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ABSTRACT

This paper provides teachers and trainers with the concepts and procedures involved in using interactive videodisc technology for instruction. Described first are types of individualized instruction that have influenced videodisc development: programmed and computer-aided instruction, as well as computer graphics. Then the author explains how video technology operates, stating the advantages of the optical videodisc over videotape. Next, he illustrates different configurations for learner interaction with video. Advantages and disadvantages of such delivery systems as optical reflective disc players and direct-read-after-write disc recorders are described. Examples of the use of interactive videodisc in on-the-job training and instruction are provided. Because few such programs are available, the next three sections elaborate a systematic process for designing, producing, and implementing video training materials. The design section follows the five steps of the Instructional Systems Development process (analysis, design, development, implementation, and evaluation). The topic of production centers around the use of the storyboard as a guideline for all production elements. Film and video production are compared. Next, major considerations in implementation are discussed: site preparation, facility requirements, teacher training, management involvement, and evaluation. The last section describes the author's production of a videodisc on machine lathe operations, a case study encompassing the stages of development, site preparation, field trials, and evaluation. (SK)

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Information Series No. 299

VIDEODISCS IN VOC ED

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The National Center for Research in Vocational Education
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FOREWORD

The Educational Resources Information Center Clearinghouse on Adult, Career, and Vocational Education (ERIC/ACVE) is one of 16 clearinghouses in a nationwide information system that is funded by the National Institute of Education. One of the functions of the Clearinghouse is to interpret the literature that is entered into the ERIC database. This paper is of particular interest to vocational education teachers, curriculum specialists, and administrators, as well as to trainers in business and education.

The profession is indebted to William P. Olivier of the Ontario Institute for Studies in Education (OISE) for his scholarship in the preparation of this paper. Dr. Olivier serves as Associate Professor in the Graduate Department of Education and the Department of Measurement, Evaluation, and Computer Applications. Previously, he was a project director at the Computer Assisted Instruction Laboratory, the University of Texas at Austin. Dr. Olivier has served on the editorial advisory board of *Computers in Education* and as a special reviewer for the *American Educational Research Journal*. He has been principal investigator for the OISE Individualization Project and the Videodisc Project that was funded by the Ontario Ministry of Education. He has published extensively in the area of computer-assisted instruction.

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EXECUTIVE SUMMARY

This paper provides teachers and trainers with the concepts and procedures involved in using interactive videodisc technology for instruction. Because this technology is relatively new, there are few programs available; the information presented here is intended to help teachers and trainers produce their own videodisc materials.

This technology is particularly useful in personalizing instruction, allowing learners to proceed at their own pace and receive immediate feedback. The teacher or course developer is provided with continuous information on student performance and the instructional effectiveness and efficiency of the course.

The first section of the paper reviews some of the methods of delivering individualized instruction: programmed and computer-aided instruction (CAI). Advantages of programmed instruction include organization of the material into manageable frames, active responding, knowledge of results, and branching. These assets are incorporated into CAI; various modes of CAI (testing, drill and practice, tutorial, dialogue, simulation, and games) as well as computer graphics are described.

Video technology extends the visual and audio attributes of CAI. The most common medium is the optical reflective videodisc—a shiny 12-inch disc read by a low-powered laser beam—that can store 54,000 frames and contains two audio tracks.

The following four kinds of configurations for learner interaction with video are illustrated:

1. The basic system features an interactive video station into which learners enter responses and from which they receive information; teachers are provided course and student performance data; and programs provide text, graphics, and an operating system.

2. In one variation, learners read text on a monochromatic monitor and graphics on a color monitor.

3. The single-screen version of the system allows videodisc information to be placed on screen simultaneously with microcomputer-generated text and graphics.

4. A less expensive version without an external microcomputer can only use prerecorded, unalterable disc information. The various configurations dictate the type and method of input: keypad or keyboard, touch screen, light pen, mouse, joystick, optical character reader, or microphone.

The two major types of interactive video systems are tape and disc. Although tapes are more easily produced, their disadvantages include slow access time, poor freeze-frame characteristics, and costly maintenance in a high-usage environment. These drawbacks may be overcome by using optical reflective videodisc players or direct-read-after-write optical disc recorders.

A brief description is provided of some of the existing interactive video training materials by General Motors, Digital Equipment Corporation, the American Heart Association, and others. Because so little material is available, the heart of the paper elaborates a systematic process for designing, producing, and implementing interactive video training materials.

The design section follows the five steps of the instructional systems development (ISD) process: analysis, design, development, implementation, and evaluation. The many skills necessary for videodisc production require a team of experts including ISD specialist, subject-matter expert, evaluation specialist, and technicians. The roles of each throughout the steps of the process are described.

The topic of production centers around the use of a storyboard—a guideline for the production of graphics, video, audio, computer text, and programs. The storyboard information coordinates the steps of the production process and assists in editing the final product. In this section, film and video production are also compared.

Because implementation is equally as important as design and production, the dimensions of site preparation, facility and equipment requirements, involvement of teachers and administrators, and program evaluation are considered.

A case study describes the author's research project at the Ontario Institute for Studies in Education, which resulted in the production of a videodisc on machine lathe operations. Encompassing the stages of development, site preparation, field trials, and evaluation, the case study illustrates the concepts and procedures outlined throughout this paper to assist those practitioners who are interested in producing their own interactive video training materials.

Information on videodisc technology for instruction may be found in the ERIC system under the following descriptors and identifiers: *Computer Assisted Instruction; Design Requirements; Facility Requirements; Individualized Instruction; Job Training; *Online Systems; *Production Techniques; Programed Instruction; Television Studios; *Video Equipment; *Videodisc Recordings; Instructional Systems Development; Story Boards. Asterisks indicate descriptors having particular relevance.

INTRODUCTION

Change, especially when based upon new technology, is sometimes viewed as a challenge and sometimes as a threat. It is the view of this author that when based upon informed choice, growth through change can be an exciting challenge. It is the purpose of this paper to provide vocational or occupational teachers and trainers with the knowledge to make informed choices about a specific new technology—the interactive videodisc. A major premise is that technology will be used increasingly to provide individualized (personalized) instruction or training to learners. Computer-aided instruction and its marriage to video technology called interactive video will be at the core of this new technological evolution in the educational and training sector. This paper is intended to provide the teacher- or trainer-user and teacher- or trainer-developer with the concepts and procedures involved in this new technology. Given the early stage in the evolution of this technology, there is an equal need for developers as well as users. To understand interactive video technology one needs to understand how this concept has emerged, beginning with its roots in individualized instruction.

INDIVIDUALIZED INSTRUCTION

One definition of individualized instruction is a one-on-one form of instruction that considers the learner's background, interests, aptitudes, abilities, and needs to impart defined knowledge, skills, and attitudes in the most efficient and effective manner possible. Because provision of an expert teacher for each learner is not practical in terms of costs and availability, certain technologies have emerged. These technologies—programmed instruction, computer-aided instruction, and computer graphics—have emerged as partial solutions to individualized instructional delivery.

Programmed Instruction

An early technological method, based upon print, was programmed instruction. Through use or reading, most readers will be familiar with linear programs, commonly called Skinnerian programs (Skinner 1968). Some readers may be familiar with branched programs, often called Crowderian programs (Crowder 1963). The basic unit in programmed instruction is the frame. A frame consists of some information followed by a question to which the learner responds and then feedback or knowledge about the correctness of the response. According to Skinner's theory, the student should not make wrong responses; therefore, the frame is a very small unit of information. A response is often a single word or phrase, and the progression through the material is invariant for all learners. Crowderian programs have larger amounts of information, and the response options provided to the student are often multiple choice. Selection of an option moves the student to another frame where knowledge of correctness of the response is given and more information is provided. With the branched format, a group of learners could have different completion rates because of the multiple paths taken through the frames. (A "good" learner would see the fewest number of frames and thus complete the material in a shorter period of time.) The best principles from programmed instruction—analysis of the material into manageable instructional frames, active responding, knowledge of results and branching—were incorporated into the next technological phase, computer-aided learning. Since many early videodisc programs seem to have been built exclusively upon knowledge of programmed instructional models and not computer-aided instruction (CAI), it is helpful to examine the learner interaction models of CAI. Also note that interactive video programs may be designed as an audiovisual extension of CAI.

Computer-aided Instruction

When first introduced, computer systems were very expensive and designed to manipulate numeric information. Soon to appear was the concept of time-sharing, a system in which many terminals, often electric typewriter-like printer stations, could share the use of one computer. Time-sharing reduced the cost of delivering computer services to many users, and computer-assisted instruction (CAI) emerged. The early forms of CAI were simply programmed instruction delivered by a computer terminal instead of a booklet or teaching machine. Business applications spurred the development of the cathode ray tube (CRT)—a television-like screen providing text and numbers in 24 lines of 80 characters with a typewriter-styled keyboard. Because of the decreasing costs of delivering CAI, the need for graphic and pictorial information and other models of learning, such as new modes of interacting with learning materials, have evolved.

Instructional programs that are computer administered need not require each student to progress at the same rate nor require each student to study the same material. CAI programs can, therefore, control the rate of progress and the amount and type of instructional and test material each student uses. CAI has demonstrated its effectiveness with students at all levels of the educational system and at differing levels of ability. The less capable student usually can achieve a higher degree of proficiency than would be possible from other nonindividualized methods of instruction. With CAI, the bright student is usually capable of covering the required materials in less time (Olivier 1973).

Early systems of CAI, and videodisc programs, often used linear and branching forms of programmed instruction as their basis. Early CAI systems assisted in record keeping, but they often only hid a multiple-choice answer from the student and "turned pages" for the student. This form of selective CAI stored the explicit curriculum content and selected the page (frame) to be displayed. Many early videodisc programs did not even hide the choices nor keep student records. The state of the art of selective CAI production now enables the computer to assist the curriculum designer with authoring systems that do not require knowledge of a computer programming language.

If a programming language with well-defined algorithms is selected, the computer can actually create or generate instructional materials and test items as needed. Generative models of CAI construction are the early forms of artificial intelligence techniques. The generative models of CAI are more applicable in science and mathematics-related areas where mathematical models apply, but they can reduce the time and work required by the author as well as requiring less computer storage. Both selective and generative forms of CAI can interact with the student in different ways.

CAI may be computer controlled (sometimes called program controlled) or learner controlled. Learner-controlled programs (Steinberg 1977) allow the student access through a "menu" to select topics and sequence through a course. The student is often allowed some control over the instructional strategy, testing, number of problems, difficulty level, and so forth.

The following scenario may help in visualizing how CAI technology interacts with a learner. A typical student interaction has the student sitting at an interactive display station and keying a simplified user identification procedure. The computer fetches a student record file, determines the starting (or restarting) point in the program, and begins running the program.

Typically, the student sees text or graphics followed by questions. The student keys or points to a response and the presentation cycle begins again. Although the student sees an uninterrupted flow of instruction, a good program is actually giving the student a highly individualized sequence by extensive branching within the program. The computer keeps a log of this interaction, and when a student's session is over, the student's record file is updated. Anytime a station is available, the student may resume the flexibly scheduled, self-paced course. Periodically, the teacher receives printed reports on each student's progress. During course testing, the developer receives detailed analyses of the instructional effectiveness and efficiency of the course by section, considering objective, topic, and so forth (formative evaluation), and makes revisions in the program until the course is validated. Among the many forms of CAI are testing, drill and practice, tutorial, dialogue, simulation, and games.

Testing

The computer can administer test questions and have results immediately available. Multiple-choice test formats can be administered, or the author may have students construct their own answers. With constructed responses, the likelihood of students' simply guessing the correct answer from a set (shown on the display) is avoided since the computer hides the possible answers. When the student constructs a response in the form of a word, phrase, sentence, or mathematical statement, the author must be capable of classifying the response. Careful wording of questions increases the possibility that the computer program designed by the author will classify or "understand" the student's response.

If there is a relationship among items in a test such that if a student can answer one question type then the student likely will answer lower-level items correctly, then the hierarchical relationship of items can be used to shorten the length of the test for many students. Many curriculum areas based upon a hierarchy of concepts and rules, such as science and mathematics, lend themselves to a hierarchical item selection test strategy (Olivier 1973).

Since the computer is accumulating a record of the sequential history of a student's responses, a model of sequential testing (Wald 1973) can be used for each item type. Sequential testing techniques vary the number of questions of each type in a dynamic fashion. If a student misses several questions consecutively, then the student would likely fail additional questions of this type, and the computer can stop the test with the prediction that the student has not acquired the concept being tested. Similarly, a student making consecutively correct responses completes a test quickly. Decisions can be made by sequential testing procedures with the same accuracy but in half the time taken by tests of fixed length (Olivier and Lomberg 1974).

Both sequential testing and hierarchical item selection testing methods require decisions based upon student performance to be made more frequently than is feasible without a computer.

A very simple extension to computer-assisted testing is to allow the computer to inform a student of errors immediately. This concept is called drill and practice.

Drill and Practice

If a student is told when the answer is correct and given the correct answer when wrong, then the student is using the computer in a drill-and-practice mode. This method is not intended as an initial instructional tool, but rather it assists the students to refine their skills. The computer's capacity to correct a mistake immediately is probably the best feature of this method. Drill-and-practice programs in mathematics and reading are in wide use at the elementary school level. Drill-and-practice methodology can be extended to give a student new information, and this extension is usually called tutorial CAI.

Tutorial

When new information is given to the student as a result of performance, the computer acts in a tutorial fashion. This method is often used, but is more expensive since it requires more information to be stored in the computer. Many interactive video programs utilize this tutorial instructional model (Olivier 1983). Some educators may feel that the student is restricted in a tutorial mode (as was the case with programmed instruction) and should be capable of engaging in an unrestricted dialogue with the computer.

Dialogue

A truly free discourse between computer and student is yet to be achieved. The area of linguistic analysis by computer is relatively new, and a learner-machine dialogue outside of limited contexts is not possible. The closest approximation to this form of interaction is that of allowing the student to assume some control over the instruction by using a limited vocabulary to request the computer to perform computations, retrieve information, plot graphs, and so forth (Steinberg 1977). Simulation is another means of CAI that allows the learner some control over the instructional interaction.

Simulation

In situations where an experiment might be dangerous, occur in too short a time, or take place too slowly, a computer simulation of the event may be used. In many cases, the computer can bring an experience into the classroom where the actual experimental apparatus would be too massive or expensive (nuclear reactor operations).

Games

Where an element of competition is utilized even a drill-type program may motivate learners. Many of the aforementioned models of interaction may be enhanced by graphics and interactive video.

Computer Graphics

The first CAI computer display was an electric typewriter-like mechanism. Today the most common display is a CRT. Many CRT devices were designed to display only textual (character) information. A raster graphics display (Conrac Corporation 1980), which is more expensive than a character display, is usually required to produce line drawings and solid areas (polygons, circles, and so forth). One measure of the resolution of a graphics display is the number of picture elements (pixels) that may be displayed on the screen. The picture elements on a medium resolution display would have about 480 vertical and 640 horizontal viewable pixels. This would give a single-intensity (on or off) pixel capability without color and intensity of shades. To obtain color (composed of red, green, and blue components), one might require 4 bits of information for each intensity. This would give 64 hues and saturations (intensities) per pixel and would require nearly 4 million bits (460.8 K bytes) of information for one display. This storage capacity is beyond the size of most personal computers, although it is approximately what is required to store one television frame (television changes frames at a rate of 30 per second). Most graphics displays, therefore, do not allow more than 16 different colors on the entire screen simultaneously, and graphics are not completely changed at a rapid rate. To be able to condense the storage requirements for computer graphics displays, an alphageometric representation, such as the North American graphic standard videotex communication protocol (American National Standards Institute 1982) was created. To achieve television-like images at a reasonable cost, a different storage medium such as videotape or videodisc is needed.

VIDEO TECHNOLOGY AND INTERACTIVE SYSTEMS

Videotape

Most readers will be familiar with the videocassette recorder (VCR). To extend the visual and audio attributes of CAI, many cottage industries began producing electronics that allowed the integration of low-cost video playback technology with microcomputers. Compared with videodiscs, VCR technology has some major disadvantages (including tape wear and machine maintenance, slow random access, freeze-frame flicker), and a few advantages (such as lower reproduction costs for small quantities of tape, availability of replication equipment). The VCR is available in two competing and incompatible formats—VHS and Beta.

The Optical Videodisc

There are a number of videodisc technologies [optical reflective, optical transmissive, capacitance electronic disc (CED), video high density (VHD)] (Heath 1981), but the only technology that has been introduced in North America and survived is the optical reflective. Because this is the only available disc technology, it is the one considered herein. Any new video storage and playback technology with the same or more features should not substantially affect the existing materials other than a cost of duplicating in the new media.

The most common optical reflective videodisc system is a shiny 12-inch disc that is read by a low-powered laser beam. The disc is recorded as a spiral track of pits in the disc material. The constant angular velocity (CAV) format stores 54,000 frames (2 interlaced TV fields each) on each side, with 1 frame of information per revolution. The disc frames can be addressed singly or by continuous playing (30 per second). When played continuously, the disc stores 30 minutes of video motion. The disc also contains two audio tracks that can be played as separate monaural channels or stereophonic sound while the disc is in forward play mode.

The Learner-Media Interface

The interface, or point of interaction between the learner and the medium, can best be understood with reference to figure 1.

The figure 1 represents a stylized system configuration. To be able to utilize the system in a way that integrates learner use with other materials, the teacher or trainer needs management information. Two general classes of information should be provided by any system: course performance and student performance. Course performance information should indicate the effectiveness across students of different sections and objectives within the course (formative evaluation data). Course performance information is difficult to collect when students are using individual microcomputer-based systems.

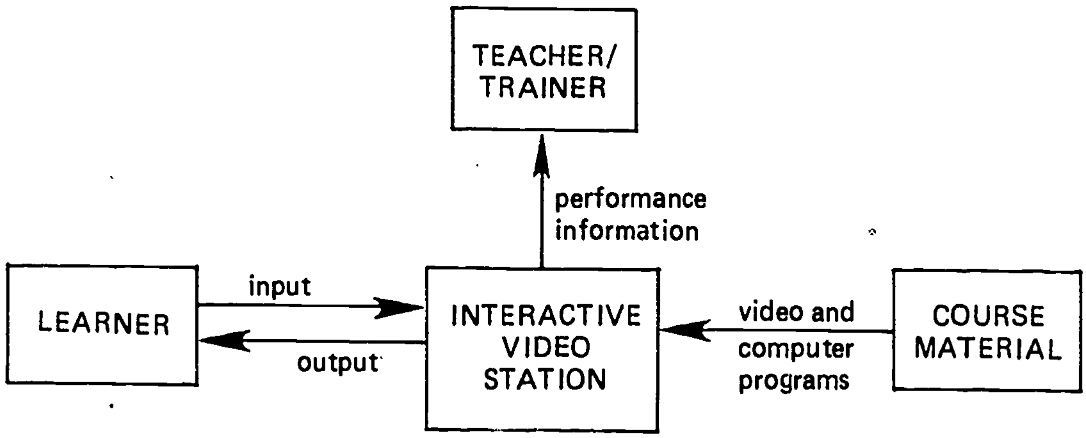


Figure 1. An interactive video station

Information about the rate and achievement of individual students should also be provided. Many systems provide little or no such student or course performance information. The diagram in figure 1 also indicates that learners enter responses (input) and receive information (output). The course material presented by the system is based upon videodisc-stored content and computer program information that judges the learner's responses and routes the learner through the material. The computer program may also contain prestored text (information, questions, and menus) and graphics.

The interactive video station can be represented by one of the alternate configurations shown in figure 2.

This configuration is often used for several reasons. First, the text displayed from a microcomputer often uses monochromatic displays. A monochrome display usually has better resolution at lower cost than a color monitor that requires a red, green, and blue (RGB) dot to be combined optically to give a white dot. Text, especially when small (for example, 24 lines x 80 characters), is easier to read on a monochromatic monitor. Also, the timing of a microcomputer screen is based upon a clock in the computer and does not coincide with an external video source. To be able to place videodisc information on a screen simultaneously with another video source (microcomputer generated text/graphics), one of the sources must accept video sweep timing from the other source (gen lock capability). The text/graphics overlay on the videodisc signal is then switched within the video monitor. This type of configuration is shown in figure 3.

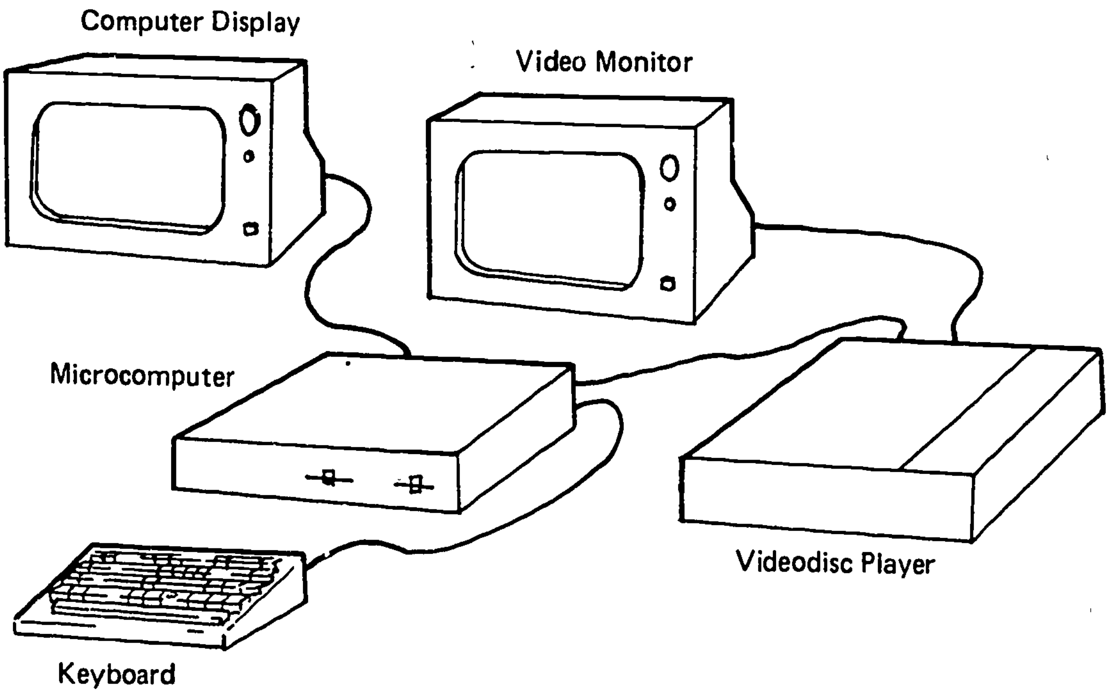


Figure 2. Two-screen interactive video station

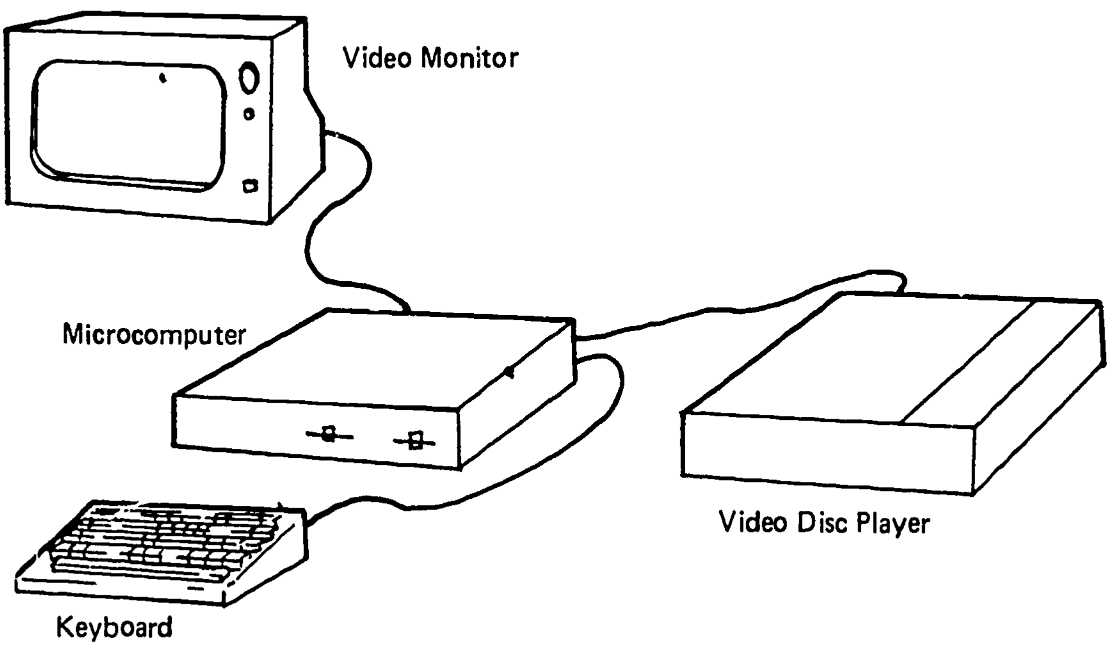


Figure 3. Single-screen interactive video display station

The station shown in figure 3 is usually more expensive than the lower-cost units that may be obtained as an add-on to an existing microcomputer system. The suppliers of this type of equipment are too numerous to mention in this review. Also, since many of these units are being produced by cottage industries, some may not be available in the near future. In any case, the learner must receive output from the interactive video station. This output may consist of visual information (text, graphics, and video) and audio. There may be one or two video screens and a speaker or earphones. An audio headset (earphone) is usually necessary where there are a number of stations in the same area.

Most stations, especially lower cost units using a single TV monitor display, are not suitable for displaying a volume of text (24 lines times 80 characters). Text being displayed on a separate monochrome monitor (with long persistence phosphors) is legible and causes less eye strain, but this method does not ease the task of directing the viewer's attention to information from the videodisc. Text (usually no more than 12 lines times 40 characters) may be recorded directly on the videodisc when the disc is manufactured, but this text may not be changed without producing a new videodisc. The videodisc player can hold a single frame on the display, but there may be a slight flicker or jitter to the image. High-fidelity monaural or stereophonic sound is available from the disc while it is playing (30 frames per second), but long sequences of audio use a substantial amount of the 30 minute total per side of the disc. There are some newly developed techniques (digitized audio) for storing about 10 seconds of voice information on a single disc frame, but such methods require an additional voice synthesizer electronics module at an additional cost.

Some interactive video units, those that do not use an external microcomputer, have a simple configuration as shown in figure 4.

This type of configuration, the first type of unit introduced, allows for use of prerecorded disc information only and may not be changed once the disc is produced. The internal computer program may be changed through the keypad, but this program modification capability is limited and not practical for most users. What is displayed to learners must be prerecorded.

The basic method of entering information into the interactive video station is a keyboard or numeric keypad. Where the station is an internal computer configuration as shown in figure 4, the responses are typically of a multiple-choice or true-false type with the learner having single-digit numeric choices. With external computer configurations, the program may allow constructed responses (the learner may key words, phrases, or numerical answers).

Another response method used by some external microcomputer configurations (such as those in figures 2 and 3) is coordinate sensing. Coordinate sensing is accomplished through use of a touch-sensitive screen overlay, which returns the x,y coordinates to the computer for response judging. This method is the most "user friendly" in that it mimics a normal pointing gesture, but some users are reluctant to touch a screen, and a user's arm can tire making repeated selections from the screen. Also, if the program sometimes uses the keyboard and sometimes the touch screen, the learner may be confused as to which type of response is to be given. An alternative to the touch-sensitive screen is the light pen, which is connected by a cable to the microcomputer and is sensitive to light coming from the screen. Light pens are prone to skid across the screen if not properly placed, and they can be made nonfunctional by careful placement of chewing gum or dark felt marker. Therefore, light pen configurations are not as popular for training environments.

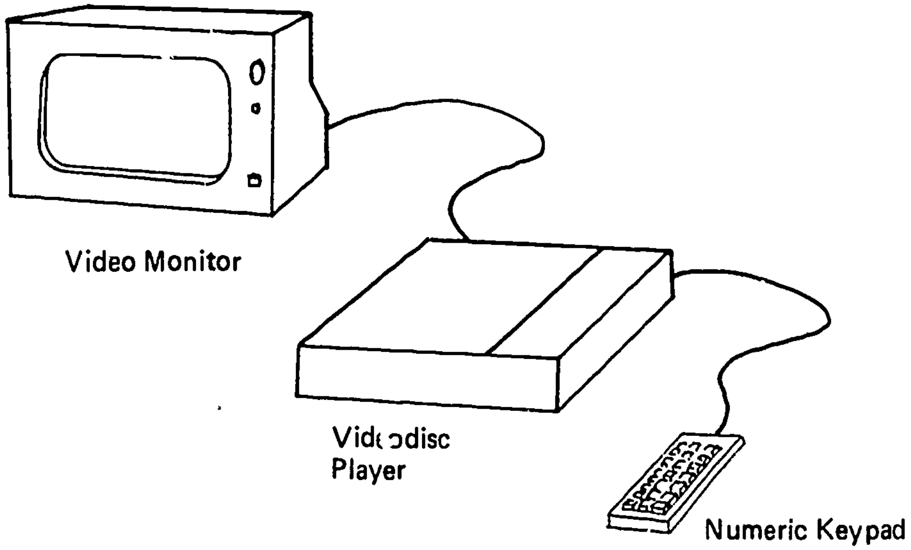


Figure 4. Internal computer videodisc station

Other popular coordinate-sensing devices are the digitizing tablet with puck (most often used for converting paper drawings to computer data), the mouse, and the joystick. With the latter two devices, a marker or cursor appear on the screen and, when it reaches the appropriate position, a button on the device is pressed.

Another type of input device is somewhat different from the others. This device uses a bar code-reading wand like those on retail sales cash registers. The text and questions in this system are printed in booklets and multiple-choice answers have bar codes printed to the side. The learner makes a choice and passes the wand over the appropriate code. The computer display presents results to the learner.

Another type of input device is the microphone. This voice-activated input recognition device is still expensive and does not yet afford a wide vocabulary. Some high-cost military simulators may use this type of device, but they are rare in most public vocational delivery systems.

Delivery Systems

Two major types of interactive video systems are in general use in North America: tape and disc. Interactive tape systems have one major advantage—an individual may produce an interactive videotape. The common optical reflective disc must still be mastered at a remote location. Also, to produce the best quality disc requires broadcast-quality video production equipment. This author uses a TV studio with 1-inch videotape equipment acquired at a cost of about $600,000. Most interactive videotape systems operate on consumer-quality equipment: 1/2-inch VHS or Beta.

The major drawbacks with tape-based systems are slow access time, poor freeze-frame characteristics, and costly maintenance in a high usage environment. These drawbacks are explained in the following section.

If a tape system has to do a lot of branching, the time the user has to wait (shuttle time) for the next sequence can be measured in minutes rather than in terms of a few seconds as is the case on a disc system. A videotape produces a poor quality (jittery and noisy) freeze-frame and can hold the single frame for only about 2 minutes before tape and head wear becomes a problem. Obtaining multiple copies of a tape is time consuming as a tape must be duplicated at the same rate it is played and then rewound. A disc master from one manufacturer costs about $1,800 and copies cost $18 each or $6.75 in quantities over 2,500. Tape copies are about $40 each with no substantial quantity discount. Maintenance is another problem with tape. This author found that in a 10-hour-per-day usage environment, tapes had to be replaced each week and the players cleaned. In such an environment, the tape player became unserviceable after 2 months and had to be discarded. The consumer-quality disc units that were used cost half the price of the random-access tape units and ran for 4 months on the same daily basis without any servicing. In general, when the situation involves heavy usage and a number of units, the disc would be preferable. If there is only one unit, if it will not get heavy usage, if access time is not a problem, or if one needs to make copies and begin using the tape or tapes immediately, then one should consider tape systems.

Optical Reflective Disc Players

Figure 5 depicts the general external control features of disc players. Normal playing time for a constant angular velocity (CAV) disc is 30 minutes per side. The CAV format is needed for single frame and random access. The players usually have a form of computer interfacing that allows a computer to send the control information to the disc player. Some less expensive consumer-quality players can be controlled by a computer (20 seconds access time maximum) but, in

FUNCTION	DESCRIPTION
Play	Normal play (x) with sound
Fast	1-3 x
Slow	1-1/124 x
Step	Single frame (freeze-frame - 0 x)
Random access	Frame and chapter
Access time	3-5 sec. max.
Audio	Left, Right, or Stereo

Figure 5. External control features of disc players

general, the player does not send a message back to the computer when the command is performed. The professional-quality players (e.g., Hitachi VIP9500, Pioneer LD-V6000, Sony LDP-1000, or LDP-2000) have bidirectional computer communication ports (RS-232 interface).

The disc player may be manually operated through keys located on the player or the remote control keypad. A form of interactive video instruction can be effected in this manner (Bunderson et al. 1984) Internally controlled players, discussed earlier, have a limited number of program steps, require multiple-choice responses, and must be carefully preplanned. The externally controlled player is the one expected to be in most frequent use in the future.

Direct-Read-After-Write (DRAW) Systems

One direct-read-after-write (DRAW) optical disc recorder is currently available (Panasonic TQ-2023F recorder/player, TQ-2024F player only). This new system allows a user to record, but not erase, a disc. The DRAW system is similar in technology to the other disc systems, but a DRAW disc will not play on other players. The Panasonic units use an 8-inch disc that holds 13.3 minutes of video, and duplicating a disc requires a playback unit (either model) and a recorder unit. The ability to record one's own disc comes at a price as the recorder costs $34,900, the player costs $3,975, and blank discs are $600 each. In considering a DRAW system versus a non-DRAW system, the following comparisons should be noted: the short duration of a Panasonic DRAW disc, about one-third that of non-DRAW systems; the price of the player, about twice that of the non-DRAW system players; and the cost of recording (DRAW recorder $34,900, DRAW disc $600 each) compared to non-DRAW mastering ($1,800 and copies $18 each). Unless the application requires immediate turnaround and the number of duplicate discs is very limited, there will be little economic justification for a DRAW system at the aforementioned prices. The reader should note that the first non-DRAW players were introduced for about $35,000 and rapidly decreased in price. The DRAW technology may become less expensive over time.

EXAMPLES OF INTERACTIVE DISCS IN TRAINING

One of the earliest examples of large-scale use of interactive video is the series of productions of General Motors (GM) (Scott 1982). The GM discs cover sales training, new product training with customer presentations, and mechanic training. These programs use an internally controlled player usually mounted on a rolling cart with TV monitor on top. Another large corporation, IBM, has made use of a series of videodiscs ("How IBM Uses Videodiscs for Customer Training" 1983) for training customers in small business computer operations. One other computer manufacturer, Digital Equipment Corporation, has produced videodiscs for new product training and field service engineers (Olsen and DiFazio 1983). The Bank of America has produced a teller training disc. Nuclear power station engineer training has also been done (Kriessman 1981).

One disc training system that has received much attention is that on cardiopulmonary resuscitation (CPR) produced by the American Heart Association (Hon 1982). This program uses a sensor-equipped mannequin as a response device, a videodisc instructional program, and a text (menu) and graphics display. Because of the complex configuration, this disc is sold with the total system: sensor-equipped mannequin, microcomputer, random-access audio unit, industrial videodisc player, light pen, and two monitors. The CPR system approaches the level of sophistication usually found only in aircraft and military simulation systems.

The military has produced a number of discs (Kearsley 1981) in such diverse areas as satellite communications ground station repair and leadership training. A number of universities and corporations also have produced discs in an exploration of the medium.

Commercial products are now beginning to appear. One such product entitled "Introduction to Computer Literacy" covers hardware, software, telecommunications, and new technologies in a two-disc (four sides) series. This product is available with a floppy diskette containing the computer program and a set of guides from JAM of East Rochester, New York. The course requires an IBM PC and a controller card in addition to a videodisc player and monitor. National Education Corporation/ICS—Intext Division of Westport, Connecticut, has produced two large sets of vocational materials. The electronics curriculum consists of 17 videodiscs, 8 workbooks (using a bar code reader in the station), and a 98-booklet reference set. The ICS mechanical/robotics curriculum consists of four videodiscs and three workbooks. These courses are currently sold as a bundled system (for example, the user must buy the discs, workbooks, reference set, microcomputer with display, touch-sensitive screen, bar code reader, and the disc player as one unit).

Because only a few programs are currently for sale, teachers and trainers will have to consider producing their own discs. In any case, a potential teacher or trainer user should know what is possible in the medium so that rational decisions and acquisitions may be made. It is easy to become sold on an expensively produced disc that is the equivalent of an audiovisual programmed instruction course and does not take advantage of the medium. The following discussion will explore the process of developing and implementing a vocational videodisc. The final section will give an overview of the development, implementation, and formative evaluation of a shop-training videodisc produced by this writer.

DESIGNING INTERACTIVE VIDEO MATERIALS

A weakness of many interactive video programs, and of most individualized instructional programs that involve interactivity, is a poor instructional design. Instructional systems design (ISD) is a fairly well-developed art. There are many texts covering this area (Briggs 1977; Reigeluth 1983; Romiszowski 1981; 1984). One individual rarely possesses all of the skills necessary to produce and use a videodisc. These skills include instructional systems design, subject-matter expertise, writing, text design and layout, photography, graphics design, television production, computer programming, project management, evaluation, and implementation. A team composed of a number of individuals is usually required to produce a quality product. The process of producing an interactive videodisc should progress through five general phases: analysis, design, development, implementation, and evaluation. These phases are taken from the *Interservice Procedures for Instructional Systems Development* (Branson et al. 1975).

Analysis Phase

The first phase is an analysis of the needs for the particular course. This is a task for the ISD specialist assisted by the subject-matter expert (SME) and perhaps an evaluation specialist. Are current techniques ineffective, inefficient, expensive, and so forth? A careful analysis is required to examine all dimensions of the current methods, if any, that are used for the training. An analysis and documentation of the current training environment and its costs and outcomes can be very valuable. For example, machine shop training may require group instruction followed by individual one-on-one use of expensive machinery. The lecture-demonstration method may not be effective because of group size. A project directed by this author found that existing group instructional methods yielded average achievement scores of 41 percent. Later, when students took this portion of the training with interactive video, the average achievement scores were 92 percent (Olivier and Scott 1983). There may also be cost savings. If individualized, self-paced learning is used, as in interactive video, then students who receive better training prior to use of the actual machine may need less time to complete the learning tasks and thus require fewer machines. Fewer machines may also be needed because the shop can be in more continuous use, especially if continuous student intake, rather than a semester schedule, is used.

The next step in the analysis is to define the actual goals of the program. What outcomes are expected for the trainees? Also, what range of skills and knowledge, abilities, and motivation will the trainees bring to the training environment? If it is a cost-sensitive situation, what constraints are involved? The number of trainees that may be served at one time is dependent upon resources: physical space, amount of equipment, trained supervisory and instructional staff, and so forth. The foregoing analysis sets the input and output conditions for the training and identifies the constraints within which the training system must operate. In general, if this analysis indicates that a technology-intensive training system rather than a labor-intensive one is required, interactive video may be a solution; however, a CAI system with text and graphics facilities may suffice.

The ISD specialist then begins a task analysis in consultation with the SME (Foshay 1983; Kennedy, Esque, and Novak 1983; Reigeluth 1983). There are a variety of techniques having different scope. In general, the task analysis will identify the component concepts and skills involved in the subject matter and yield an ordering or presentation sequence for the task components. Test items are then constructed for all components. Test item construction should involve the measurement/evaluation specialist. A learning hierarchy is based upon observable behaviors and suggests a bottom-up (simple to complex) sequence. An information-processing analysis requires a flowchart of the operations and decisions to be constructed and instruction follows the flowchart from input to output. Concept hierarchical analysis yields a hierarchy that is then taught from the top down. Having completed the task analysis, the production team may then move to the design phase.

Design Phase

The first step in the design phase is the specification of the learning activities. These specifications should generally inform the learner what is expected, provide for practice, and give guidance with feedback. Gagne' (1977) has given the events of instruction that serve as good general guidelines for designing instruction. The objectives may then be classified for the type of representation required for learning to occur.

If learning can be expected with textual information, then text should be used because text can be conveyed by the widest range of media (print, alphanumeric and graphics computer displays, and interactive video). The major media decision for text is then one of cost (initial production, delivery, revision, replacement, and convenience of use).

Interactive video is an expensive delivery medium and using an actor to read text is'a questionable technique because of the cost. This "talking head" technique also conflicts with self-pacing, because the learner must accept information at the rate at which the actor is speaking. On the other hand, jumping back and forth between a printed text and viewing video and graphics on a screen could be distracting or confusing to the learner. The ICS electronics course cited earlier does seem to make good use of this print and video integration. Reproducing and distributing multiple versions of texts could be more expensive and texts, being highly portable, are prone to disappear. This writer's experience with school environments has shown that even chaining texts to a computer learning station does not keep print from disappearing.

When text alone will not suffice for learning, then graphics may be needed. The cost of graphics varies greatly depending upon the complexity or resolution needed and the number of colors. High-bandwidth RGB monitors are an expensive item as are the computer's speed and main memory requirements for high resolution graphics. Merrill and Bunderson (1981) have given some helpful guidelines for using graphics.

Interactive video can include the characteristics of most other media. An interactive video system containing a full range of display functions (text, graphics, video, and audio) and comprehensive input media (full alphanumeric keyset and coordinate sensing device) has the necessary attributes. It is such media integration that excites the imagination of many ISD specialists.

Once the learning events have been categorized as to needed medium, the production team can make a choice, weighing the costs of the delivery system. Freedman and Gruebel (1979) have suggested some cost-benefit analysis techniques to be used in media selection. The next step is a review of existing material that could be used in the production.

Development Phase

The development phase is discussed more completely in the next chapter; however, one of the development products, the storyboard, is introduced here. The storyboard is useful in the initial tryouts of the curriculum. One feature of ISD is successive revisions toward a final goal. It is helpful to produce a rough draft of the material and simulate the role of the interactive video system with a small sample of learners. Such a simulation is usually done one-on-one with a trainer showing material to the student and noting the problems encountered. A storyboard technique, as shown in figure 6, may be helpful. A storyboard will also allow for an editorial review by SMEs. It may be very informative to have an SME go through the storyboards with a student from the intended audience allowing the student to ask questions and make comments. Many errors in this and earlier phases can be corrected before expensive production is begun. The use of a storyboard in developing the instruction is explained in detail in the chapter on production.

Implementation and Evaluation Phases

The implementation and evaluation phases will be treated in detail in a later chapter on implementation. It is necessary to select a site for field testing to ensure a representative situation for the eventual distribution of the finished product. The experience of this author has shown that the instructional staff must be adequately trained and motivated to use the material that has been developed. To conduct a comprehensive evaluation, the learner audience may be pretested, and the data-recording and analysis features of the computer may be used to process the information collected during the instruction. Most evaluation techniques have emphasized textual questions, but this may predispose the learners to place undue emphasis on the textual aspects of instruction in a visual learning environment. Postinstructional interviews with learners, as well as structured posttests, retention tests, and attitude measurement, will also provide useful formative evaluation data that may then be used to revise the instructional material.

PROGRAM SPTC AUTHOR ____

___ Video - Reel ____ IN : : : OUT: : :
___ Audio (left/right)
___ Superimpose ___ Comp. Graphic
___ Char. Gen. ___ 35 mm.

___ Computer Program Frame 3-1
___ Text
___ Graphic x Response Judging
___ Narration ____
IN : : : OUT : : :

Volume DISC> SPTC Frame 1 (Blue)

1-Cyan	PARTS OF THE ENGINE LATHE
2-Cyan	------------------------------------
3-White	Would you like to start with a
4-White	review of the parts of the lathe
5-White	or a quiz?
6-White	
7-White	
8-Yellow	Type R or Q, then RETURN.

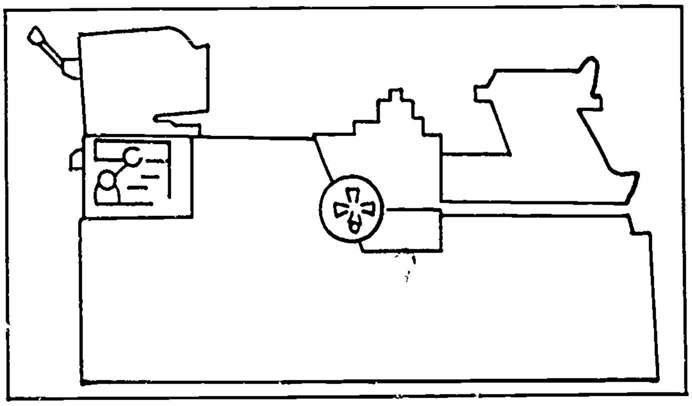
If R →→ 2
If Q →→ 0
else →→ Please type R or Q"

Account ZWO File ____ Page ____
Hold for ____ sec., or x c/r or ___ Narration Videodisc frame 22020-22023
Transition cut
Time Code IN :12:14:00 OUT :12:14:03 duration : :03 sec.____

---

x Video - Reel 1 IN : : : OUT : : :
x Audio (left/right)
___ Superimpose ___ Comp. Graphic
___ Char. Gen. ___ 35 mm.

___ Computer Program Frame 3-2
___ Text
___ Graphic ___ Response Judging
x Narration 5
IN : 11:01:00 OUT : 11:04:18



The four major parts of the lathe are:

Account ____ File ____ Page ____
Hold for ____ sec., or ___ c/r or x Narration Videodisc frame 2202-22132
Transition Pan left and zoom in to next
Time Code IN :12:14:03 OUT :12:17:21 duration : 3:18 sec.____

Figure 6. Sample storyboard

PRODUCING INTERACTIVE VIDEO MATERIALS

A variety of skills in many media are required to produce an interactive videodisc. This section will cover production skills and techniques. For more detailed information, readers may wish to consult a comprehensive reference text on video production by McQuillin (1983), *The Video Production Guide.*

Storyboard

The discussion of the design phase in the previous chapter introduced the concept of a storyboard and its possible use in editorial evaluation and testing with students. The storyboard is also used as a guideline for the production of the graphics, video, audio, computer text and graphics, and computer programs. Figure 6 is a completed storyboard from an interactive videodisc course on using a machine lathe for single-point thread cutting. This storyboard is taken from the third section of the course, which teaches the names of the parts of the lathe, as is noted in the upper right-hand corner. Response judging is checked to verify that the information found below illustrates the type of answers expected by the computer program and to determine the storyboard program frame number that should be executed next. In this first frame, the "if R -> 2" means that if the program judges the student's response to be the letter "R," then it will branch to the second frame. Likewise, "if Q -> 10" means jump forward to frame 10 and do as instructed on that frame. The last line "else -> Please type R or Q" means that if anything else was keyed, then the computer should display the message "Please type R or Q" on the student's screen. The top left of the page indicates that the source of the question is to be the TV studio character generator. The center top of the page is for the visual information to be stored in the computer and is not used because the question text will be stored on the videodisc as created by the character generator. The boxed area in the left center of the frame is a representation of the TV screen. Pasted into this box is a printed output from the computer program that identifies the information to be loaded into the character generator. The first line names the computer disc file "DISC SPTC," the page in that file "Frame 1," and the background color of the screen "Blue." Down the left side are eight lines with a color name that tells the color of text, if any, displayed on that line. The information to the right of the line numbers is the text that will appear on the screen. This frame was created interactively using a specially designed word processing type of computer program on a CAN-8* CAI system. The CAN-8 CAI system is used also to do all graphics production, storyboard composition, and videotape editing for producing a videodisc. The system, available from Homecom Learning Systems, Limited, Toronto, Canada is also used to operate CAI, graphics, and interactive video terminals.

Just below the boxed area is the CAN-8 computer system account name. The file name and page number for a computer graphic or animation would be given here. The next line informs the programmer whether the display is to be held on the screen of the learner's station for a certain

*CAN-8 is a registered trademark of Homecom Learning Systems. Limited, Toronto, Canada.

number of seconds until the student presses the return key or until any narration has finished playing from the videodisc's audio track. The transition specifies that the character-generated text is to disappear as soon as the student presses the return key.

This transition information is also needed by the person doing the videotape editing. The time code in-point indicates that the master videotape for this frame begins at 12 minutes, 14 seconds, and 0 frames. This sequence lasts for 3 video frames or 1/10 second. The ability to read this information depends upon the still-frame playback capability of the videodisc player. The CAN-8 computer program has also calculated that this will appear on the videodisc at frames 22020-22023. The programmer will use the midpoint (frame 22021) when writing the computer program that runs the learner's program. Three frames have been used because the computer-controlled videotape editing equipment can sometimes produce a bad edit and the first or last frame can be of poor quality.

The second frame on this storyboard page shows that narration is already recorded on another videotape and that a shot showing the lathe moves (pans) to a close-up shot of the next part of the lathe. The storyboards give a great amount of detail that is necessary for all aspects of the production. These sheets unambiguously specify how the videodisc will appear. One videodisc produced by this author required more than 1,000 pages of storyboards. Such an extensive amount of preplanning can help keep the costs of a production within reason.

Two other sets of material are produced from the storyboards: the shooting script and the narration script. The shooting script is a list of all the video that has to be produced and is used by the video production crew for cost estimates and scheduling. The narration script is a double-spaced, word processed listing to be used by the narrator for the audio recording. The handwritten storyboards, first draft, were used as a source document and were input into a word processor, another CAN-8 program, that could then print with narrow margins for storyboard pasteups and typewritten pages with regular margins for the narrator.

Editing

This author uses 1-inch Type "C" videotape for all production because of the high technical quality and single-frame editing accuracy. The videotape editor uses the storyboards as a script for the entire process. There are special requirements (for which, see Minnesota Mining and Manufacturing Co 1981) that can be obtained from the disc-mastering facility that will give the format for the customer-produced videotape to produce the videodiscs. The editing process must adhere to these specifications.

Once the replica discs are returned from the mastering facility, the computer programs may be tested with the disc and implementation can begin.

Film

Film comes in a variety of still and motion formats. Still (for example, 35 mm) film and camera equipment may be used because it is the most portable and least expensive visual medium. Still photography is commonly used for copying manually produced graphics, text layouts, and artwork on a copystand; for copying computer graphics; and for taking location photographs. The film should be produced with a view to its use on a TV screen; 35mm film has a different aspect ratio than TV. Film is wider and if the image fills the film area, some of the image will be cropped (cut off) on TV. Animations, a series of still images in different positions, may be done with 35mm film, but accurate registration is a problem and the image may jitter on video. Film is a convenient way to transfer high-resolution computer graphics. Most high-resolution computer graphics equipment is incompatible with video recording. Photographing from a TV or RGB monitor screen produces unacceptable results, so this transfer usually occurs through a film recorder (a special flat screen black-and-white monitor with color filter wheels packaged in a special enclosure with associated electronics and camera mount for a motorized 35 mm camera). The major problem with using 35mm is the cost of converting the film to videotape. Optical tele-cine equipment and techniques may be used, but the labor involved in editing the videotape is expensive.

Motion picture film, 35mm or 16mm, has special problems. Professional film cameras record only the image and are synchronized to a magnetic audio recorder. These two media are then combined on a copy of the original film, and this involves more time, equipment, and labor. Normally, sound film is shot at 24 frames per second. Television operates at 30 frames per second. If a one-to-one correspondence were used, then the image would be slightly faster. To compensate for this, alternate film frames are transferred to three, then two video fields. This technique's speed matches and allows for use of the still-frame mode on the videodisc player. If the image being taken by a film camera is moving, a slight blur will occur because the entire frame is being exposed at once. On the other hand, video cameras sweep the image each 60th of a second and combine two separate sweeps (interlaced fields 1 and 2) for one frame. A moving video sequence looks accurate, but if a videodisc is in freeze-frame mode, the image will jitter because a single TV frame is composed of the 2 swept exposures taken at different times (1/60th of a second apart) and then interlaced on one display.

Video

High quality video production requires a studio, but production may be done on location. A studio needs space for the set and camera operators, as well as all the lighting equipment. A tall ceiling with a lighting grid is required, and sound isolation from outside noises is needed for audio recording. Newer TV equipment of high quality is smaller and more portable than in the past and may be used outside the studio. Lighting equipment is still cumbersome at best, and location production requires a team. If one were producing an operator-training disc about a three-axis milling machine, the production would probably be done on location rather than in a studio, considering the setting and problems of moving equipment. The greatest problems in location production are lighting and sound. Production for a videodisc requires more care with bright reflections (hot spots) than might normally be taken with industrial-quality video. If one is using a narrator, then audio may be added in the studio and not done on location. If a person is on screen and talking, the audio must be recorded while the person is speaking. Video and film production require a team: at the very minimum, individuals to operate the camera, video recorder (primarily to monitor the audio), and lights as well as a director. Production is a labor-intensive and costly operation.

The major advantage of video over film production is that videotape is less expensive than film, and processing is not required before the results can be seen. With video, the quality of the production can be viewed on a monitor while the production is in process and the results replayed immediately. Note that the person using a videodisc for learning is likely to compare the production with broadcast television and the highest standards apply to the production. The same guidelines do not seem to apply to textual CAI, perhaps because the learner usually does not have a basis for comparison.

IMPLEMENTATION

There are several major factors to consider in implementation of an interactive video training system. It is not practical to assume that the technology can be dropped into a school or training facility and perform to the design specifications. Many earlier technologies that promised to revolutionize training are now sitting in storerooms collecting dust. Implementation requires careful planning and preparation. This phase should be given the same care as the design of instruction. Too many instructional and educational technologies have failed to reach their full potential because of poor instructional design and careless implementation planning.

Site Preparation

Many factors must be considered in physical preparation of an interactive video training site. Enough time should be allowed for the ordering and delivery of equipment. Is the equipment available "in stock" or is there the possibility of back order? One missing piece of critically needed equipment will cause the entire learning station to be inoperable. Are there enough stations for the scheduled use, and is there enough space in the room for both the units and traffic flow? What is the room lighting like? Television is usually viewed in a room that would not be good for normal classrooms. If the learners will be using other media such as print material, then there must be sufficient lighting. Will the lighting interfere with viewing the screen? Will the lighting cause reflections on the screen? Screen glare and reflections can be tiring for the learner.

Electrical requirements must also be considered. The amperage for each device is not great, but there may not be sufficient amperage for a number of learning stations. A personal computer may draw 4 amps of electrical current and a 14-inch color monitor 2 amps. The disc player may draw 1 amp and a touch screen an additional amp. In a two-screen display the station may draw as much as 10 amps. Electrical wall outlets usually allow about 15 amps maximum, but local electrical codes may allow 24 wall sockets (12 duplex outlets) on one 15-amp circuit. The station may have five plugs that need sockets, and it is advisable to use a power distribution bar to keep wires from running around the room. With a power bar on a station, which gives one plug for the station, two stations might be plugged into one wall outlet and a fuse may be blown or a circuit breaker tripped. This doesn't even account for the fact that there may be other outlets in the room or adjacent rooms. For any given system, one has to determine the power requirements, the sum of all individual components.

Will there be sufficient space to place all of the components at a station and still leave the learner a place to write and operate a coordinate sensing device such as a mouse? Determine the sizes of all units and their physical arrangement, paying attention to access for use and maintenance and for heat to escape.

There are a number of special cables carrying video, audio, data signals, and electrical power. There are about six different commonly used video and TV connectors, and any given piece of equipment may have only one type. This means that the cables supplied with the equipment, if any, may not be compatible with the equipment on the other end. The same connector compatibility applies to all the other cabling. Also, can the cables be tucked away or will the learners feel they are climbing into an untidy spider's web to work at the station?

Consideration should be given to a specialized desk or carrel that gives the learner a place to work in a comfortable position for typing and writing, a place for all the cables, air flow for the equipment so that overheating does not become a problem, and security for the equipment and controls. It can take considerable time to readjust color, brightness, RGB/line/VTR/TV switches, vertical hold, and contrast controls on a TV monitor; to replace discs; and to reset audio switches on a disc player for a number of units. Are power switches, diskettes, videodiscs, and other equipment accessible?

Is the video screen the right size for the application? A 12- to 14-inch screen is all that is needed if the learner will be only 2 feet from the screen. Larger screens make the learner want to back away. Also consider the noise factors. Will learners be distracted by other noises around the station? With multiple units in one location, earphones may be a necessity.

The final major consideration relates to environmental validity. Will the test site be representative of the eventual use? A first implementation may have unusually well-trained teaching staff, atypical students, and extra personnel. If the technology is being sent to remote locations, will all of the problems at remote sites have been anticipated and corrected? Any substantive interactive video program requires adequately trained support staff.

Teacher Training and Integration

Have all teachers or trainers been involved in the development or is this a solution that they don't see as necessary or practical? Where does the program fit into the curriculum and is the staff prepared to integrate use of the new system with the other learning materials and events? Individualized training with different completion rates can cause problems with scheduling. What do you do with a learner who finishes earlier than planned or needs more time than planned? Will other instructors allow students to miss their class if the student needs more time with the program? Are there "free" periods when the stations can be used?

It is necessary for teachers who will supervise the students to be trained in the content and range of material in the program. Interactive video programs are not as easy to review as a book or film. If a learner has a question, then the teacher should know what actions the program has performed so that additional information can be supplied to the learner. If the program is in the early stage of development or is the only version, then it may be necessary to have trained instructional staff available on demand. Instructional staff should be shown how the program will ease their task or at least provide better learning for the students. If the program causes more problems for the staff than it solves, implementation could be jeopardized.

Management

Management personnel of a school or training facility should be involved in the implementation because any new system will probably cause additional work load or a change in normal operational procedures. Scheduled use and supervision should be planned on a day-to-day basis.

Is someone trained in front-line maintenance and in how to register students and help them get started? Also, any practical system should produce reports on a scheduled or demand basis so the instructional staff can track the learners.

Evaluation

In addition to classroom management information provided by the system, is there a plan for formative and/or summative evaluation and are there procedures for data collection? Will there be time for extra testing of the learner population for pretests, posttests, retention tests, attitude questionnaires, and interviews?

It should be obvious that many factors must be considered in the implementation of a new technology. Careful planning is a necessity.

CASE STUDY: MACHINE LATHE OPERATIONS

The case study described here represents a component of a 2 1/2-year research project conducted at the Ontario Institute for Studies in Education (OISE) with funding of $1.73 million. The major goal of this initial study (1980-1983) was to apply computer technology to reduce delivery and production costs while assisting course designers in producing high-quality validated learning materials. One objective of the project was to produce a videodisc in machine shop training. The other objectives were to establish a complete interactive video production facility, including TV studio and equipment, computer graphics production, a CAN-8 minicomputer-based system, and software to assist production and delivery and to design hardware for an interactive video station—three printed circuit cards and a desk to house the equipment. This author was responsible for the proposal, design, production, and management of the project.

Development

The initial analysis of machine lathe operations was done by two graduate assistants consulting with a shop teacher, the subject matter expert (SME). The teacher's demonstration of the use of a lathe in single-point thread cutting was audiotaped and photographed. The assistants then consulted texts and assembled the analysis and design: a list of prerequisite skills; concepts, rules, and procedures to be learned; and items to be used in measuring the attainment of objectives. This set of materials was reviewed by the SME and revised. One of the assistants then tried the entire process while being talked through by the other, who followed the printed material. Once the material was validated, detailed storyboards were produced and again checked by the SME. All graphics and animations were produced on a high-resolution computer graphics display using CAN-8 software and photographed as 35mm slides or 16mm motion film on a computer-controlled film recorder. Text to be stored on the disc was input and edited on other, less expensive color graphics terminals and converted by the computer to the format required by the TV studio character generator.

CAN-8 CAI computer programs were produced to (1) control the tape and disc players, (2) present textual material, (3) judge student responses, (4) generate problems, (5) collect and record student performance data, (6) administer tests with a sequential decision process, and (7) control the branching while allowing teacher selection and resequencing and learner control.

Video production for the lathe operations occurred at the technical school with one assistant acting as the lathe operator. The video sequences that taught the learner how to use the interactive video station were done at OISE, and the narration was recorded in an audio studio at OISE. Telecine work and video editing was done in the TV studio. The final master tape was assembled and copied to 1/2-inch tape for the interactive videotape stations used initially.

Site Preparation

Electrical wiring was installed into a specially prepared classroom at the school and special desks with locking drawers, cooling fan, and locking plexiglass lids were built and installed. A leased telephone line to the OISE CAN-8 system was installed and a CANNET communications computer was installed in the classroom. Conduits were also installed to carry data cables to the 10 stations. As soon as the site was prepared, the shop teachers were shown the program and then observed while they went through the program in student mode. Final adjustments, taking the teachers' comments into consideration, were made to the computer program.

Field Trials

Schedules were prepared to integrate the course into the various classes. Half of a class used the terminals while the other half did desk work, then, two days later, the two groups switched places. One of the assistants administered the pretests, posttests, attitude questionnaire, and retention test and was available at all times while students were using the stations. Later, the teacher observed the students operating the lathe and rated their performance.

Individual student profiles that summarized the events and routes through the course and class summaries were available from the system and provided to the teachers. Detailed logs of each student's performance were analyzed by CAN-8 programs and these data, along with the other tests, were used by the evaluation specialist. The course was revised and then mastered on videodisc. The disc version was used in a subsequent school year and validated (Olivier 1981; Olivier and Scott 1982, 1983). Also two doctoral theses (Arce 1983; d'Arce 1983) were conducted using the same videodisc with changes to the computer program that applied different instructional strategies. These presentation strategy changes significantly improved retention scores.

Evaluation

The evaluation was conducted to measure usage, reliability, achievement, and attitudes. During the first year, four groups of students (two in grade 10, two in grade 11) at the technical high school completed the program. Following some minor computer program revisions, the second year also included 4 groups, bringing the total number of students to 107. Program completion times averaged about 2 hours, with a range of 65-190 minutes. The equipment proved highly reliable, and no downtime was experienced.

The results of the achievement testing were very positive. Average pretest scores were 41 percent, and posttest scores averaged 92 percent.

After completing the program, students answered a questionnaire about the program and all aspects of its presentation. Ninety-six percent of the students said they would like to use the program again. More than 90 percent of the students described the experience as "fun," "interesting," "understandable," "satisfying," and "useful." The visual quality of both the graphics and the printing on the screen was rated as "good" or "fair."

Since there were only two teachers involved in the evaluation, the collection of teacher attitudes was more informal. The teachers were pleased by the students' reactions and felt that there was great improvement in motivation that carried over to the shop. Both teachers were enthusiastic about the method of instruction and wanted to continue having their students use the system.

Interactive video is a relatively new field. The technology is just beginning to stabilize and a few substantive programs are beginning to appear; although most programs produced to date are for research or internal use. If anyone is considering use of interactive video for training they are likely to have to produce a disc themselves.

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