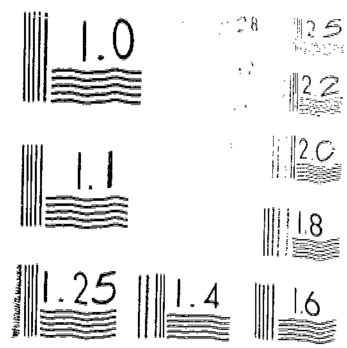
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ABSTRACT

The large number and known career patterns of engineers make them an important target population for the use of videotechnology in programs of continuing professional education. Currently, universities use videobased instruction with engineering students on and off campus. A variety of signal delivery systems are used to link job sites to campuses. Projections of video course enrollment in engineering shows continuing steady growth even with present technology. New developments including videocassettes, videodisc, cable television, satellite distribution, interactive linking of input/receiving stations and computer control of cable delivered systems can accelerate this growth. Expansion could also be facilitated by cooperative development of curricula by engineering colleges, expanded participation of engineering faculty and increased capital investment in video publishing. The report contains a bibliography and a listing of university video based engineering programs. (KB)

CREATING EDUCATIONAL OPPORTUNITIES FOR ENGINEERS WITH COMMUNICATION TECHNOLOGIES

by

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Prepared
for
Alfred P. Sloan Foundation

October, 1975

ABSTRACT

Engineering leads all other professions in the use of video technology by universities for off-campus instruction. Over 14,000 engineers annually complete 30-45 hours of graduate credit instruction at their job site. Most of the instruction consists of regular campus classes which are captured in the classroom by video for delivery. The part-time, adult students met regularly in small groups in the remote locations to participate. Faculty are in close communication with the adult learners who frequently outperform the campus students. In the past eight years, 24 major programs of graduate education in engineering have been built with local financing to employ a variety of video delivery methods.

Younger engineers predominate as participants in the video-based graduate programs. In order to reach more engineers in the mid-career age group, new curricula designed to serve the career patterns of the profession are needed. Videopublishing aimed at meeting this large, unserved need is only now getting underway. New technology promises to materially aid videopublishing ventures in the near future. The Sloan Foundation and others interested in the future welfare of universities, would find many investment and study opportunities associated with fledgling videopublishing enterprise. The natural advantages of engineering as a prototype over the other professions is its size (a million engineers is a population exceeded only by teachers), its base of current participation (far more than the other professions in terms of videobased instruction), and market aggregation (engineers are often employed by large firms in large groups).

BACKGROUND ON ENGINEERING PROFESSION

Over a million people declare themselves to be engineers. Nearly all are men and many are without college educations in engineering. They are engaged throughout the United States in practically every field of human endeavor--manufacturing, construction, business and finance, education, government, health care and other services. Change, as well as diversity, characterizes the engineering profession. The change is wrought not just by the development of new technologies, but also by societial attitudes toward technology. One of the difficulties in coping with change is the relatively slow growth of the profession; the median age is 43, and new graduates entering the field today barely exceed those who leave the work force through death, retirement or change of occupation.

Statistical studies of the engineering profession enable us to examine the summary assertions in detail (e.g., refs. 1, 2 and 3).

The employment of people in engineering, as measured by the manpower statistics of the Department of Labor and the Bureau of the Census, is not the same as the employment of engineering graduates. For example in the 1970 census, 45 percent of college graduates whose highest degree was in engineering reported their occupation as something other than engineering, while 53 percent of those who gave their occupation as engineering either had a highest degree in some other field or did not have a college degree at all.

The people without formal engineering education who list their occupation as engineering, have not been subject to detailed studies. It is an unfortunate fact that we know little which would assist us in determining the educational needs of this group. John Alden (ref. 2) states that "there is reason to believe that large numbers of people without engineering degrees were brought into the work force during the 1950's and 1960's, because an adequate supply of graduates was not available." Arguments are sometimes given that this group of non-graduate engineers, like the overwhelming majority of engineering technicians who also lack schooling, should be given

TABLE 1. The Engineering Population in 1970 (ref. 2)

Occupation Engineering			Occupation Other Than Engineering	
Highest Degree/ Engineering	Highest Degree/ Non-Engineering	Less Than B.S. Degree	Highest Degree/ Engineering	
585,200	180,900	476,500	Scientific & Technical	84,800
			Managerial & Other Engineering-Related	152,000
			Other	248,000
				484,800

Source: NSF Postcensal survey

opportunities for formal education on a part-time basis on the job. This "upgrading" issue will not be pursued herein, in part because of my limited experience with the population, but also because the graduate portion of the population presents a better defined challenge. However, it is urged that studies of this important resource be pursued. People who self select and persevere in a profession should be helped.

A concise profile of the majority of the degreed engineers is attached as Appendix A. The data base summarized in the appendix is more than adequate to define the potential participants of any videobased, continuing educational program devised for engineers with engineering degrees. It should be noted, however, that the EJC data may appreciably underestimate the total, degreed engineering manpower numbers, because many practicing engineers are not active in technical societies.

Recent publications by the National Science Foundation (ref. 3) give detailed data on approximately one million engineers in more detail than Appendix A.

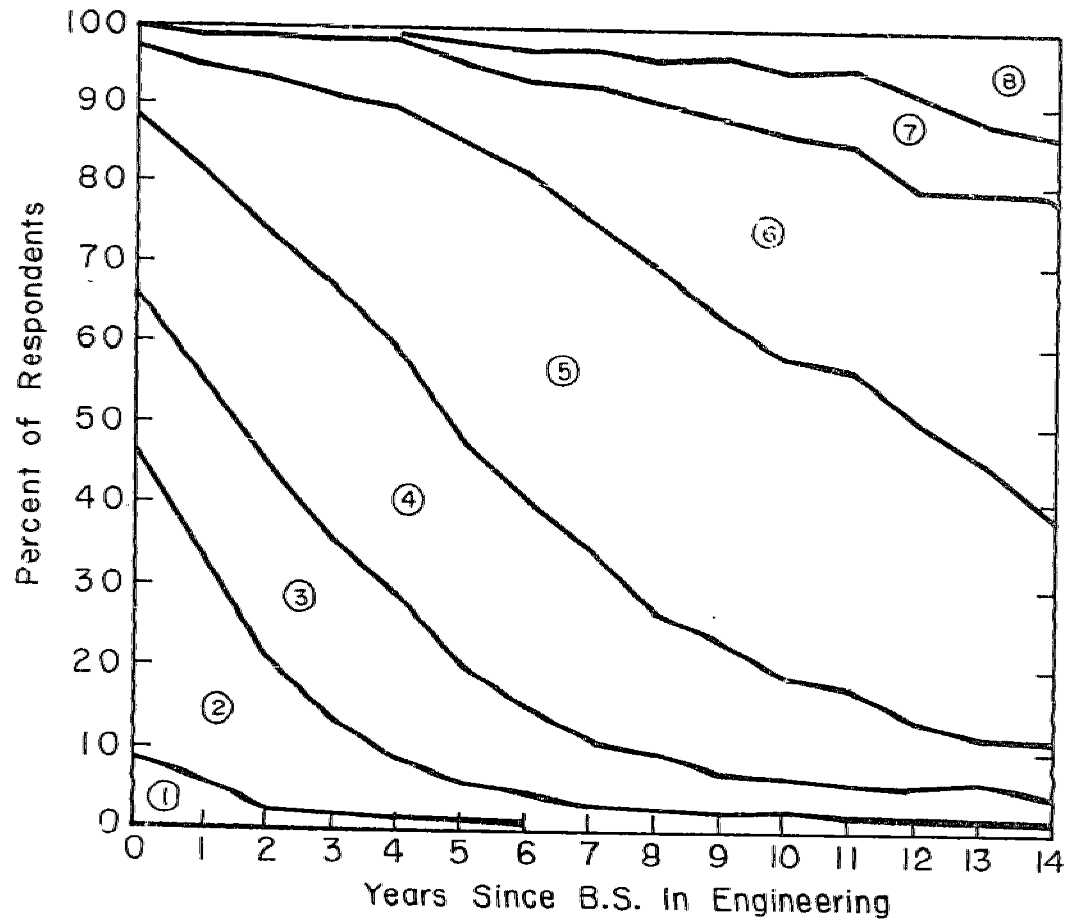
The dominance of "management" as an employment function (Figure 8, Appendix A) is an important clue to the changing roles most engineers experience during the first half of their careers.

Figure 1 charts the rapid change in technical responsibility experienced by over 950 engineering baccalaureate graduates of the University of California at Berkley and Los Angeles who reported in a 1962 survey (ref. 4). Fourteen years after graduation, the majority carried significant managerial responsibility as indicated by the titles: Division Engineer, Chief Engineer and Vice President of Engineering. Another reflection of career patterns is presented in Figure 2. The practice of industry to develop managerial talent of the young engineering graduate is again clearly evident. Ten years after graduation, only one-third of the respondents were engaged in work which is primarily or entirely technical, but by fifteen years after graduation this proportion is less than one-tenth. Viewed another way, one-third of the engineers perform work that is primarily or entirely administrative after ten years experience, and by fifteen years this has grown to fully three-quarters of the engineers. Nevertheless, over 80 percent of the engineers reported that their technical education was either important (15%), very important (~20%) or essential (~55%) to their work and these ratios changed little with years of experience! This fact emphasizes that the supervision of engineers is highly technical in nature. The University of California data cited above have been replicated to a surprising degree of detail by alumni studies of Purdue University (ref. 5) and Colorado State University (ref. 6). The great similarities in these data suggest national trends because there are obvious differences in the regions served and in the academic programs of the four universities.

Clearly continuing education of engineers which is closely job related, must recognize the evolving roles which most engineers experience. Educational opportunities keyed to employment function which are both conveniently available and "effective" from the practicing engineer's viewpoint, are very desirable. But this anticipates the recommendation and projections of this paper, which are best judged in the light of recent history.

RECENT HISTORY

Television (distance seeing) had little application in engineering education in the broadcast mode until the advent of inexpensive



TYPICAL POSITION TITLES

1) Instrumentation, Draftsman
2) Engr. Draftsman, Equipment Tester, Junior Engr.
3) Design Draftsman
4) Process Engr., Chief Draftsman
5) Project Engr., Senior Design Engr., Proc. Engr.
6) Division Engr., District Engr., Asst. Chief Engr.
7) Chief Engr., Mgr. of Engrg.
8) Vice President of Engrg., Mfg. of Major Division – Large Organization

FIGURE 1 - TECHNICAL RESPONSIBILITY OF ENGINEERING GRADUATES

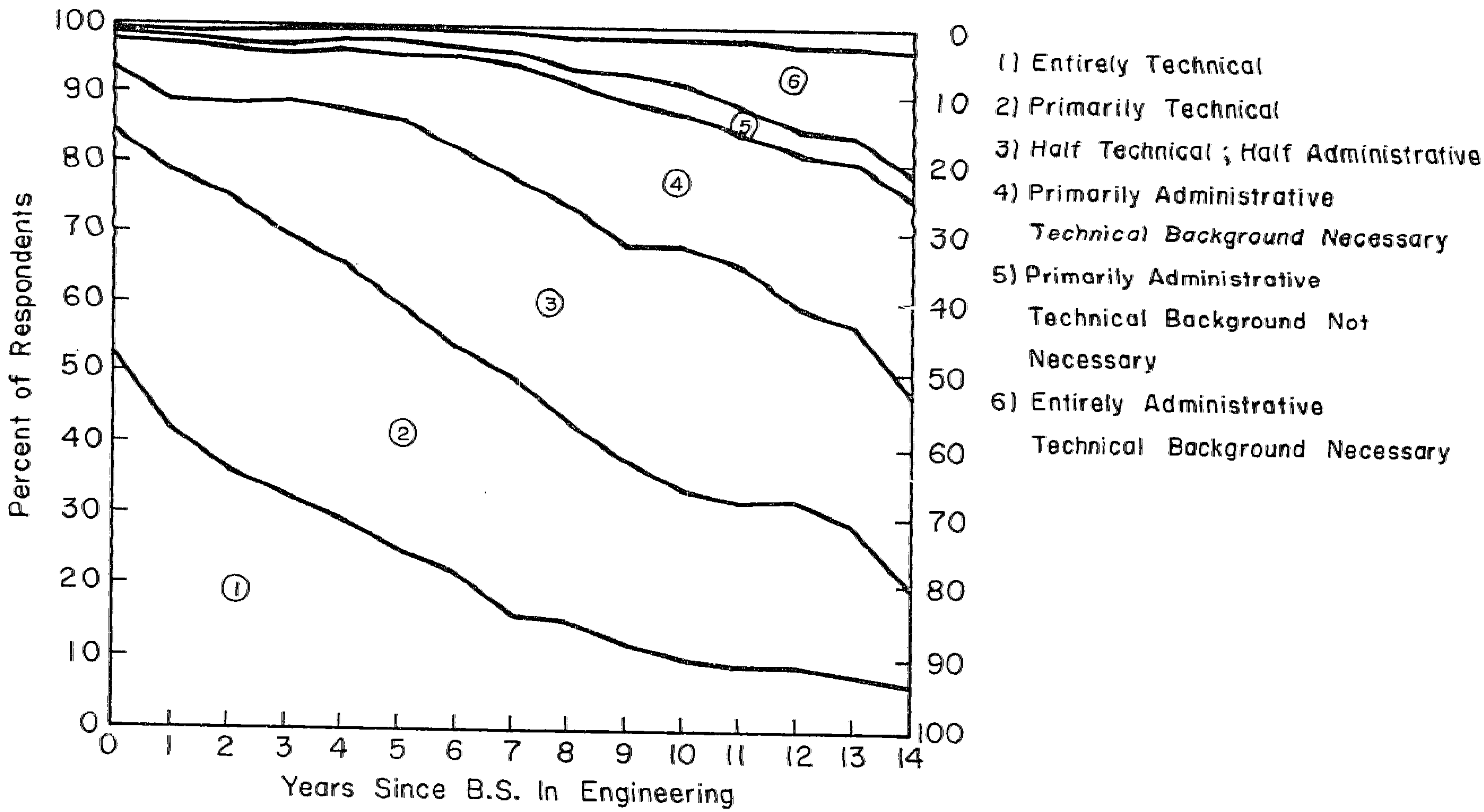


FIGURE 2 - TECHNICAL-ADMINISTRATIVE FUNCTION OF ENGINEERING GRADUATES

videorecorders. When time independence to distance viewing became available at a reasonable price, many uses were found. In this context, it is worth recalling that as recently as eight years ago, good quality black-and-white videorecorders were priced in the range of $50,000 to $100,000. Today, color videorecorders that increasingly approach the performance of the sophisticated units are available in the $1000 to $6000 range.

In the following paragraphs, on-campus applications and off-campus applications are discussed with emphasis on the latter. Outreach applications which are videobased in graduate engineering education, continuing education and other areas are highlighted whether originated by universities, industry, consortia of the two, technical societies or government agencies.

<u>On-campus applications</u> - The laboratory or experimental component of engineering education is a rich area for the application of videocassettes. Open schedules of laboratories greatly increase equipment utilization, and these are increasingly possible because students can obtain professional instruction on the use of the equipment and demonstration of the experiment by videocassette. Video is also a laboratory instrument aiding in studies of motion, such as environmental pollution studies in wind tunnels. Instruments which are difficult or dangerous to display have been viewed at a distance by video.

Lecture presentations by video on the other hand, have not gained general favor on campus. Successful applications have been reported in classroom instruction on engineering graphics and drafting, and in supplemental instruction for freshmen in a dormitory. On most campuses though, engineering is a distant second to the biological and health sciences in employing video and other audio-visual presentations for instruction.

Details with appropriate references on the use of television on-campus in engineering education, are given by Miller and Baldwin (ref. 7) in a recent monograph. Delivery systems such as direct access, dial access and cable are discussed in terms of convenience, reliability and cost.

Off-campus applications: (a) graduate education - The *Goals of Engineering Education* report in 1968 (ref. 8) recognized the need for developing "on-campus study programs for employees of nearby industry and government laboratories," as well as for continued experimentation in "extending high quality advanced-degree education to engineering students employed at locations remote from established campuses." This recommendation is widely supported in the engineering academic community as this summary will demonstrate. Early experiments with leased microwave links for an occasional class have evolved into large operational programs using a variety of dedicated delivery systems the year around.

Table 2 lists the videobased engineering graduate programs by originating university together with the following information: program starting date, delivery method, number of remote locations served, number of engineering courses and total enrollments off-campus and an indication of whether graduate business courses are offered in conjunction with engineering courses in the delivery system. This table was developed from the 1973-74 survey of Schmaling (ref. 9).

With only three exceptions, the graduate courses are regularly scheduled offerings on-campus which are attended by full-time students. The classes are held in specially equipped studio-classrooms so that not only the lectures but also the student questions and discussions are transmitted. To convert a regular classroom for video origination together with the usual control equipment costs about $25,000-$35,000.

Although the studio-classrooms are similar, a variety of signal delivery systems are employed to link the job sites to the campus. The first major system (1964) at the University of Florida employed two-way, point-to-point microwave which was leased from the telephone company, to link the main campus to several extension centers in central Florida. In 1969, Stanford University began serving in-plant classrooms in the San Francisco Bay Area with a four channel ITFS (Instructional Television Fixed Service) system which featured FM-talkback capability. Colorado State University was

TABLE 2

ENGINEERING GRADUATE PROGRAMS

OFFERED OFF-CAMPUS BY TELEVISION

1973-1974

Program (Starting Date)	Delivery Method	Remote Locations	Engr Courses	Engineering Enrollments	Graduate Business Courses Also
University of Rhode Island (1961)	Microwave	1	10	84	Yes
University of Florida (1964)	Leased Microwave	Program ended 1972			
Southern Methodist University-TAGER (1967)	Microwave + ITFS	7	72	635	No
Colorado State University (1967)	Videotape	31	113	1450	Yes
University of Tennessee (1967)	Videotape	11	49	617	Yes
University of Colorado (1968)	Videotape	23	13	266	Yes
Stanford University (1969)	ITFS + Videotape	36	150	2008	Yes
ACE at Stanford (1969)	ITFS + Videotape	36	74	2670	Yes
Iowa State University (1969)	Videotape	19	33	309	No
University of South Carolina (1969)	ETV + Videotape	25	28	550	Yes
M.I.T. (1969)	Videotape	55	12	2050	No
University of Michigan (1970)	Leased Microwave + ITFS	9	40	774	Yes
University of California at Davis (1970)	Microwave	5	30	225	Yes
Purdue University (1970)	Microwave + Videotape	7	11	214	No
University of Minnesota (1971)	Microwave + ITFS	10	59	698	No
Oklahoma State System (1971)	Microwave + ITFS	NA	NA	NA	No
Rochester Institute of Technology (1971)	Videotape	6	21	644	No
Case Western Reserve (1972)	ITFS + Videotape	25	25	521	Yes
University of Southern California (1972)	ITFS	10	72	395	No
University of Arizona (1972)	Videotape	9	10	500	Yes
University of Pennsylvania (1972)	ITFS	4	43	131	No
Cornell University (1973)	Videotape	3	5	75	No
University of Wisconsin (1974)*	Videotape	NA	4	NA	No
University of Maine at Orono (1974)*	Microwave & Videotape	1	3	90	Planned
University of California/Berkeley (1974)*	ITFS + Videotape	2	18	35	No
Worchester Polytechnic Institute (1975)*	Videotape-In Planning				
Georgia Tech*	In Planning				

*Data for initial year rather than 1973-74 the first (1967) to employ courier-carried videotape as a delivery system; tapes are returned, erased and reused on a schedule. Today, most microwave and ITFS receiving sites are equipped with video-recorders to store the instruction temporarily for either review or make-up of missed classes. By scheduling occasional visits and regular office hours for telephone consultations, faculty employing videotape have largely overcome the talkback disadvantage of videotape delivery. The convenience of decoupling campus and part-time student schedules is, of course, a major advantage of videotape. Newer systems tend to employ combinations of delivery methods to fit the specific geographic areas.

A study of the Stanford ITFS, University of California at Davis and Colorado State University showed that the dominant cost in all three systems is administrative program management and technical manpower to run the video technology (ref. 10). This factor accounted for $20-30 of a "total" cost of $30-50 per TV classroom lecture hour. Furthermore, another $4-7 per TV classroom lecture hour is required to outfit the TV classroom regardless of delivery mode. Audio talkback, if used, is surprising expensive, perhaps $1-7 per TV classroom lecture hour. The choice of a delivery system without talkback for minimum cost follows these general guidelines: widely scattered, small class sections tend to favor videotape; small classes in a geographic radius of 30-40 miles tend to favor ITFS if channel capacity is available; and large installations over 50 miles distance tend to favor either point-to-point microwave or videotape depending on frequency of use.

In the "total" cost cited above, <u>no</u> provision to pay the instructor is included, the argument being that the instructor is simply adding off-campus students to a regularly scheduled class. Even with this drastic assumption of cost allocation, only one university (Stanford) is presently fully recovering the incremental costs of its television delivery system (ref. 11). It is significant to note that virtually all tuition and other direct charges are paid by the employer in every system.

It should be no surprise that regular campus classes appeal primarily to the young engineering employees. Several universities listed in Table 2 report that only between 5–15 percent of the off-campus course enrollments are engineers over 35 years of age (ref. 9).

Federal government grants were not a significant factor in the development of any of the systems listed in Table 2. User subscriptions to a capital fund, private foundation donations, state and university funds built the systems to date. The engineering outreach programs are a local, grassroots response to a professional need. The initial capital investment in an ITFS or microwave system may run $300-$600,000. Videotape systems start at about $50,000 and scale to the same level. In only ten years, three major changes in videotape technology have obsoleted first the 1 inch tape Ampex machines, then the 1/2 inch EIAJ machines, so today's choice is the 3/4 inch cassette machine. Ten year amortization of ITFS or microwave equipment is realistic, while for videotape equipment three years would be a better estimate. Incidentally, the 1/2 inch Philip's cassette machine is widely used in Europe, but has gained little of the U.S. market to date.

Before concluding this discussion, some mention should be made about related technologies. Electrowriters of various kinds are employed for off-campus instruction in engineering. Slow-scan TV has also been employed. The attraction of both is the potential for interactive instruction with graphs while employing regular telephone service bandwidth. But the operating and capital cost of such systems does not compete well with videotape delivery if live talkback is not essential for the instruction. Very few systems are operational today which rely on electrowriters or slow-scan TV.

Audiocassettes and radio have not been tested to any great extent in engineering outreach programs of universities. Audio combined with printed material offers an inexpensive method of instruction which a number of technical societies plan to employ in self-study correspondence programs.

Off-campus applications - (b) continuing education: The majority of the student participants in the graduate education programs listed in Table 2 are not seeking academic degrees. Many employers have accommodated the in-plant delivery of videobased instruction under the traditional tuition refund fringebenefit. So many engineers are forced to take the courses for credit to be reimbursed. Some universities offer special auditor rates on a subscription basis to encourage wider participation in regular academic courses. But whatever the student motive, the instruction is scheduled in 30-45 hour courses which are offered to regular campus graduate students.

Special curricula are developed to serve the continuing education needs of engineers in the Stanford system by the Association for Continuing Education, (ACE). This non-profit organization is a unique regional consortium of universities and employers of engineers (ref. 12); ACE uses the Stanford ITFS delivery system. The Universities of Southern California and Pennsylvania report occasional use of their systems to offer non-credit, continuing education short courses. However, instructors drawn from industry rarely teach these courses, though this was part of the original rationale for forming ACE, apparently because the continuing education offerings are generally after regular working hours and some company's have enough red-tape to discourage potential instructors.

Videopublishing offers the potential of reaching larger audiences nationwide over a period of time. To date, however, only five universities have produced more than one subject in a professional studio manner for distribution nationally. The Center for Advanced Engineering Study of MIT, with the aid of a Sloan Foundation grant, has produced 24 packages which include videotaped lectures and demonstrations, lecture notes, a self-study guide with problem solutions and a coordinated textbook. The use of these materials for non-credit study nationally is summarized in Table 2. The University of Wisconsin Extension has four video-based courses in engineering with specially designed textual materials. Rochester Institute of Technology has produced ten courses in a studio for national distribution. ACE has developed two topics, as has CSU. Overall though, videopublishing in campus studios for engineering continuing education is in its infancy--and it is too early to know whether the baby will live!

Other non-university organizations have produced videobased courseware for the use of practicing engineers. Commercially, the most notable are: Advanced Systems, Inc. who list over 50 multi-media courses varying from 3-10 video sessions each in management and electronic data processing; Texas Instruments who list over 10 multi-media courses of about 10 sessions each on solid state electronic technology; and, Hewlett Packard who list over 160 topics in electronics and in how to operate and maintain a wide range of specific equipment. Many other firms have employed videobased instruction for in-service training and some like IBM and Bell Telephone Laboratories have modest catalogs covering a variety of subject matter. With the exception of the Advanced Systems, HP and TI courseware, there is little use of other materials across company lines.

The directory of packaged videotape/film continuing engineering study (CES) courses compiled by Collias (ref. 13) contains a few listings produced by various technical societies. Still fewer are offered by textbook publishers. A more complete catalog which includes not only engineering but also management and general education, is now available (The Video Bluebook, Patricia Goff, Editor, Essette, Inc., 866 Third Avenue, New York, New York 10022).

Many government agencies have produced single topic films, but very few CES courses are available. For example, the 1975 catalog of the National Audiovisual Center of the General Services Administration will list four videobased courses on air pollution control technology produced by EPA.

Distribution and marketing are often cited as major stumbling blocks to videopublishing. With few exceptions, videopublishing today is a mail order business promoted by mail and personal referrals. Some producers will sell a preview package consisting of a sample lecture or excerpts of several lectures together with the supporting manuals. With the exception of MIT, the sale or lease price is a flat fee independent of the number of students who use the material. MIT has a graduated fee schedule based on the number of students and a life-time lease price which is attractive if over 100 students are to use the package. MIT now plans to offer its packages on a more conventional price structure in the near future.

In the last two years, several joint marketing arrangements have been formed. A commercial distributor, Genesys Systems, maintains a lending library of videotapes available for loan either on an individual fee basis or through a subscription rate. The Genesys Systems library includes selections from Rochester Institute of Technology, University of Arizona and ACE; the majority of the tapes are classroom sessions not studio productions. Advanced Systems offers the packages of the University of Wisconsin in its catalog. In these arrangements, the producing university typically receives 12-15 percent of gross sales revenue after a modest minimum sale. The MIT packages are available directly from the Center for Advanced Engineering Study, and on a regional basis through the University of Kentucky and CSU. At CSU, the lease of the material is supported by a faculty expert who is available for advising, tutoring and testing for credit if desired (see Appendix B). In turn, MIT will add approved CSU packages to its catalog. Currently, a number of universities are working with the support of a Sloan Foundation grant to form a consortium which would enlarge and modify the basic MIT/CSU agreement.

Most of the cooperative arrangements mentioned above are too new to be assessed. Yet all fall far short in scope of the joint venture proposed by Bowen and Collias (ref. 14) at the August, 1974, workshop in Dallas.

Off-campus applications: (c) other outreach programs - Community colleges frequently have difficulty in supplying a complete curriculum to students who intend to transfer to engineering colleges. Cooperative programs between an engineering college and neighboring community colleges to develop curricula and produce videotaped instruction have proven successful in several locations (e.g., CSU, University of Minnesota, State University of New York at Stony Brook).

Another application has provided instruction to high school students in rural areas where enrichment curricula for college bound students are not available (ref. 15).

Public libraries often have video cassette playback equipment. These facilities offer an individual an alternative to group study on the job site. The Denver Public Library and CSU have offered about five courses in engineering and business each quarter for the two years. Each SURGE cassette or lecture is made available at the library for about 4-5 weeks. About three people view the tapes free of charge for every tuition-paying, credit-seeking student. The numbers of people served have been relatively small to date, about 6-8 per course.

Many U.S. colleges of engineering have entered into cooperative agreements with foreign schools over the years. Yet I am aware of only one contract which employs videotapes to assist in the exchange of information and talent.

SOCIAL SETTING FOR IN-PLANT PROGRAMS

When Dean Thomas Martin developed the first large system at the University of Florida, he initially delivered the video signal to extension centers which had resident faculty. A good rationale can be made for such a plan, but extension centers are destined to be night schools whether videobased or not. When Dean Martin moved to SMU and helped plan the TAGER system, he put the receiving sites in the industrial plants and he advised me to do likewise with SURGE. Night school is a lonely commitment offering little opportunity to interact with other part-time students and rarely does it involve any working colleagues. Extension centers are synonymous with commuting. Video made the invasion of the job site possible, greatly increasing the attractiveness of regular university offerings to the working engineer through convenience.

Fringe benefit policy to refund tuition to the few younger employees who commute to night school has in the last ten years changed dramatically. In-plant conference rooms dedicated much of the working day to small groups of engineers taking videobased instruction are commonplace. A few companies provide local tutors drawn from the engineering staff to support videotaped instruction. The part-time students meet regularly before or after class to discuss problems and assist each other. The drop out rate in this setting rarely exceeds 10 percent despite unforeseen job and family commitments. Indeed, Gibbons and Kincheloe (ref. 16) have presented statistical data which show that the part-time students in settings such as these can significantly outperform campus students with comparable academic records in the same course.

While much of this is both revolutionary and positive, few managers of engineers encourage formal study. Selection of educational experiences generally relies on the individual engineer's selection from a "cafeteria" of study opportunities promoted by neighboring colleges. In the most enlightened industrial setting only 2-4% of the engineering staff work hours are devoted to any formal study (Bell Telephone Labs is a single exception). Over a third of the engineers in these same firms (the most enlightened!), have no regular plan of continuing education activities of any kind: reading; attendance at technical meetings or seminars; self-study; credit or non-credit course enrollment.

Universities face human and financial resource problems of their own. While many engineering faculty appear stimulated and rewarded professionally for pioneering these videobased outreach programs, the salary policies of universities are notoriously insensitive to the effort. Development of short courses and new curricula geared to the needs of practicing engineers is simply not happening. These are times of retrenchment and cutback, and there is little venture capital within the college budget to encourage entrepreneurs. Grants to universities made by the federal government (NSF Education Division and NIE) have been sporadic and rare. The growth of new videobased graduate programs to reach engineers at their place of work is frequently stimulated by a neighboring branch of a large corporation which is served by similar programs in other sections of the country.

The dominant external factor in the whole process is, of course, the general health of the United States economy. When business is good and tax revenues up, both private and public universities can attract funds to support promising programs. Laws requiring continuing education experiences to maintain licensing as a Professional Engineer are sometimes proposed as a potential stimulus. However, less than a third of the practicing engineers with degrees bother to be licensed as professional engineers, so a law based on registration requirements would have limited impact.

On the other hand, the 1967 federal age discrimination law is rapidly becoming effective. Recent increases in court awards to complainants under this act have not gone unnoticed in industrial board rooms (ref. 17). Age discrimination is a "hot issue" as any officer of a major technical society can attest these days (e.g., refs. 18 and 19). Continuing education is, of course, only one of many components necessary to remedy age bias, but some of the other components such as job enrichment and rotation, career planning, and employee evaluation are likely to be complementary and stimulate organized study on the job. Continued liberalization of tuition refund policies is virtually assured.

PROJECTIONS BASED ON EXISTING TECHNOLOGIES

Video cassette technology will increasingly dominate engineering outreach programs of universities. The video recording may be courier delivered or it may be made "off the air" on the site. Either way, the convenience, flexibility and relatively low cost (when reused) will progressively make video cassettes the delivery system of the day.

Colleges of engineering will continue to lead the universities in developing outreach programs. Geographic areas not now served by video delivery of regular campus graduate courses will gradually obtain services. Industrial and government centers such as Washington, D.C., Baltimore, greater New York City-New Jersey-Connecticut, Chicago, Boston, St. Louis, Pittsburgh, Houston and Seattle currently lack regional videobased programs.

Schmaling (ref. 9) tabulates historical data on number of programs, number of courses offered and total course enrollments off-campus for most of the videobased programs listed in Table 2. Figures 3, 4 and 5 were prepared from these data in order to show in a more quantitative fashion what the growth rate has been in videobased outreach programs at the graduate level. The author has shown his estimates for continued growth based on existing technologies. If no major changes in the nation's economy occur, we should experience a growth of approximately 50 percent by 1981

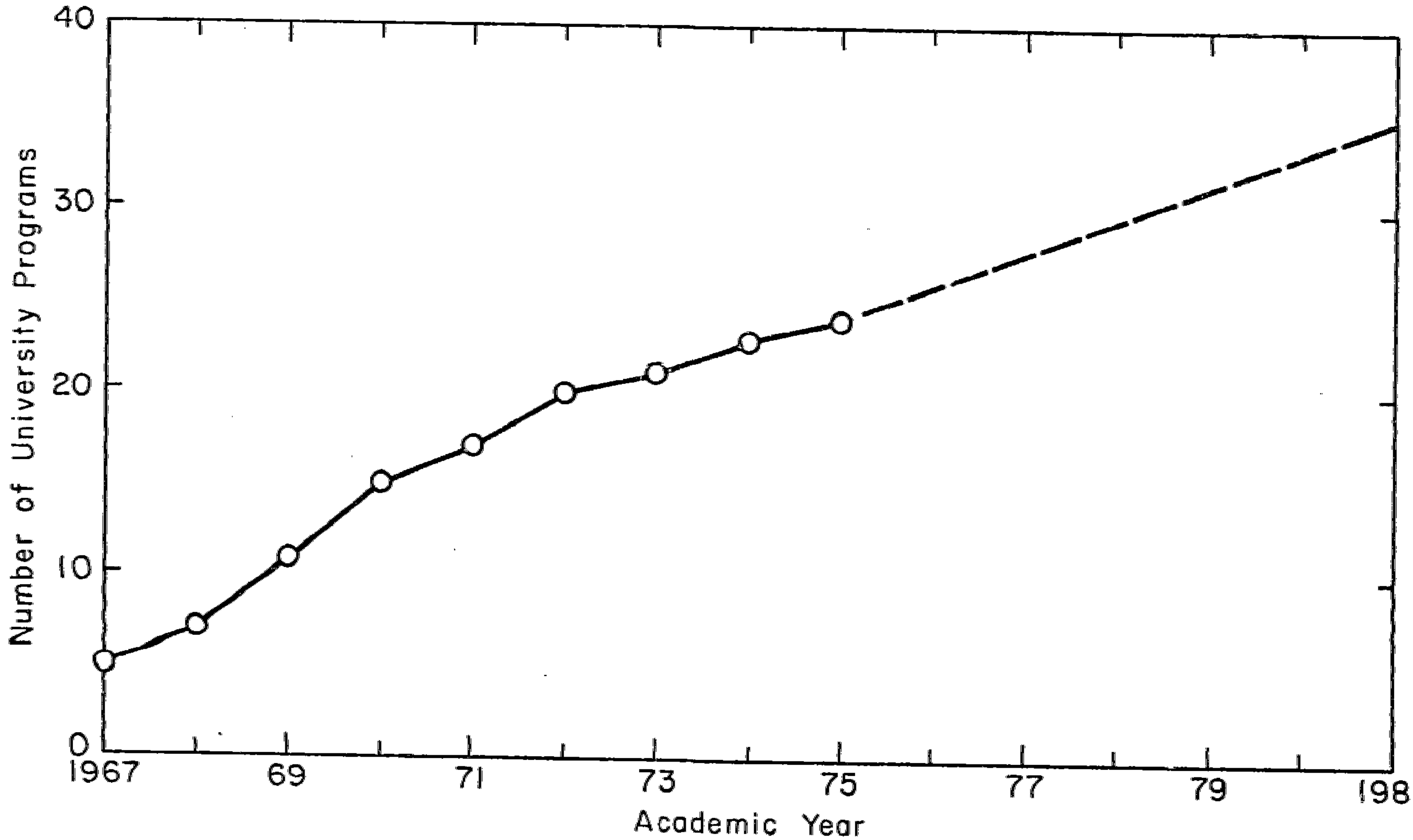


FIGURE 3 - HISTORICAL GROWTH AND PROJECTION OF VIDEOBASED GRADUATE PROGRAMS IN ENGINEERING (EXISTING TECHNOLOGY)

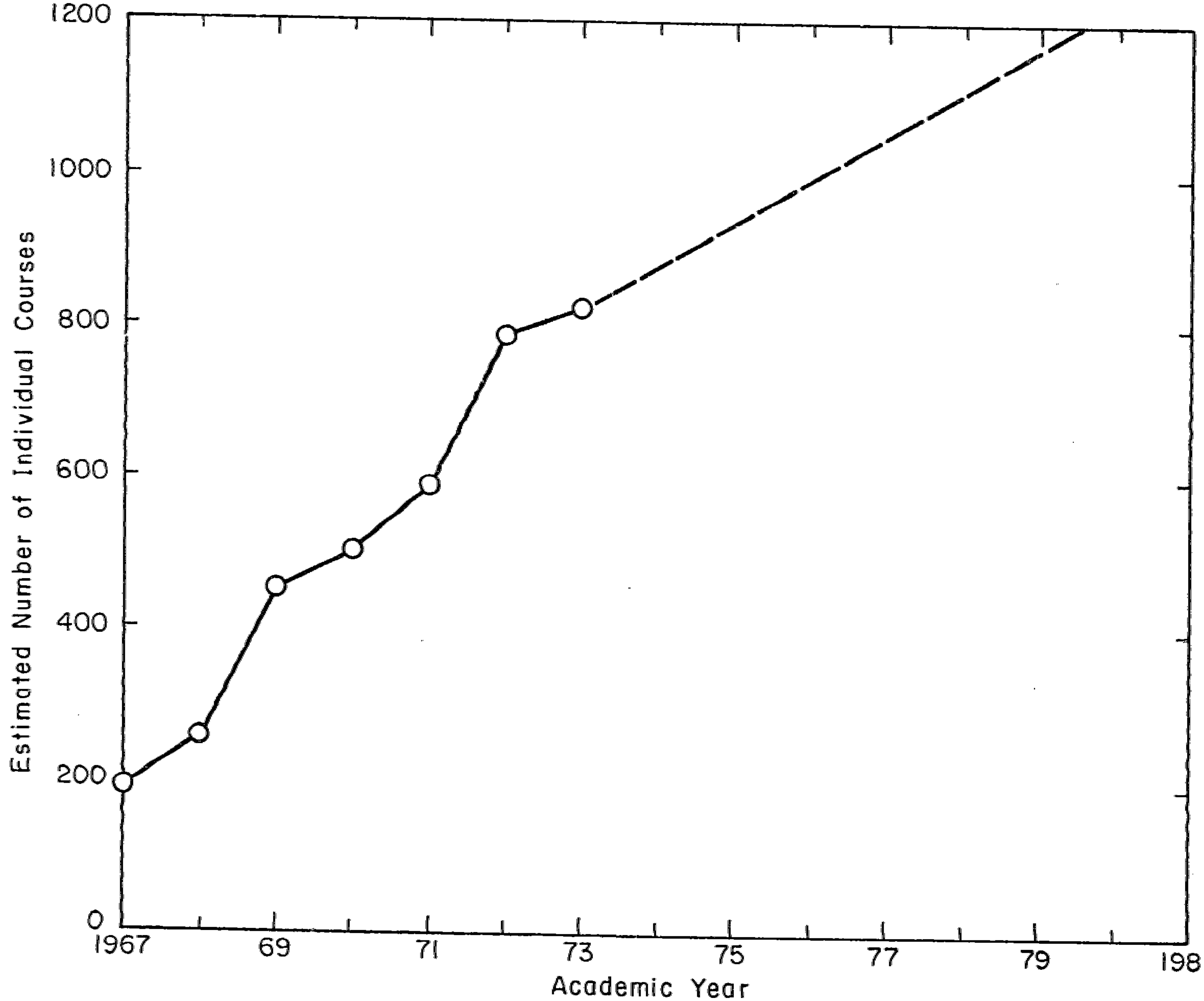


FIGURE 4 - HISTORICAL GROWTH AND PROJECTION OF VIDEOBASED GRADUATE COURSES IN ENGINEERING (EXISTING TECHNOLOGY)

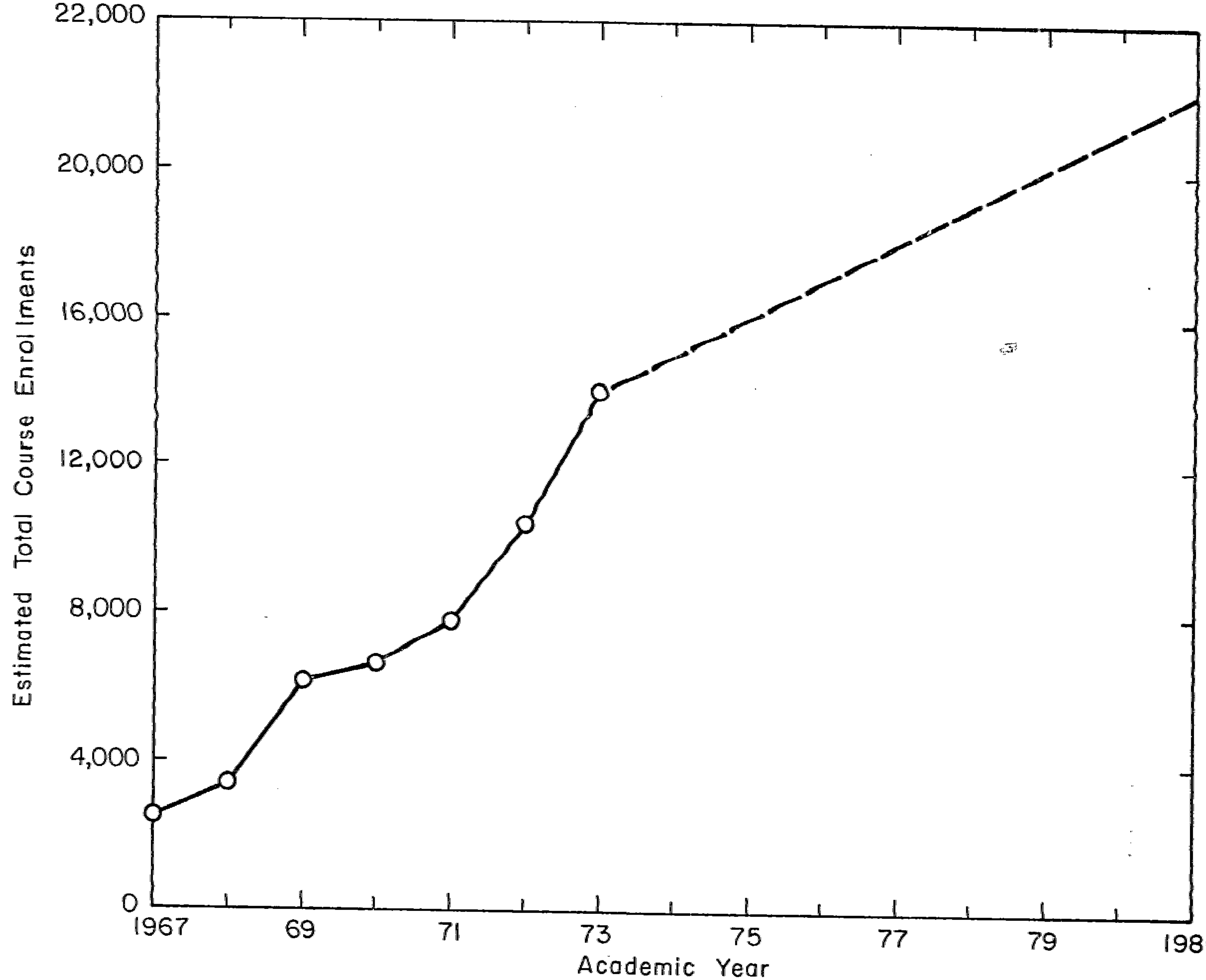


FIGURE 5 - HISTORICAL GROWTH AND PROJECTION OF VIDEOBASED GRADUATE COURSE ENROLLMENTS IN ENGINEERING (EXISTING TECHNOLOGY)

in the number of universities offering engineering programs by video together with a corresponding increase in course offerings and enrollments.

The levelof participation in today's engineering programs is impressive in itself. Over 14,000 enrollments in graduate engineering courses offered by universities off-campus by video were reported in 1973-74 academic year. The great bulk of these courses involve at least 30 to 45 contact hours of formal instruction. No other professional discipline offered by universities can come close to this level of activity today, although the potential for graduate business enrollments is at least as great.

The existing technology could be exploited more fully in continuing education of engineers if:

(a) consortia of colleges of engineering could work closely on curricula development tailored to the evolving career functions of the engineer as well as technical updating,

(b) venture capital became available to encourage videopublishing while at the same time,

(c) the engineering faculty of the consortia colleges accepted roles in career planning, advising, tutoring and testing in making videopublished courseware available in their geographic region.

Unlike videopublishing for general education of adult learners, the production of continuing engineering study packages need not employ expensive animation or visual techniques to gain acceptance. Children's TV Workshop is not the model. The adult engineer judges the quality of instruction primarily on the utility of the subject matter or course content to the job and secondarily on the clarity of the presentation. There is no plea for less "face-on-tube," especially if it raises the price of instruction significantly. The curricula content design is the key and the great diversity of job functions in engineering is the dilemna.

If videopublishing creates a new, greatly enlarged market for on the job study, it will not have the benefit of existing curricula materials. Books are generally lacking too. There are, of course, successful short courses which deal with portions of the technical update needs, but very few successful short courses such as the

A.I.Ch.E. "Today Series" are available on videotape. Furthermore, very few programs are designed to prepare engineers for the changing job functions and responsibilities which they experience. The potential impact of convenient, effective instruction on the job based on videopublished materials is enormous. Video technology development is well timed to the evolutionary changes which are also occurring in the management of human resources in U.S. industry.

POSSIBLE IMPACTS OF "NEW" TECHNOLOGIES

This brief discussion is divided into "videobased" and "computer based" headings and hybrids are considered under the latter heading.

New videobased technologies - The videocassette will be hard to beat for many educational applications. Cassette machines are increasingly reliable and trouble free, copies are easily made locally, and the tape can be erased and reused many, many times making the cassette cost per use very nominal.

How might the videodisc impact CES activities in the next five years? The mass, home entertainment market is clearly the goal; this focus will bring mixed blessings to the university. Low player prices are promised ($400-500), but centralized disc production facilities seem inevitable. Master tapes from university studios would be sent to a central facility to be converted into videodisc form. In production runs of a thousand, MCA/Philip's now give informal quotes of $5-6/disc. Clearly this production system precludes the use of videodiscs in the on-going graduate outreach programs described earlier. For example, CSU each class day of an academic year forwards by United Parcel Service over 50 videocassettes per evening to off-campus sites for use the following day. The role of videodiscs will be in videopublishing for national distribution of studio produced courses.

The MCA/Philips machine has a number of features which make it more attractive for educational applications, such as freeze frame capability, automatic retrieval with digital counter appearing on the screen and "infinitely" variable forward/reverse speeds. Furthermore, the optical laser system precludes mechanical wear so that many more plays per disc should be attainable, which is an attractive library feature. Since no university has experience with the equipment, it is premature to discount the RCA capacitance system.

Videodiscs promise to make videopublishing a commercial enterprise. The publishing houses and industrial training organizations which have yet to produce either films, audiocassettes or videocassettes for higher education in any abundance, may be enticed into the business by the videodisc. One obvious reason is ease of control of reproduction, and hence copywrite protection becomes less of an issue because purchase of the disc should be cheaper than making a videotape copy. The natural advantages of the continuing engineering studies marketplace over the other professions is its size (a million engineers is a population exceeded only by teachers), its base of current participation (far more than the other professions in terms of videobased instruction, ref. 20), and market aggregation (engineers are often employed by large firms in large groups). Furthermore as Rothenberg (ref. 20) points out, the development of continuing education in medicine and law has not centered in the universities, whereas the colleges of engineering are "the organizations most uniquely equipped to serve the market. Aside from their primary qualification as educational institutions, universities are 'neutral' organizations within a region, able to gain electronic entrance to, and disseminate information among, many corporations and thus precipitate an information flow which otherwise might not exist among competitors. Evidence indicates that universities are willing to form consortia to program for these networks, presumably because the economics of regional operation demand it" (ref. 20, p. 58). Clearly, the courseware on videodiscs could be produced and marketed by commercial firms, in a manner somewhat analogous to textbooks, and regional colleges of engineering could employe these materials in off-campus CES programs. There are many instructional services for the university to offer; to shift the emphasis away from the lecture itself could have significant benefits.

Videocassette libraries are expensive to maintain today, because a blank standard 3/4 inch cassette of an hour's length costs about $20-23. Videodiscs may not only lower the cost of storing an hours program by a factor of 5, but the disc format is more easily and conveniently stored. The practice of leasing videobased programs for a three-six week period will almost certainly disappear in favor of direct purchase of materials with subsequent librarying for future use. The lower initial cost of videodisc materials could lower prices of packages by 20 percent, but this gain can only be obtained in larger markets than we now have. Herein lies the hope; larger markets are the key to appreciably lower package prices and developing competition to serve the larger market.

Other "new" video technologies are delivery systems of various sorts. The recent study entitled, On the Cable: The Television of Abundance, explores a number of applications to health care including the continuing education for doctors. While unfortunately having less general appeal, the characteristics of the new cable systems which are attractive to doctors apply equally well to engineers. If individual study in the office is envision for the physician, the typical university program listed in Table 2 reaches 4-6 engineers per location. Time independence is virtually essential if more than single topic, one-time presentations are delivered. So the cable of abundance almost surely will deliver its CES programming to an automatically controlled videocassette recorder. Replacing the courier with cable delivery may not seem like much of an advantage, but be assured that universities would welcome the opportunity! The use of single video copies rather than multiple recordings together with simplified logistics would yield great cost savings in materials and labor to the university if the cable were available at nominal or no cost and if the geographic coverage of the cable system was adequate.

Prior to the incorporation of The Public Service Satellite Consortium (Federation of Rocky Mountain States, 2480 W. 26th Avenue, Denver, Colorado), a workshop was held on satellite delivery of educational television at Palo Alto, California on November 4-6, 1974. NIE sponsored the workshop of two dozen invited attendees from a wide cross section of education (Children's Television Workshop, PBS, medical schools); seven attendees were active in the major engineering graduate programs listed in Table 2. The proposal which we discussed envisioned a commercial, common-carrier satellite with high power television distribution channels costing $4-5 million per channel year. These satellites would nationally distribute television programs to ground receiving stations costing $5-10,000 each. Satellite rental was envisioned as costing $500-1000 per channel hour for national television distribution. Thus, massive distribution of video material at far less cost than distribution through film or tape libraries was proposed as the rationale for the satellite. A number of information bulletins have been issued by the new Consortium. Reference 22 discusses the general notion.

A high power, common-carrier satellite would be configured with one or two input stations and, hopefully, several hundred or more receiving stations. It would be videotape recorder playing by satellite into another videotape recorder. The competitors are United Parcel Service and U.S. Postal Service. Federal subsidy of any educational institution use is mandatory. In this context, the characteristics of the continuing engineering marketplace aluded to earlier make CES a logical professional discipline to involve in any test program.

A far more exciting configuration of a satellite system would involve a live, interactive linking of input/receiving stations in najor population centers. The potential for dispersed, national neetings and seminars with talkback is exciting and would have application across all the professions. Such a system would compete well with the airlines for the time of busy professionals. This alternate configuration received brief mention at the Palo Alto meeting, but no serious study nor proponent has yet appeared!

<u>Computer-based "new" technologies</u> - Computer control of video-frames delivered into the home by a cable system with data links back the computer is the subject of much technical study, a few commercial ventures and several demonstration projects (e.g., Appendix A, ref. 21). The technology does not appear out of reach and a broad range of use can be envisioned. The specialized educational needs of engineers and the fact that their job sites form natural clusters for large numbers of engineers, suggests that this variation of cable technology is not likely to impact CES. Engineers typically eed access to the computing power and flexibility of th

developed "in-house" or commercially, than by regional universities unless there is a dramatic change in federal funding in the area. Department of Defense contracts and their spin offs offer essentially the only stimulus to university engineering faculty interested in the applications of CAI to education. A rich potential surely, as PLATO and TICCIT illustrate, but the cost of developing courseware and aggregating the market are enormous for CAI compared to video technology.

SOME STUMBLING BLOCKS AND INVESTMENT OPPORTUNITIES

How will the instructional materials for an abundant educational resource for engineers in practice be created? A single institution clearly can not accomplish the task. Joint ventures involving the universities and industries of a region, such as ACE (ref. 12), are a possibility. Consortia of regional universities or associations like ACE with ITV outreach programs into national associations may be essential. There are many variations within each of these organizational arrangements. The tasks of curricula development, video production and distribution could be greatly aided by an organization with a national outlook. Within each of these tasks there is need for coordinated experimentation. For example, consider curricula development. A convenient chart, Figure 6, which illustrates the scope of the curricula development task has been developed by Tribus (ref. 25). Traditional engineering education emphasizes the front face of the cube: fundamental disciplines with scientific logic and method as foundations. Graduate programs and technical update activities usually focus on these slices. The right hand face displays engineering functions: technology works through organizations of engineers usually organized to perform specific functions. Some of the more successful non-credit, short courses are organized along these orthogonal slices, but much more development of curricula along these lines is necessary to make continuing engineering studies attractive to practicing engineers. Finally, the top face of the cube displays the needs of society which are served by technology, again in orthogonal slices. A specific example, will

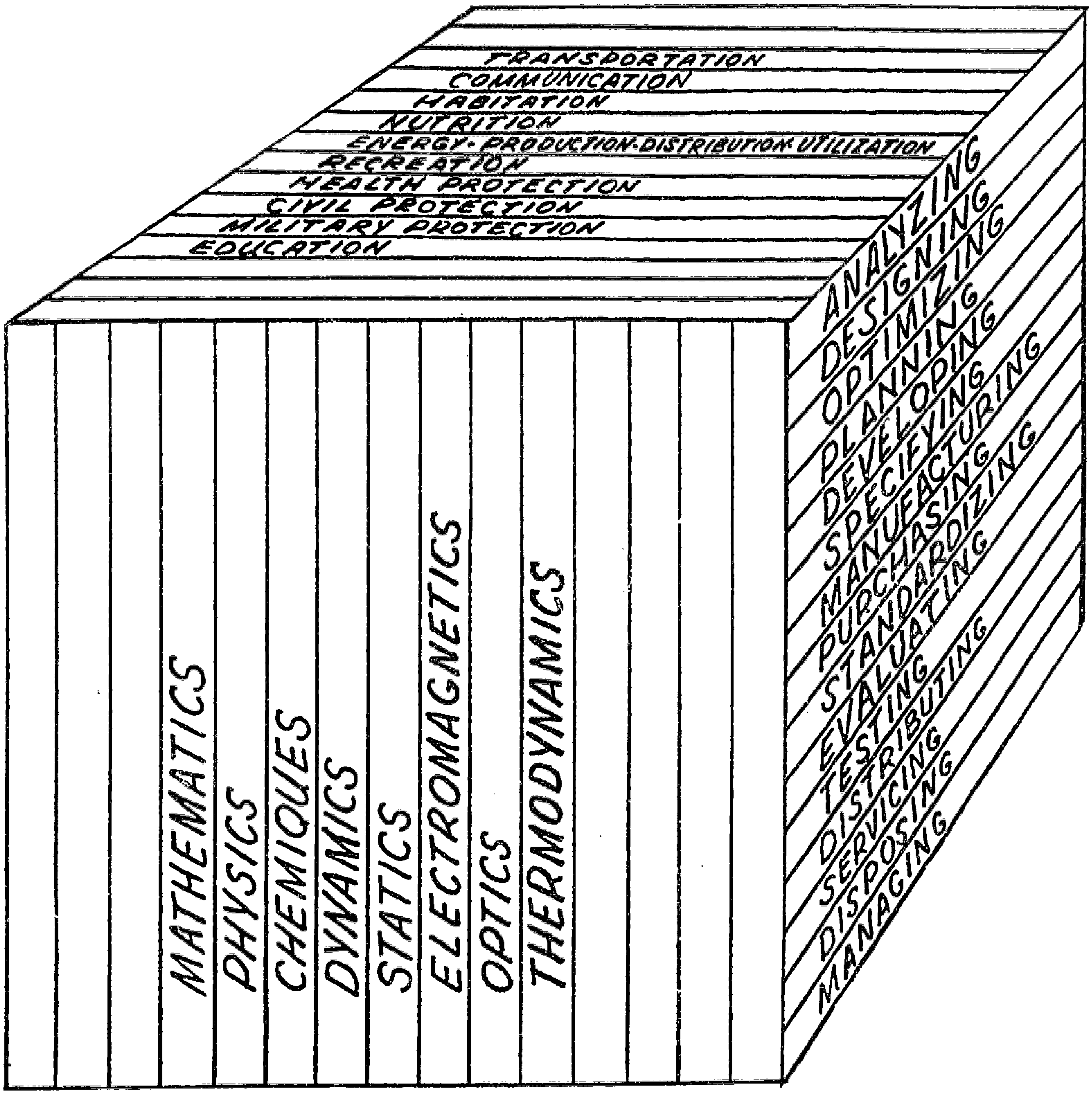


Figure 6. The Three Faces of Technology (from Tribus, ref. 25)

but the examples and methods which would interest them clearly differ depending on the organizational objectives. One set of examples might serve the communications industry while another would be necessary in the housing industry.

A variety of curricula development proposals are in various stages of test. The American Chemical Society has a $830,000 grant from NSF to develop curricula materials for its members. Written materials for individual study with audiocassettes to stimulate group discussion appear to be the primary delivery method. The Chemical Engineering Department of MIT in conjunction with the Center for Advanced Engineering Study has just started work under a $770,000 grant from NSF to map career needs of that discipline and demonstrate modular delivery. The IEEE has proposed a "Mid-Career Academy" which would develop six structured educational programs to update a member's technical knowledge. Correspondence modules for self-study would be organized in a hierarchical manner and diplomas issued to individuals who pass machine graded examinations for a prescribed number of modules. The IEEE program is not yet funded. The strongest point of these efforts, in my opinion, is the focus on career mapping and specification for curricula content design. The weakness is the correspondence or self-study delivery system which tends to be "open loop" instruction. Consider an alternate delivery system which employs what we have learned in operating the university based systems listed in Table 2.

Videobased instruction by universities off-campus operates "closed loop." Feedback between university instructors and the off-campus students occurs naturally and regularly, and not just an examination results. Typically the number of off-campus students in a given course is small (10-15 total in 2-3 groups of 3-5 students). An instructor can extend personal attention in such a setting. Telephone calls and occasional visits to the plant are usually encouraged. Instructors learn to delegate local tutoring and coaching to able students in each location (e.g., ref. 16). Professional interest in current applications and extensions of current theory are stimuexperienced. This system is operational and offers a natural testing ground for curricula development for continuing education.

A national association of university ITV systems in engineering could link instructors in several locations in a curricula development alliance. Videobased materials would form a personal link between the originating instructor, his instructor peers at other ITV systems as well as the adult-student-leaders of the study groups. In this infrastructure, curricula materials could be tested inexpensively and revised prior to studio production and videopublishing. Thus, great productivity gains are possible through video without impersonalizing the instruction. A detailed plan is now being prepared which will develop the notion outlined above into a formal proposal.

The importance of these videobased outreach efforts to the long term health and effectiveness of higher education as a whole needs to be stressed. Engineering is serving as a change agent; administrative models are being explored and set at every level. Faculty compensation expectations for videopublishing, pricing schedules for materials offered to mature professionals, inter-university agreements to exchange or use videobased materials and many, many more precedent setting actions are being made by engineering college administrators. How well will these precedents serve higher education as a whole? Will videopublishing accrue financial rewards to the faculty <u>and</u> university? Will responsiveness to the marketplace jeopardize university integrity? Formative studies of these issues are not underway nor proposed, yet such an investment is overdue.

By no means then, is the task outlined here as simple as replicating on a large scale an existing prototype.

Preliminary studies have shown that an economically viable plan can be developed in the sense that, after an initial investment in planning and production, user fees would sustain an efficiently managed, national program. It should be emphasized that the national program would consist of a pooling of a dispersed

How will an abundant educational resource be managed on the job? Company policies and practices in the area of continuing education will be sorely tested by an abundant, convenient and relevant resource. The human side of the enterprise deserves careful planning and study, both from the individual engineer's point of view and the employer's perspective. A coordinated agenda of activities dealing with these realities must accompany any implementation of the kind outlined above. Many of the people to undertake this endeavor must be recruited outside of faculties of engineering.

An abundant educational resource based on communications technologies offers some exciting new opportunities for "cooperative" education programs in engineering. Cooperative education places the student in alternating experiences on the campus and on the job. While "coop" programs are widely tauted as a way to attract and motivate minority students in engineering, no program in operation today employs video technology to improve campus/industry liaison and student instruction.

SUMMARY

Too often, educational technology is discussed as a revolutionary substitute for teachers. This perspective distorts the fact that significant gains in faculty productivity are being made today through videobased outreach programs which are intensely personal and professionally rewarding to all. The further development of these instructional services depends on sharing of videopublished materials. An infrastructure in engineering is now being formulated to assure that all parties to this effort accrue benefits.

It is time to review and consolidate what is now known in continuing professional education. Factors contributing to the need for review are:

(1) changes in the cost of the technology of production, particularly the videodisc;

(2) changes in public standards of social and economic

Rising costs will ultimately compel the use of more capital and technology in education. Professional schools are logical first candidates for the application of technology because the costs of instruction in these areas are markedly higher than in the liberal arts. To date, the national studies of these issues have relied more on speculation than on logical extensions of existing knowledge. We need fewer scenarios and more thoughtful plans of action.

REFERENCES

1. ___________, A Profile of the Engineering Profession, Engineers Joint Council, New York (March, 1971).

2. Alden, John D., Opportunities for Engineering Graduates, Engineering Education, 64, pp. 493-497 (April, 1974).

3. Seltzer, Norman, Scientific and Engineering Manpower Redefined: 1972 Postcensal Survey of Professional Scientific and Technical Manpower; Vol. I - Demographic, Educational and Professional Characteristics, NSF 75-313 (May, 1975) Vol. II - Labor Force and Employment Characteristics (in press).

4. Case, H.W., LeBold, W.K. and Diemer, W.D., The California Bachelor of Science in Engineering Graduate, Vol. I. UCLA EDP Report No. 10-64 (Aug., 1967).

5. LeBold, W.K., Thomas, E.C., Gillis, J.W. and Hawkins, G.A., A Study of the Purdue University Engineering Graduate, Purdue Engineering Bulletin, XLIV, No. 1, (Jan., 1960).

6. Dubois, J.P., The Colorado State University Graduate: A Centennial-Year Study, CSU (Sept., 1971).

7. Miller, David C. and Baldwin, Lionel V., Use of Television for Presentations, Chapter in Teaching Aids in the College Classroom, American Society for Engineering Education, (June, 1975).

8. American Society for Engineering Education, Final Report: Goals of Engineering Education, Journal of Engineering Education, (Jan., 1968).

9. Schmaling, George P., Status of Video Based Graduate Engineering Education in the United States, Workshop on Continuing Education for Engineers at Midcareer, Colorado State University, pp. 1-58, (August, 1974).

10. Loomis, H.H., Jr. and Brandt, H., Television as a Tool in Engineering Education, IEEE Transactions on Education, E6, Issue 2, pp. 101-109, (May, 1973).

11. Morris, Albert J., Down, K.S., Munushian, J., McGhie, L.F., Rubenstein, R. and Hike, R.C., Final Report on Cost Effectiveness of Continuing Engineering Studies by Television, CES Division, American Society of Engineering Education, (May, 1974).

12. Davis, Charles M. and Gunderson, N.O., Description of a Successful Joint Venture in ITV-Based Continuing Education, Workshop on Continuing Education for Engineers at Midcareer, Colorado State University, (August, 1974).

14. Bowen, C.G. and Collias, A.J., The Case for Coordination in Post-Degree Engineering Education, Workshop on Continuing Education for Engineers at Midcareer, Colorado State University, (August, 1974).

15. Ward, R. and Maxwell, L.M., HI-TIE: The University, the High School, and Engineering, Engineering Education, 65, No. 4, pp. 325-328 (Jan., 1975).

16. Gibbons, J.F. and Kincheloe, W.R., Educational Effectiveness of Video Tape for Off-Campus Instruction at Stanford University, American Society of Engineering Education 83rd Annual Meeting, Event 2642, Fort Collins, Colorado, (June, 1975).

17. Rawlo, R.L., Fight Against Age Discrimination Stepped Up, Chemical and Engineering News, 53, pp. 9-10 (April 7, 1975).

18. Rivers, Robert A., Age Discrimination Patterns in Engineering Employment, in The E/E at Mid-Career - Prospects and Problems, The Institute of Electrical and Electronic Engineers, Inc. (1975).

19. ___________, Engineering Society Tackles Age Bias, Chemical and Engineering News, 53, p. 7 (Sept. 22, 1975).

20. Rothenberg, Donna, Continuing Professional Education: Status, Trends and Issues Related to Electronic Delivery, Memo No. CG-75/5, Center for Development Technology, Washington University, St. Louis (August, 1975).

21. ___________, On the Cable: The Television of Abundance, Report of the Sloan Commission on Cable Communications, McGraw-Hill Book Co., (1971).

22. Hupe, Howard H., An Educational Satellite, Its Costs and Effects on the Educational System, Educational Technology, 14, No. 10, pp. 48-52 (October, 1974).

23. Hayman, R.W. and Lord, W., A Technology-Based Educational System Using Computer Management, Educational Technology, 1, No. 12 (December, 1972).

24. McWilliams, Erik D., Report of Progress for the Field Test of the TICCIT System of CAI, NSF Directorate for Science Education, (Sept. 12, 1975).

25. Tribus, M., The Three Faces of Technology and the Implications for Engineering Education, R.P. Davis Memorial Address, West Virginia University, (March 17, 1975).