stake in how effectively continuing education will evolve during the next decade.

NSF is to be congratulated for the leadership it has exhibited thus far.

Proposal

To ensure that the gathering CE momentum is not lost and that the CE direction is carefully set, I would suggest the following:

That NSF establish a Commission on Continuing Education for Engineers and Scientists for a period of 3-5 years to:

1. develop a national continuing education strategy;

   Note: the iterative process for developing a strategy includes an evaluation of the environment, national needs, current and potential resources, stakeholders, alternative approaches and objectives.

2. promulgate the strategy to organizations and individuals throughout our society and to encourage them to accept, develop and implement their role in that strategy;
3. support organizations and individuals in undertaking key CE projects as a means for continually updating and evolving the strategy and its implementation;
4. support organizations and individuals in undertaking key CE projects for experimental purposes;
5. support organizations and individuals in the preparation and development of CE materials, techniques, systems, etc., having potential wide application and usefulness;
6. support and/or conduct appropriate conferences, short courses, workshops, etc.; and
7. advise NSF, the Congress, and others in matters relating to continuing education.

Note: Items 1-7 are not intended to be carried out sequentially.

The part-time Commission should be comprised of diverse individuals including representatives of the following:

- employers (industry, government, etc.);
- purveyors (universities, entrepreneurs, "in-house" industrial/governmental educators, etc.);
- professional societies;
- specialists (psychologists, educators, etc.);
- professionals (engineers, scientists, faculty, etc.);
- et al.

The Commission should also have some full-time staff to provide continuity for the total effort and support to the "part-time" Commission members.

How the Commission specifically relates to NSF is best developed by the NSF staff who are experts in such organizational and fiscal matters.

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* The precise definition of Continuing Education requires attention as part of Item No. 1 in the purposes of the Commission. It is intended, however, to recognize that Continuing Education, however defined, is an element in a complex process of professional and career growth that takes place within the total context of life, including work itself.

A Proposal for a National Commission on Continuing Education

Early in the Saturday morning session a proposal was offered by one of the participants, Lindon Saline, for establishing a "Commission on Continuing Education for Scientists and Engineers." This idea was discussed both at the meeting and through later written comments received from individual conference participants. What follows is a summary, prepared by Foundation staff, of the responses to the plan for a commission.

At the meeting, all participants endorsed the general idea of a commission either explicitly or implicitly in the sense that no dissenting views were expressed. Subsequently, 15 persons provided written elaboration of their views. The written responses, in addition to supporting the notion of such an organization, discussed the following topics:

A. The need for a Commission or the Rationale for its Establishment.

1. Such an entity could provide coordination and focus to an unorganized, decentralized and fragmented set of activities. Interest and investment in continuing education and/or continuing professional development has grown remarkably but unsystematically during recent years.
2. Continuing education and/or continuing professional development are essential to maintaining productivity. This requires the status and public attention that a commission would provide.
3. A theoretical and empirical base of knowledge is being developed regarding the factors which influence professional productivity (and its obverse, professional obsolescence); this provides a timely opportunity for progress.
4. A comprehensive understanding of the totality of problems and processes of professional development could be provided by a temporary commission.
5. Demonstrated legislative interest at both the national level (Kennedy bill, Mondale bill) and State level.

B. The Commission's Purpose

1. To develop an awareness of the importance of improvement of technical vitality through continuing education as a national need.
2. To develop a national continuing education strategy. This would involve an iterative process including the evaluation of the environment, assessment of need, current and potential resources, stakeholders, alternative approaches and objectives.
3. To generate and disseminate information regarding continuing education and/or continuing professional development.
4. To support, using NSF-provided resources, experimental activities in continuing education.

C. The Organization of the Commission

1. To be part time and comprised of 10–20 individuals representing employers, purveyors of continuing education, professional societies, professional scientists and engineers and specialists such as educational or developmental psychologists; and
2. To have a small full-time professional staff.

D. The Commission's Name

1. To emphasize the process of continuing education *per se*, or
2. To emphasize the larger notion of continuing professional development.

C. Evaluation of the Commission's Work

1. Provide for yearly external evaluation of the commission's activities.

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