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High Technology Electronics: New Solutions in Continuing Engineering Education

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Electronic equipment advances in the 1980s provide new tools for continuing engineering education. Shortages in engineering manpower in the coming 20 years will require engineers to maintain technical competence for extended worklife. The use of satellite and digital communications offers engineers new ways to maintain viability.

INTRODUCTION

DEREGULATION in the USA has led to rapid gains in the telecommunications field. Privately owned satellites, uplink earth stations, and receive-only earth stations combined with private ownership of and operations of Very Small Aperture Terminals (VSATs) have worked to the advantage of business and education. Competition by equipment suppliers, satellite owners and communications service providers has resulted in lower cost for voice, video, and data transmission. A digital CODEC that cost $350,000 in 1981 now costs less than $30,000, and projections indicate even further reductions by the early 1990s.

The USA faces critical shortages within the next 20 years in its supply of technical manpower resources. Engineering student enrolment peaked in the USA in the early 1980s and is expected to continue to fall well into the late 1990s. Fewer high school graduates are electing to major in fields of mathematics, science, and engineering. The percentage of high school seniors intending to major in a quantitative science has dropped from slightly over 19% in 1983 to less than 13% in 1989 [1]. If this trend continues, US advances in science and technology will be adversely affected, as well as the nation's economic vitality.

TELECOMMUNICATIONS

The term telecommunications is a broad one, meaning the transmission of voice, video and data via electronic delivery methods. It is best thought of as communication over some distance by the best and most cost-effective media. It is not just telephone, satellite, or fiber-optic dependent, nor is it just analog or digital transmission. It is an optimization of media usage based upon desired end results. People frequently become infatuated with a single transmission medium and try to force all problems and situations to be addressed and solved by that medium. Thus, non-cost-effective solutions (which reflect badly on the high technology being utilized) can be inappropriately implemented.

Continuing engineering education in the USA uses a variety of telecommunications media to solve problems of distance education. Selection of the appropriate media is most important if large numbers of practicing engineers are to continue their education.

Figure 1 portrays the relative cost of utilizing various delivery media and hopefully offers insight into selection criteria. It is admitted that the various delivery media *are not* equal in their pedagogical effectiveness. Some media seem to favor cognitive knowledge transfer and others favor transfer in the affective domain. Effectiveness of media is an area needing further research, and the discussion is beyond the scope of this paper.

Continuing engineering educators within the USA are using all of the delivery systems portrayed in Fig. 1, and the extent and effectiveness of each

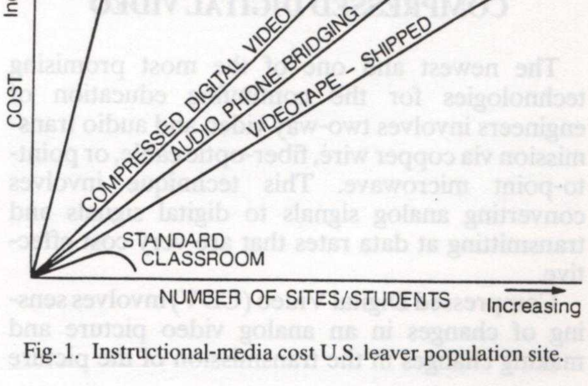

Fig. 1. Instructional-media cost U.S. leaver population site.

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system will be the focus for the remainder of this paper. Discussion will pertain to educating post-graduate technicians and engineers who continue their education on a part-time basis, normally at their work site or home.

STANDARD CLASSROOM

Traditional in-class instruction with teacher and student face-to-face is still the most widely utilized method of continuing engineering education available within the USA. Providers of such education and training include universities, professional societies, and private individuals, but by far the largest provider is American business and industry.

The standard classroom method is labor intensive and is provided at a relatively low cost when only a few students or a few teaching sites are to be served.

There are literally thousands of short courses, workshops, seminars, and conferences presented each day within the USA, and the majority are presented in the traditional way, requiring learners and teachers to be in the same place at the same time.

VIDEOTAPE

The advent of the low-cost videotape recorders and play-back units has resulted in widespread use of stand-alone video-based instruction.

Videotape programming tends to be both labor and capital intensive with significant equipment requirements for producers and users. Labor intensiveness is caused by duplicating, shipping, and library (storage) requirements.

Benefits include convenience for users, timely availability of needed subject matter, extended life of expenditures, and access to potentially the finest instructors available in the USA and elsewhere. Shortcomings involve the lack of interaction with instructor(s) and a need for personal, self-directed and self-paced motivation.

A free catalog describing over 300 different video-based courses can be obtained by writing to AMCEE in Atlanta, Georgia, USA [2].

COMPRESSED DIGITAL VIDEO

The newest and one of the most promising technologies for the continuing education of engineers involves two-way video and audio transmission via copper wire, fiber-optic cable, or point-to-point microwave. This technique involves converting analog signals to digital signals and transmitting at data rates that are very cost effective.

Compressed Digital Video (CDV) involves sensing of changes in an analog video picture and making changes in the transmission of the picture by updating only for the changes. Thus, a full-motion picture that would require an equivalent data transmission rate of 90 Mbps can be transmitted digitally at rates of only 1/120–1/240 of the analog equivalent rate and still be relatively full motion.

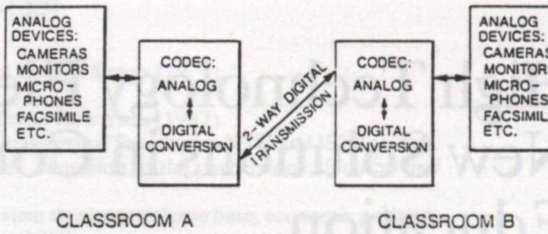

Fig. 2. Compressed Digital Video (CDV) system.

CDV is a relatively new technology with the first CODEC device (analog to digital to analog devices) being available in the early 1980s. Figure 2 illustrates the various devices involved in a CDV classroom. Students are located in both classrooms with the instructor located in one of the rooms. All participants see and hear each other just as if they were in the same room together. Complete interaction is available to students and faculty in either classroom even though the distance between classrooms may vary from a few feet to many miles.

Cost of equipping a single classroom varies from about $50,000 to upwards of $200,000 depending on the features desired in the room. Large monitors, more expensive cameras, complicated audio requirements, and amenities in the room can increase the cost of room design and equipping. Classrooms serving students in distant locations are currently being operated by the University of Missouri–Rolla, Penn State University, the University of Texas–Austin, Oklahoma State University, and the University of Oklahoma, to mention only a few.

CDV is capital intensive as an educational delivery media but offers great potential for reducing the cost of education by utilizing a single faculty member to teach students at distant locations, by reducing the engineers' time away from the job for study and by providing an interactive methodology that is both motivational and personal to the engineers' needs.

Figure 2 shows a simplified view of the CDV classroom arrangement. In fact, many classrooms can be linked together simultaneously for expanded viewing of presentations.

CDV is (or, is apparently) costlier than videotape instruction for a given number of sites or students, but it provides interaction between students and faculty.

SATELLITE DELIVERY

The use of satellites for transmission of continuing engineering education has grown rapidly in the 1980s and shows no decrease or levelling off in growth in the near future.

Engineering education within the USA has been the leader in providing continuing education to its profession.

The economics of satellite delivery are portrayed in Fig. 1. Satellite delivery is capital intensive due to high studio costs, high production costs, and high transmission and receiver costs. Its advantage is in its ability to serve many sites and many students over wide geographical areas simultaneously. At Oklahoma State University, one 6-h program was taught to 28,000 participants attending at 612 receiving sites in the USA and Canada. Total cost for the program was $45,000 or $1.60 per participant. Another recent OSU program involved 18 h of instruction ovr a 3-day period and trained 2,700 inspectors for the US Environmental Protection Agency. Total cost for the EPA program was about $15,000—meaning that each inspector was trained near his work site (thus, no lost time or money in travel expenses) for a cost of $5.56 per person.

An interesting point to note in Fig. 1 is that due to high fixed expenses, it costs about as much to reach the first receiving site and student as it does to reach thousands. Variable costs (room rental, catering, and printing expenses) are relatively small when reaching additional sites or students once the program is delivered to the satellite.

The total number of satellite uplink earth stations and receive-only earth stations (TVROs) is very large and growing each day.

A recent Task Force study by the American Society of Engineering Education urges increased utilization of instructional television and makes the following observation:

> Video technologies, in the form of live and video-taped instructional television (ITV), with and without talkback capability in the case of live ITV, has brought about a 'video revolution' in education and training—both on campus and at remote sites, for continuing education. The Task Force finds that the problems of distance, logistics, and system economies, seen with conventional ITV are largely eliminated with the use of satellites for transmission [3].

CONCLUSIONS

Continuing engineering educators in the USA are using new, high-technology, electronic devices to expand educational opportunities for the nation's technical workforce, thereby lowering the cost of education.

The useful work life of practicing engineers is extended by continual technical updating as demand for higher technical skills and more technical manpower increases. Higher productivity results when engineers are trained at their work site and not required to spend their time in travel and other activities which take them away from their jobs. Sharing of knowledge and experiences between nations of the world would seem to hold the promise of greater prosperity for all people and better understanding between nations. 'European Integration 1992' seems to offer educators the opportunity for greater cooperation.

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