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DESIGNING AN INTERACTIVE VIDEO DISC SYSTEM NETWORK
FOR EFFECTIVE TRAINING MANAGEMENT

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Abstract

Within the past two years, there has been a breakthrough in interactive videodisc training systems technology that has been made possible through the personal computer. This has resulted in many companies and individuals entering the field, both in the development of computer hardware and software as well as the preparation of interactive videodisc authoring languages and courseware. Overlooked in this technological gold rush has been the need to provide effective curriculum, module, and course management, as well as the measurement and monitoring of student progress through this new training medium. This paper discusses the factors necessary for proper curriculum and student learning process management within an interactive videodisc-based training environment. It presents a concept whereby the interactive videodisc training delivery system is managed by a microcomputer-driven system, offering curriculum and student records management capabilities as well as operational capabilities that drive the videodisc-based training workstations.

Training and the Computer - An Overview

One of the earliest applications of computer technology has been in the field of training and education. The optical mark-sense reader has been used to grade test scores. Administration of school records has been on an automated basis ever since the inception of the Hollerith punched card and electric accounting machinery. Computerization has assisted educational administrators for other items such as school census, attendance reporting, school health statistics, and a wealth of other applications.

Yet, the traditional mode of instruction delivery--eyeball to eyeball-- has survived three generations of computer technology, despite some significant inroads the computer has made in the now-recognized field called Computer Based Training (CBT). A number of initial attempts to administer lessons to students have been made via programmed learning techniques. Still other attempts have been made to manage the volume and types of instructional delivery through computer-managed systems which address the curriculum, the learning modules within the curriculum, and the actual lessons which make up a learning module. Examples abound, such as the TICCAT project started by MITRE Corporation and now being marketed by Hazeltine Corporation, and the PLATO system which was originated at the University of Illinois and now is marketed by Control Data Corporation. In the late 1960's, Westinghouse Electric Corporation developed a concept of modularized educational delivery called PLAN (Programmed Learning According to Needs) which was marketed for a brief period by its subsidiary, Westinghouse Learning Corporation. Despite these and numerous other projects, the little red schoolhouse concept remained intact.

However, the fundamentals of training and education at all levels, from elementary school to post-matriculation and on into commercial and government education programs have been subjected to increased demands in the current decade. These demands are:

- o The way we live is becoming increasingly dependent on hi-tech products and services. Stand-up, lecture-based training

cannot do an effective job of explaining complex and involved subjects.

- o The number of Instructors is declining, as is their caliber and proficiency. One Instructor attempting to teach thirty students is a difficult assignment.
- o The learning capacities of various students is different, and because of equal opportunity pressures, traditional learning methods are becoming more and more ineffective. Barriers such as language, sight and hearing handicaps and physical handicaps are being recognized as factors defying the stand-up mode of Instruction.

Notwithstanding these problems, the use of computer-based training systems as a solution have caused doubts in some educators' minds. Besides the apparent investment costs in hardware and educational courseware, the management issues have become recognized issues. There is a philosophy that adheres to the eyeball-to-eyeball training concept. It believes that since a human being (the instructor) witnesses bodies being brought into a classroom, lectures being presented, books being read, and a grade-pass-fail structure being invoked, the management of the instructional program and its effectiveness is guaranteed. Having a student learn from a teaching machine defies all perceptible attempts to manage the training process. In the opinion of educational traditionalists. Yet, should a multi-million dollar system fall due to inadequate training, the argument could never be resolved as to whether the operator-trainee did not learn or whether the classroom system did not teach.

Enter the optical laserdisc. This new-found ability to present visual photographic material, both in still frame and in motion picture sequence added a missing ingredient to the computer-assisted instruction delivery. Coupled with the evolution of the personal computer, a more powerful teaching machine thus became available. The ability to train via photographic presentation with sound narrative was transported from the audio-visual room to the student's desk. Yet, the issues of effective management still remained. This paper will attempt to summarize what is currently at hand and what must be developed to form a truly effective training management system.

Components of a Computer-Based Training System

Computer-Based Training (CBT) consists of two major components (Figure 1). One is the delivery system, frequently called Computer Assisted Instruction or CAI. The other is the management system, called Computer Managed Instruction. CAI deals with the student-system interface and the presentation - response setting between student and machine. CMI relates to the management of curricula, the proper sequencing of lesson material based on student progress and student learning needs, and the overall administration of the training function.

Instructional Delivery Systems

The IBM-PC and IBM-PC-compatible family of computers comprise the major hardware element of today's CAI system. Instructional systems as a whole have been classified by levels, set forth by the Nebraska Videodisc Design/Production Group (1980) as follows:

Level One - delivers video with limited interactivity at minimal cost. Level One systems consist of a standard videodisc player with only a video monitor. This is essentially one level above a straight linear system consisting of a commercially-available videocassette recorder and a television set.

Level Two - systems are stand-alone, programmable systems where digital data is encoded on the videodisc to allow computer control. Limited interactivity is needed. The viewer makes a choice for a simple program selection. The system requires no external computer.

Level Three - systems represent a combination of a videodisc player and an external computer. Full interaction between student and machine is supported with overlays of computer graphics and text able to be superimposed upon the video image. The recall of explicit video and graphic presentation based on student response is provided. Level Three systems support inter-system networking and use of peripherals such as a touch-screen, a light pen, a keyboard, and a mouse.

The Army Electronic Information Delivery System (EIDS) represents a major refinement of the Level Three System. Instead of a separate computer and laserdisc player, it combines the two functional elements inside a single shell, with reduction of the many cable interconnections necessary to integrate video, audio, and digital signals. The video monitor and the combination of laserdisc player and computer exist as two separate units. Additionally, the 5 1/4" floppy diskette ports have been replaced with 3 1/2" micro floppy diskettes, with the 5 1/4" floppy diskette ports being relegated to that of an option. The EIDS prototypes have already been delivered in an earlier procurement/development contract. Mass procurements have been started for what will total 40,000 units by 1988.

Laserdisc Technology

The optical reflective laser format of optical videodisc is the predominant format in use today. Other formats have either been offered and withdrawn or are too limited and specialized to be considered at present. The optical reflective laser format can store 54,000 frames of single video image on a side, along with accompanying audio track. This format is used to store digital information as well as a complete sound spectrum of audio signal which has been digitized. In addition to video applications, the optical reflective laser format has been used for CD-ROM (compact disk-read only memory) and the compact disc (CD) players which have captivated the hi-fi/stereo marketplace. The amount of digital information capable of being stored on an optical reflective laser format videodisc extends into the billions of bytes per disc.

In video applications, the 54,000 frames limit the playing time to 30 minutes per side. The disc must be turned over to allow each side to be played. Discs cannot be updated. Once mastered, they must be used until a revised copy is prepared from a subsequent pressing. Each frame has its own index tag, permitting direct access to any frame on the disc. The seek-and-play time is a function of the laserdisc player. With the exception of Philips NV, all laserdisc players are made in Japan. Pioneer and Sony are the dominant manufacturers of laserdisc players, and 3-M corporation is the apparent leader in pressing of optical reflective videodiscs.

Computer Technology

The IBM-PC and PC-compatible family of microcomputers (Figure 2) are the foremost drivers for Level Three type systems. However, these microcomputers require sufficient capacity in terms of processing power, main memory size, and expansion slots. Vital to the Level Three system is a linkage board which resides in one of the expansion slots and allows the video and audio output from the laserdisc player to be accessed and subsequently displayed on the monitor. These linkage boards operate in a conjunction with other I/O signals to and from the processor to drive touch-screen overlays, a serial mouse, or other x - y devices such as a joystick or a trackball.

The I/O devices must use other expansion slots in the PC, some of which are otherwise used for communication ports or printer ports. A PC driving a full complement of these devices might have to avail itself of every one of its expansion slots and communications channel capabilities to be all things to all users. Experience gained so far at FSD in using a Honeywell PC/AP as an interactive videodisc driver has indicated that if the PC is used for that purpose, it cannot be used as a terminal emulator without reallocating the COM1 and COM2 channels and installing additional communications boards. Also, since the existing IBM CGA-compatible graphics I/O board was hand-wired to the videodisc linkage board, it became impossible to swap the IBM CGA-compatible graphics board for a more powerful one, such as the STB Graphix Plus II. This served to restrict the color palette available for overlay graphics to a very narrow range.

Experience gained thus far with existing DPS-6 mini-computer or Micro-System 6/10 systems supporting the CAN-8 Instructional language operating system (Figure 3) has also indicated that if these computers are to be used for interactive videodisc training applications, they cannot be used for other purposes. Possibly a co-processor arrangement might be established whereby GCOS6 MOD400 operating systems could co-exist with the CAN-8 operating system. At present, the MicroSystem 6/10 must operate solely with the CAN-8 operating system and procedural language. However, communications capabilities with other DPS-6 or MicroSystem 6/10 computers are preserved, thus enabling large networks of computers and workstations to be developed. The possibility of designing networked systems that can support both the educational

delivery as well as educational management requirements is sufficiently exciting to explore it as an entrance into the Federal market for training systems.

Management Systems

While all of the excitement is currently at the delivery level with videodisc as the "shining star," the concurrent requirement of systems to monitor, guide, and manage the training function has not occupied the same level of interest. Yet, it is essential that teaching machines be linked to some form of management system if educational administrators are to measure the effect of this new mode of training delivery.

Most of the PC-based systems can accommodate one or more authoring languages. These are mostly non-procedural languages which enable the courseware to be written. The majority of these authoring languages provide for corrective branching upon the student's entry of a wrong answer. Additionally, they allow for timed response and then execution of one or more subsequent branches if a response is not forthcoming. A few of the better authoring languages will edit student responses and will perform conditional branching if specific answers have been entered.

The functioning of these authoring languages based on PC-supported systems has mainly been directed at specific course presentations rather than the capture of data related either to the course or the student. The data that is captured is done so on MS-DOS based files and must be uploaded to a central processor for subsequent analysis of student and courseware performance from multiple workstations. Of the PC-based authoring languages that have been examined, most of them have capabilities to register students, record responses and test scores, aggregate correct/incorrect responses, and evaluate timed responses to questions. However, the ultimate analysis of this data for management requirement purposes must be done by a processor that can receive DOS files on a regular basis and perform the conversion of data into information. This can be done by mailing diskettes into a processing center or by polling every PC workstation to upload the various DOS files.

It is in this area that the Honeywell-driven CAN-8 system has a decided advantage. The CAN-8 educational courseware is designed as integral components of the CAN-8 management system, thereby permitting an analysis of both the courseware and the student progression through lesson, courses, and modules. Thus, educational administrators are able to receive immediate information in virtually any format on student performance, both individual and aggregate.

The collection and analysis of course and learner profile data and its subsequent use in recommending additional courses or remedial instruction enable the computer to serve as a powerful decision support unit. The Honeywell systems can function in a true loop and feedback mode through recommendation of subsequent courses, administration of courseware, and evaluation of results. Figure 4 presents this graphically.

Thus, we approach a key issue in instructional delivery systems. Although the PC-based systems offer high versatility in manipulation and access to laser videodisc material, can they supply equally versatile and effective capability in managing the entire training process within a client organization? At present, all of the emphasis on these systems has been as stand-alone teaching machines. The issue of effective training management has not surfaced as yet. But when it does, it is likely that a massive networking design issue may confront these stand-alone units.

Methodology

Managing the training process is necessary because one critical cost element may be obscured in the rush to optical videodisc units. This is the cost of developing courseware. If videodisc-enhanced courseware is to be effectively used, a major effort must be placed on the adequate design of learning modules, of courses to be administered within each module, and of individual lessons within each course. At every step of this design, provisions must be made for an adequate testing program and an adequate remediation sequence for students who encounter difficulties in grasping the material that is being taught.

To understand what is involved, let us look at the general and specific methodology in establishing a video based learning program. Figure 5 illustrates

the goal-setting process. It resembles a pyramid, with the overall training program as its apex and the individual lesson at the bottom. The fulfillment of overall goals and objectives must be measured by the success of the individual courseware elements and the students being trained. This is exactly where the management reporting functions became important. The courseware design comes in at the learning module and below, to detail the steps necessary for the preparation of each course and its attendant lesson. The reporting of significant data to serve management analysis must also enter in at this point.

Figure 6 describes the methodology involved at the lesson level. This aggregates upward to the module level, since students may have varying levels of difficulty with each lesson or course, and alternate pathing may be needed based on individual student learning profiles. Data capture and the requirement of various skills in courseware production are specified.

It can be seen from Figure 6 that a wide range of professional skills and talent are needed in the courseware development process. Where preparations of automated data processing systems involved the user, the systems analyst, and the programmer, the preparation of courseware involves the educator, the systems analyst, the programmer, video camera persons, video production facilities, video manufacturing facilities, and all of the artists, narrators, and effects persons required by the sophistication of each video production. Miller and Sayers' estimates that anywhere from \$40K to \$75K is required to produce one disk side of 54,000 frames, equivalent to 4 hours of instruction. The development time ranges from 4.3 weeks for basic productions to 25 weeks for complex productions.

New developments in production tools and software and video editing facilities may decrease the editing time and the mechanical reproduction complexity, but the time and costs represented by art/photography, program design, and TV production will still be affected by labor costs, which will tend to rise. Thus, \$75K per videodisc side is a good planning figure to use for disc production.

More than one lesson can use a single disc, depending on the duration and complexity of the lesson. However, the design of any video based educational system must recognize that until the era

of the erasable videodisc arrives, once a disc is mastered, it cannot be updated. Thus, while it is easy to revise the courseware in terms of software driven by the computer, the optical disc cannot be updated. The obsolescence factor of disc thus becomes another cost consideration. It is for this reason that it may be bad practice to encode the software as digital files onto the laserdisc, to be read in by the computer and then executed. While this eliminates the possible error of using the wrong program for a given videodisc, it also raises the obsolescence vulnerability.

Design of an Effective Integrated System

With all of the factors thus examined, how can we make the most of the new optical videodisc technology to where an effective, properly managed training system can be instituted?

Five factors are essential. These are summarized in Figure 7 and are explained as follows:

Establish a Computer Network

Analogous to the saying, "No man is an island" is the observation that a teaching machine, for all the investment in courseware it represents, cannot serve as a stand-alone unit. It is impossible to account for its usage or its effectiveness if it sits on a desk as a record-playing machine. In order for management to assess its performance, it must have a communications capability. To ensure that it produces reliable data, it cannot be entrusted to record its usage on a DOS file and have data up-loaded or mailed to an administrative processing unit. Thus, a network consisting of a processor which has a file server and executive decision making capability is a vital element.

Networks can utilize any of the commonly used topologies, ranging from a hub-and-spoke, switched dial-up capability to a LAN. LANs are particularly useful in that many workstations can be interfaced to it on high-speed lines. LANs can gateway to other LANs in other facilities, and can utilize various common purpose servers. As an example, student records and student profiles can be maintained on a central file server or central processor. Reports can be produced on a print server.

Figure 8 illustrates an Ethernet LAN with multiple workstations and servers. This shows how numerous interactive videodisc

workstations can be set up within a building and networked to a central processing facility that maintains student records, student learning profiles, and courseware evaluation files. The access to these records can be through VIP-series terminals or through PC's using terminal emulator software. Gateway servers enable a LAN serving a given facility to interface to other facilities, conceivably through carriers such as TYMNET or the DDN. The CAN-8 system is ideally suited to this type of structure.

Because of networking capabilities of the DPS-6 as host to the CAN-8 software, other networks are possible. A single DPS-6/95 can drive up to 128 workstations concurrently, and multiple DPS-6's can be networked, with a single processor functioning as a management computer. Figures 9, 10 and 11 illustrate these topologies.

Develop a Functional Learning Workstation

Current Level Three workstations have been characterized by a laser videodisc player cabled to a PC which is in turn cabled to a video monitor and a keyboard. The result is a relatively complex array of cables, junction boxes, and electrical outlets to connect up a typical workstation. The EIDS prototype has attempted to simplify the connection of components by specifying only two boxes; one being a combination videodisc player and PC driver; and the other being the video monitor with audio speakers. It is felt within several areas that the EIDS specifications may influence the design of interactive videodisc workstations to be used in other areas of the Federal Government and possibly the commercial sector as well. Sony Corporation of America has already developed such a prototype for EIDS in its VIEW-2 product.

Since the Honeywell - supported CAN-8 product developed by Homecom Learning Systems Ltd. of Canada used Sony equipment for its workstations, it is not unreasonable to consider that a future Honeywell CAN-8 system could use a functional workstation patterned after the Sony VIEW-2 product. This workstation could use an integrated communications interface adapter in addition to the PC chassis mounted in the same box as the laserdisc player. Its external appearance would be similar to the VIEW-2, except that it would not have diskette ports.

It would have an RS-232 interface to a LAN port, and a modem or a direct-connect cable to a Micro System 6/10 chassis. Connections from a touch screen monitor and/or a serial mouse used in development systems would utilize a single cable running from the RGB monitor to the laserdisc/processor chassis.

It is anticipated that development systems (i.e. systems used by courseware developers instead of students) would avail themselves of MicroSystem 6/10 units for work which would use diskette based software, or would utilize a separate VIP-terminal to DPS-6 host for software development.

Courseware Development

Unlike the present array of courseware available through authoring systems, courseware development would be conducted on a top-down basis, with management and evaluation of student progress included as necessary design elements. This would shift the emphasis from individual courses and modules to courses related to the total training objective. The progression of events would then follow the steps as outlined earlier in Figures 5 and 6. The programming of the actual courseware and all of the videodisc production would take place with essentially the same methodology as before, but some economies of video production might be realized. These would center about planning for those video elements which would be relatively immune from obsolescence, or greater planning for overall video production which would last through a number of product system generations over which the courseware might apply.

Management Reporting and Administration

This component of an effective integrated system would cover the information and administrative requirements of management. It would use the courseware, student enrollment, student attendance/session reporting, and student learning profile databases to permit management to receive effectiveness information. This would respond to the general and to the specific answers management seeks, such as number of students entering, matriculating, failing, and recycling through the training function. The impact of each course upon students could also be studied, such as difficulties with specific blocks of learning, or difficulties of certain

student profile characteristics with the learning experience or with specific modules.

The methods of presentation--report, graphics, visual display and hard copy output would also be considered under an effective integrated system.

Support

In order to ensure that the user receives a totally functional computer-based education and training system, it is vital that the supplier of such a system be prepared to support every element of it. Recalling the description of the system components presented earlier in this paper, they represent a widespread assortment of products and services, all of which must function together in an integrated system. At present, no single source of supply exists where every component of a computer based education and training system is manufactured or developed. Figure 12 presents a matrix relating the products and services of an integrated computer-based training system with their sources of supply. It can be seen that the waterfront is most definitely not covered.

Currently, only one vendor offers a computer, the videodisc linkage board, videodisc software, and communications. All other components are procured from external sources and training/consultative services are offered as additional market items to orient users in developing applications. The remaining vendors and specific suppliers have concentrated on manufacture and marketing of their products and services within their own area of specialty. No single source of supply has directed any major effort towards providing an integrated network type system, capable of responding to management needs as well as delivery of instruction to the student. Potentially, the CAN-8 system operative on Honeywell DPS-6 and Micro System 6/10 hardware offers a comprehensive response to both the needs of management and operational educators, with only the peripherals hardware and applications software requirements coming from other sources.

The interactive training market is growing rapidly and the technology to support this requirement is advancing just as rapidly. The ability to provide customized, auditable training for high tech workers is crucial to industry and government alike and will rapidly replace many traditional classroom training programs. The results will be more cost effective training with increased productivity for the work force.

1. Miller, Rockley L. and Sayers, John H.; The U. S. Videodisc Market; Analysis of Forecasts to 1990; Monitor Report Series A151185, Videodisc Monitor, Falls Church, VA November 1985.