DOCUMENT RESUME

ED 339 356 IR 015 305

AUTHOR	Martorella, Peter H.
TITLE	Interactive Video and Instruction. What Research Says to the Teacher.
INSTITUTION	National Education Association, Washington, D.C.
REPORT NO	ISBN-0-8106-1083-3
PUB DATE	Jul 89
NOTE	34p.
AVAILABLE FROM	National Education Association Professional Library, P.O. Box 509, West Haven, CT 06516 (Stock No. 1083-3-00, $3.95).
PUB TYPE	Guides - Non-Classroom Use (055) -- Information Analyses (070) -- Reports - Descriptive (141)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Classroom Techniques; *Computer Assisted Instruction; Computer Simulation; Computer Software; Elementary Secondary Education; Futures (of Society); Instructional Effectiveness; Instructional Systems; *Interactive Video; Microcomputers; Systems Development; Videodisks; Videotape Recordings

ABSTRACT

This state-of-the-art report on interactive video and instruction begins with a brief review of the current status of technology and technology transfer in schools. The nature of interactive video is then considered, including instructional applications of the technology and the components of an interactive video instructional system. Discussion of interactive video systems in the classroom provides a holistic view of computers and imagery in instruction together with a summary of implementation issues related to six components of such a system, i.e., video monitors, computers, software, interface devices or cables, videodisc or videotape data, and videodisc or videotape players. Five examples of classroom applications are then described: (1) Laser Learning Reading Program for teaching middle grade students reading comprehension; (2) Target Interactive Project (TIP), alcohol and drug education; (3) Project CENT, consumer education; (4) the National Gallery of Art Program; and (5) Project Interact, which is designed to help teachers transfer interactive technology into classrooms across all subjects and grades. The effectiveness of interactive video systems is then explored in the context of research on computer-based instruction and research on interactive video, and an agenda for future interactive video research is proposed. A look at some current and future developments in videodisc and interactive video technologies and their role in the school of the future concludes the report. (74 references) (DB)

What Research Says to the Teacher

Interactive Video and Instruction

A National Education Association Publication

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Interactive Video and Instruction

by Peter H. Martorella

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National Education Association
Washington, D.C.

Printing History
First Printing: July 1989

Note

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Library of Congress Cataloging-in-Publication Data

Martorella, Peter H.
Interactive video and instruction / by Peter H. Martorella.
p. cm. — (What research says to the teacher)
Bibliography: p.
ISBN 0-8106-1083-3
1. Interactive video—United States. I. Title. II. Series.
LB1028.75.M37 1989
371.3'34—dc20 89-33869
CIP

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INTRODUCTION

Among the many challenges that face American public schools as they approach the twenty-first century is how to effectively and creatively harness modern technology to significant instructional ends. The average citizen now takes for granted on-line searches of gigantic information bases, instantaneous video and facsimile transmissions over hundreds of thousands of miles, and personal computers of all stripes.

To be sure, microcomputers—the nation's most visible symbol of high technology at work in daily life—are a permanent fixture in U.S. schools, much like television sets. With exceptions, however, their full potential impact on the array of required subjects and topics in the curriculum has yet to be realized. Beyond programming, word processing, data base management, and calculation applications, newer technologies have yet to emerge as a significant instrument of curricular change in classrooms.

Further, the schools are now in danger of experiencing a cultural lag with respect to the technologies that they do employ and demonstrate. As microelectronic innovation swiftly outpaces increases in instructional resources, both the hardware and software for microcomputers that schools offer students continue to fall behind what is available in the commercial and governmental sectors.

TECHNOLOGY TRANSFER IN SCHOOLS

The issue of technology transfer in schools becomes more urgent when we consider how many aspects of our daily lives and of those of people all over the world already have been dramatically transformed by microprocessor-based technologies. Apart from the social, economic, and even political changes such tools have spawned, they have shown the capacity to spark and aid learning in a variety of situations. They have demonstrated this capability with all ages and types of students, while simulating patience, humor, excellent memories, personalized assistance, and immediate feedback on demand.

Their merits notwithstanding, microcomputers have been criticized from an instructional perspective as providing students with arcane, superficial, or trivial subject matter, and as being dull. Whatever the validity of the criticisms, they reflect the state of software development rather than the limitations of the medium. They also underscore an urgent need for software that can more adequately address significant curricular objectives across required subjects (13, 14, 17, 46).*

More traditional imagery-generating technologies, such as television and film, have long been vehicles for classroom instruction, and a wealth of instructional data exists in these formats. Marrying these traditional media forms to newer microprocessor technologies has resulted in videocassette and videodisc recorders/players with increasing levels of sophistication for learning applications (17, 33, 50, 51, 52). Both the quality of the visual image and the capacities of such media for allowing users to manipulate the ways in which the visual messages are analyzed continue to improve. Their presence in homes and schools also is increasing.

THE NATURE OF INTERACTIVE VIDEO

Picture a tenth grade class studying world history. A small group of students is huddled in front of a videodisc player, a computer, and a color monitor. In the player is a disc called *deltalia*, which contains 15,000 frames of text, 20,000 still photographs, and 500 computer graphic maps, charts, and diagrams. These are organized into 53 chapters presenting information on Italy from its origins to today. On the computer screen are instructions for students and a menu of topics relating to Italy, including—

Seas, coasts and islands
History from World War I to the present
Music
Fashion
Present-day industry

As students select a topic from the menu, clear, crisp, videodisc images appear on the color monitor within three seconds, providing visual data on the topic. The data includes aerial photos, maps, and pictures; each image is keyed to a printed text that students can reference. After viewing the data, students are queried on the computer screen concerning what they have seen. Depending upon

*Numbers in parentheses appearing in the text refer to the Bibliography beginning on page 29.

their answers, they may be given a review, moved to a new, related set of videodisc images, or returned to the menu to make a new selection.

Consider also a fifth grade class with the same equipment. This time it is placed in front of an entire class using a videodisc entitled "Mastering Fractions." In addition to traditional mathematical problems and written instructions appearing on the computer screen, students and teacher can access instructional materials on the videodisc. They include images of fractions dancing and then falling in place in the form of an equation. These visual referrents help concretize otherwise highly abstract processes for students.

Applications of Interactive Video

These materials already exist, and are helping to enliven a growing number of classrooms across the United States. The new medium that they represent, *interactive video*, has increasingly gained acceptance in many sectors of society (18, 34, 35, 52, 56, 63).

When the instructional assets of visual media such as videotapes and videodiscs are combined with those of personal computers, an opportunity exists for creating a new hybrid medium in which the whole is greater than the sum of the parts (33, 35, 41, 43, 44, 57). Video data can be accessed and analyzed in the same fashion as symbolic data. Computer software can be used to access video material in the same way that computer-generated graphics or expository texts are used in computer-assisted-instruction. Both computer data and video data can be mixed in instructional programs such as reviews, branching, questioning, tutorials, and simulations.

It also is possible to organize and access video data in nonlinear ways for instruction. In interactive video systems hardware and software allow searching to any spot on a tape or disc before playing begins. In the illustration from *de Italia* given earlier, for example, the system searches for and plays only from the segment of the videodisc that relates to "Fashion," if students select that category from the menu. Messages also may be placed over the video material to pose a question or call attention to a special aspect. These "graphic overlays" allow the instructor to stimulate thinking or emphasize a point.

Interactive video already is widely used by the military and industry for individual employee training (63). It also may be used effectively for presenting information to large groups of people (48).

For example, in commercial applications a store may install an interactive video system with a touch screen near an entrance to inform customers about products.

Interactive video has been used less extensively in elementary, secondary, and postsecondary education, but such applications are growing. They include social studies, special education, science, mathematics, art, reading, guidance, vocational education, and teacher education (7, 12, 39, 45, 46, 52, 56, 63, 64, 66). The Educational Testing Service has made a major commitment to use interactive video systems as part of the national standardized testing program for teachers. One dimension of the test will include simulated classroom vignettes, which testees will view and then be queried about.

Components of an Interactive Video Instructional System

Interactive video systems may be either tape- or disc-based (8, 34, 36, 57, 61). Apart from an emphasis on user control of the sequencing of video data (interactivity), there appears to be no conventionally agreed-upon definition of interactive video (63). Since the spotlight of our discussion is *classroom applications*, where the focus is upon materials designed by an instructor to achieve certain curricular objectives, we will consider a basic interactive video system to have the following components:

- One or more video monitors
- A computer that can communicate with the videodisc or videotape player
- Software that enables an instructor or students to provide directions to the computer and the player
- An interface device or a cable that enables the computer and the video player to communicate with each other
- Videodisc or videotape data
- A videodisc or videotape player.

These six components comprise an interactive video system that provides the opportunity for user interaction with a videodisc or videotape player. They also include the necessary elements for systematically designing instruction correlated to classroom objectives.

INTERACTIVE VIDEO SYSTEMS IN THE CLASSROOM

How do interactive video systems operate in classroom settings? As individual schools and school systems acquire increasing numbers of computers and videotape and videodisc players, the opportunity exists for developing interactive video applications across all subjects and grade levels (7, 43, 52, 62, 69). This section explores the rationale and mechanics of implementing systems, and points to some illustrative applications.

A Holistic View of Computers and Imagery in Instruction

Apart from the criticisms of existing computer software discussed earlier. a serious problem with much of the current generation of computer-based instruction is the limited quality and scope of the imagery it can represent (46, 72). As a corollary, it lacks the capacity to simulate realistic environments involving concrete referrents.

The powerful effects of imagery on learning have long been recognized by both educators and lay audiences (10, 74). White (46) has asserted that "Imagery is the language of the information age" (p. 2). Among others, Bruner (10), for example, has pointed to children's dependence on imagery representations of information for learning during certain developmental stages. He notes that they pass from a stage of dependence upon enactive (hands-on) modes of learning, to dependence on imagery modes, to reliance upon symbolic forms.

In contrast to conventional computer-based instruction, interactive video systems, with their high levels of imagery and their opportunities for realistic simulations, permit a holistic type of computer-based instruction. More fully exploiting the potential power of both the computer and the laser videodisc player, they offer a far richer learning environment than conventional instruction (2. 43, 70). In addition, through the use of videodiscs and videotapes with simulation software, interactive video systems can create in the classroom an approximation of a real hands-on experience, a sense of enacting an event.

Creating Interactive Video Systems

Full discussions of the mechanics of creating an interactive video system are available from several sources (24, 36, 60, 61, 67). The following pages briefly summarize some of the salient implementation issues related to the six components of an interactive video system that were outlined earlier.

Video Monitors

Systems may use a single monitor and alternate between screens of computer instructions and video data. More common are systems that use a separate monitor for each type of data (60). Typically, this involves a monochrome monitor for computer output and a color monitor for video player output.

Computers

While videotape or videodisc players can be manually controlled to sequence instruction, a computer is necessary to provide the full potential of interactivity. The computer allows both learner and instructor to control the direction of instruction, raise and respond to questions, and alternate among various media. Moreover, it permits individualized instruction.

Several computers can be adapted for use in an interactive video system. The most frequently used, however, are IBM, Apple IIe, and Macintosh (60). Much of the software that is available to allow the computer and the video player to communicate has been developed for these three systems.

Software

Interactive video instruction requires software that enables an instructor or students to provide directions to the computer and the player. Such software allows the instructor to author lessons that draw on the capabilities of both the computer and the video player. An earlier generation of software required a trade-off of ease-of-use for sophistication in applications. That is, generally the easier a piece of software was to learn to use, the more limited were its instructional options.

In turn, software that permitted such things as multiple branching, touch screens, graphics, scoring of student responses, and various forms of feedback typically was complicated to learn, often requiring special training. Software also was specific to a particular type or model of computer, and prices varied according to the sophistication levels of the software. Examples at both extremes are Laser Write for the Apple IIe computer system, which requires no programming experience and sells for under $100, and Learning System/1 for the IBM, which requires special training, and sells for over $5,000 (1, 60).

Macintosh's newest software innovation, HyperCard and related HyperStack software, shows promise of revolutionizing the process of authoring instruction for interactive video (1, 26). These new types of authoring tools are free (public domain availability through Apple Inc. or user groups) or relatively inexpensive (approximately $100). They alter computer programming and greatly simplify it. Commands are easily mastered and sets of instructions, images, and drawings from one program are easily copied into another. For example, a set of commands to operate a video player can be copied from one instructional module to another. All this is accomplished without sacrificing sophisticated instructional applications.

The HyperCard environment offers several advantages for developing interactive video instruction based upon the general philosophy outlined above. It is relatively easy to comprehend with little or no computer or programming training. Unlike most computer environments, it simulates the way in which an individual's cognitive structure operates when questioning or problem solving. It also allows for easy copying of sets of information from one place to another, and the easy use and comparison of multimedia.

Not insignificant is the fact that HyperCard software applications are inexpensive. HyperCard itself is bundled with new Macintosh sales, and stacks that make interactive video applications possible are provided by Apple without charge or are marketed commercially for prices of $10 and up. User groups often make HyperCard stacks available at cost. HyperCard-based interactive video software also is available at moderate costs (approximately $100) through companies such as the Voyager Company (1351 Pacific Coast Highway, Santa Monica, CA 90401), or through user groups.

While instructors need not construct their own programs from scratch, since they may use the "skeletons" of former programs or "scripts," mastery of a few basic commands is necessary to use the HyperCard Videodisc Toolkit. The three shown in Figure 1, along with a sample program in HyperTalk, the language of HyperCard, cover the fundamentals that are needed to operate a basic interactive video system.

• blankVideo

Turns off the picture on the video monitor for the next playVideo, searchVideo, or stepVideo command

```
on mouseUp
   blankVideo—turn off the video image while going to the start frame
   playVideo 1000, 1500—play the videodisc from frame 1000 to frame 1500
end mouseUp
```

• controlVideo <keyword1, keyword2, . . .>

Controls one or more functions of the videodisc player. The parameter list is arbitrarily large, and consists of a series of keywords. The following keywords are recognized:

init or reset	Stop and reset the player.
eject or reject	Eject the disc from the player (some players merely spin down the disc and do not actually eject it).
stereoOn	Turn on both audio channels.
audio1On	Turn on audio channel 1 only.
audio2On	Turn on audio channel 2 only.
audioOff	Turn off both audio channels.
pictureOn	Turn on the video output.
pictureOff	Turn off the video output.
frameOn	Turn on the display of frame numbers.
frameOff	Turn off the display of frame numbers.
modemPort	Use the modem port to communicate with the player.
printerPort	Use the printer port to communicate with the player. NOTE: *LocalTalk networks, E-Mail packages, DCEVS, INITs and other software which initialize the printer port at boot time will not always give up control of it without removing the software from the startup disk and rebooting the computer. Therefore simply plugging in cables to control the videodisc player and sending a* controlVideo printerPort *command may not allow control of the player through that port. It is usually easiest to use the modem port.*
port <n>	Use port number n—1 is the modem port, 2 is the printer port.
baud <n>	Use baud rate n. The baud rate can currently be 600, 1200, 1800, 2400, 3600, 4800, 7200, 9600, 19,200, or 57,600.

defaultComm	Set the default communications parameters for this player, including baud rate, data bits, stop bits, and parity.
frameMode	Subsequent playVideo and searchVideo commands use frame number rather than chapter numbers. NOTE: *This is the default mode, and the global variable videoMode is empty while* frameMode is chosen.
chapterMode	Subsequent playVideo and searchVideo commands use chapter numbers rather than frame numbers.

```
on mouseUp
   controlVideo pictureOn, frameOn, stereoOn, chapterMode
   —show the image on the video monitor, display frame numbers, turn on both
   —audio channels, and search and play by chapter number (rather than frame)
end mouseUp
```

• playVideo <first, last>

Plays the videodisc from the first frame specified to the last frame specified.

If first is left off or is "here," play begins wherever the player is when command is issued (i.e., no search is done first) until the specified last frame.

The last frame of the disc can be specified by "last." If the second argument is left off, "last" is assumed. If last is less than first the sequence is played in reverse. If last is 0, 1 or "last frame," continuous play (forward or backward) through the videodisc is assumed.

If a blankVideo command was issued since the last playVideo, searchVideo, or stepVideo command, the picture will be turned off while searching to the first frame. If n videoFramesPerSecond command was issued since the last playVideo command, the speed specified in the videoFramesPerSecond command will be used.

```
on openCard
   playVideo 1500, 2500—when the user arrives at this card
   —(when the openCard message is sent) play the videodisc starting
   —at frame 1500 and stop play at frame 2500
end openCard
```

Figure 1
Sample Videodisc Controller in HyperCard Videodisc Toolkit

The Voyager VideoStack, sold by the Voyager Company, is a piece of software that is similar to the Toolkit. It further simplifies some aspects of the process of constructing interactive video lessons by asking the instructor to provide information related to a video segment. For example, in Figure 2 an instructor "makes an event," a script to play a video segment, by indicating choices. In this case the choices are to (a) have a motion rather than a still sequence; (b) begin at frame 440 and end at 850; (c) play audio track 1 but not 2; and (d) enter the beginning and ending points of the video segment manually, rather than playing the disc to locate the desired start/stop.

Event Maker automatically summarizes the list of commands, as shown in Figure 2. Once the instructor creates an event, he/she can click on the rectangle in Figure 2 that reads "Make a button that does this command." This permits the creation of a button that represents directions, or a program that has been written invisibly for the instructor, to carry out the operations on the Event Maker card.

The button then can be shaped in a variety of ways, given any name, and moved or copied anywhere in a program of instruction that incorporates the video segment prescribed on Event Maker. VideoStack also provides a number of predesigned buttons, such as those shown in Figure 3, that may be copied onto cards. When copied, these buttons will carry out the operations specified; for example, the button "Play Fwd," wherever it is copied in a program, will send directions to the player to begin playing forward anytime the button is clicked.

VideoStack also permits overlay messages to be inserted on the video monitor screen with the use of certain disc players. In addition, it has a "slide-tray" feature that allows the instructor to sequence still frames into a list with descriptions and then play them back manually or automatically, much like an annotated slide presentation.

Interface Devices or Cables

The simplest connection between a computer and a video player is a single cable that attaches to the rear of both units. This carries the necessary communications to alternate designated video- and computer-generated information. Cables that carry the video and audio output from the video player also are required. If the computer system does not contain a built-in monitor, cabling is necessary for the computer monitor.

A relatively simple installation of an interactive video system, using a Macintosh computer and two monitors, is shown in Figure 4. (*Note*: The Macintosh computer has a built-in monitor.) More

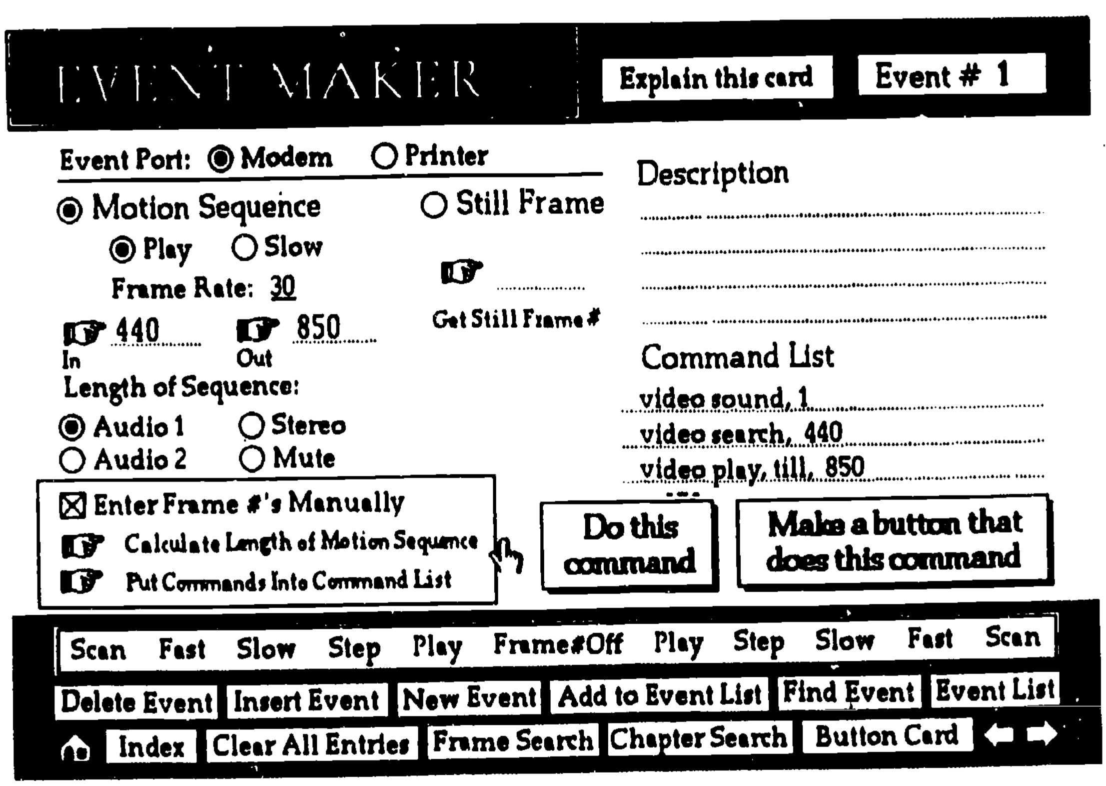

Figure 2
Event Maker Card
(Voyager Videostack)

Figure 3
Predesigned Buttons Card

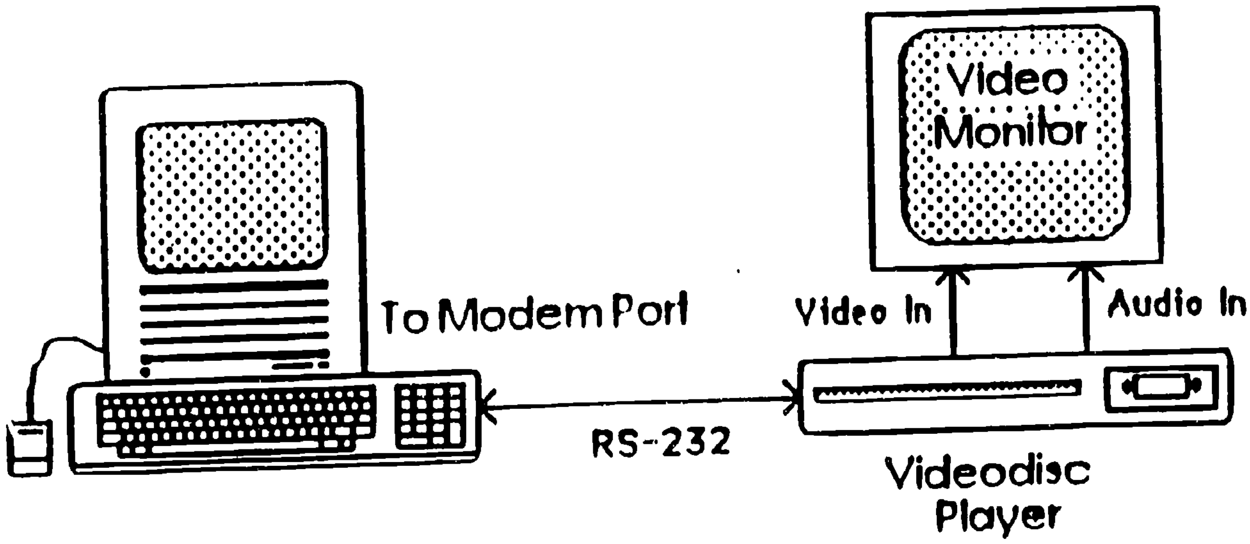

Figure 4
An Interactive Video System

complex installations require some combination of multiple cables, internal installations, separate cards that contain software instructions and must be inserted in the computer, and "black boxes" that interface with both the computer and player (24, 25, 36, 60, 61, 67). Cable and interface devices normally are specific to computer models and even players, and cannot be used interchangeably with different systems.

For certain types of unit, it also may be possible to overlay (place over an image) on the video monitor a message such as, "What is the problem in this situation?" Special interface devices, such as those designed by MicroKey System for insertion in the IBM, permit overlays of graphics or texts on the video monitor (60).

Videodisc or Videotape Data

Both tape and disc formats have relative advantages and disadvantages from the perspective of classroom instruction (11, 23, 24, 25, 56, 68). Videotapes in one-half-inch formats covering many subjects addressed in the school curriculum are readily available. Since the software in tape-based interactive video systems allows for nonlinear presentation of the tape material (i.e., skipping from place to place on the tape), tedious editing of material is not required. Further, tape may be easily revised to refine or update information.

The disadvantages of tape, however, are significant for classroom applications. Accessing tape can be relatively slow, particularly where a long sequence of tape is used. Tape also is subject to expansion and contraction, affecting frame access, and its visual quality is poorer than that of discs.

In contrast, videodiscs have many advantages (18, 37, 51, 54, 70, 73). Their data can be more quickly accessed. For example, typical search times to access a segment are three to eight seconds (51). Also, disc pictures are sharper and freeze frame, reverse, and slow motion sequences are easier to manipulate than with tape. For classroom applications, discs also have the practical advantage of being far more durable with handling than tapes.

Often called laserdiscs because the players use lasers to read them, discs come in two basic formats, each with different instructional implications. Those labeled *CAV* (Constant Angular Velocity) permit precise frame location for selecting and stepping still frames, slow motion. This format allows for 30 minutes of 54,000 frames of information per side. Each frame is numbered and can be addressed by that number.

The second format, *CLV* (Constant Linear Velocity), allows for twice the amount of time per side, 60 minutes. As a trade-off for the increased amount of time, this format does not allow individual frames to be addressed. Searches are by time, and hence, are less precise, although they are satisfactory for many instructional applications. Many more laserdiscs are currently available in the CLV than in the CAV format.

The primary disadvantages of videodiscs relate to the costs and difficulties associated with their production and the fact that once mastered, they cannot be modified. Where existing disc materials can be used, however, the costs relative to tape often are comparable. Prices of commercial videodiscs range from several thousand dollars to no cost for promotional or special educational discs (see, for example, *de Italia,* available from the Giovanni Agnelli Foundation [Via Giacosa 38, Turin, Italy]). Increasingly more discs are being produced that have potential educational applications (71). Such discs may be used in an interactive video system for a different instructional or informational purpose than the author intended. As an example, a videodisc designed to demonstrate exercise techniques could also be used selectively and in a nonlinear way to illustrate certain psychological principles such as reinforcement. This process is referred to as "repurposing" a disc.

It also is possible to create or master an original instructional disc for interactive video applications. The cost of a single master ranges from $300–$2,000, depending upon the quality and quantity of discs desired (60, 63). As the quantity increases, the per unit cost decreases. A master disc may be made from either a one-inch or a three-quarter-inch videotape. All material to be included on the disc must first be transferred to one of these tape formats.

Videodisc or Videotape Players

In addition to identification of laserdiscs by formats, laserdisc players themselves have been classified into four categories—Levels I-IV (52). Each type of player may be classified according to its different capabilities and level of interactivity. Level III players, the type required for the interactive video applications we have been discussing, range in price from $700–$4,500. Major manufacturers include Sony, Pioneer, and Hitachi.

Some videodisc players permit overlays of text material on the video monitor without the use of any special interface device. Such players—for example, the Pioneer LD-V4200 Laserdisc player—have a built-in device that permits a number of lines of text to be superimposed over a video segment or on the video monitor screen.

High-quality, industrial-type, and therefore expensive, videotape players are required to provide the necessary accuracy for accessing the targeted tape segments. They range in price from $900 for a simple play-only unit to several thousand dollars for high-quality professional units. Major manufacturers are Sony and Panasonic.

CLASSROOM APPLICATIONS

Perhaps the easiest way to visualize both potential applications and different types of interactive video systems is to provide some examples. This section briefly considers some summaries or snapshots or both tape and disc systems at various age levels, elementary through postsecondary, across different subject areas, and for students of differing ability levels. The illustrations involve both commercial "off-the-shelf" and instructor-designed materials.

Laser Learning Reading Program

Laser Learning, developed by Hoffman Educational Systems (1720 Flower Avenue, Duarte, CA 91010), is a commercially designed product for teaching middle grade students reading comprehension skills. It requires an Apple II computer system, a Pioneer LD-V2000 disc unit, and a special interface card supplied by Hoffman. Included with the program are software, 18 custom-designed laserdiscs that contain material related to reading instruction, and teacher materials. In addition to reading instruction, the system provides homework assignments and reports on student progress and related letters to parents.

Target Interactive Project (TIP): Alcohol and Drug Education

TIP is a commercially designed system for high school students. It is produced by Target (11724 Plaza Circle, Kansas City, MO 64195), a service organization of the National Federation of State High School Associations. It uses an IBM System/2 Model 30 computer with a sophisticated touch-screen, intelligent monitor, an integrated hardware and software system call InfoWindow, and two Pioneer LD-V6200A disc players.

TIP provides a framework for students to develop decision-making skills related to handling alcohol and other drugs. The system allows students to identify with any one of seven characters and to follow their progress through an evening at a party with no parents present. As the evening evolves, characters face decisions and consequences, and the viewer can choose among options.

Project CENT: Consumer Education

Tape-based interactive video systems generally employ original video data. In some cases, however, developers have obtained permission to use commercially produced tapes. Project CENT (Consumer Education and New Technology, Lafayette School Corporation, Lafayette, IN) directed by Joanne Troutner (67), is built around the rich video data base already developed in the series entitled *Trade-Offs*, a collection of videotapes made available by the Agency for Instructional Television (Box A, 1111 West 17th, Bloomington, IN 47401) for teaching junior high school students basic economic principles related to consumer education. *Trade-Offs* consists of a series of 20-minute tapes that cover such basic economic principles as increasing productivity and personal decision making.

Using this videotape data base, the project constructed a series of lessons that transformed the material into an interactive video system.

This allows students to interact with the material through a series of focused questions and branches to relevant segments of the tape. Troutner and her associates developed their system around an Apple IIe computer, interface components, and authoring software provided by BCD Associates, and a Panasonic videotape player.

National Gallery of Art Program

One of the exceptional applications of videodisc technology was the creation of the *National Gallery of Art* videodisc (Voyager Company, see p. 11). The immense storehouse of riches in the nation's gallery was captured in vivid color suitable for viewing and analysis in ways that would be difficult or impossible in person. Represented in CAV format on laserdiscs, specimens of this outstanding art collection could be presented in separate frames, examined in collections by artists, periods, styles, time periods, or whatever other unit of analysis an instructor wished to organize.

Interactive video affords the additional opportunity to guide the viewer through the analysis with queries, prompts, and opportunities for in-depth annotations related to the art and artists' works viewed. For example, a student viewing both Picasso's cubist and representational works could opt to have an explanation of the context and significance of the works in the evolution of the artist's career. Similarly, the viewer could ask to have the artist's work arranged in chronological order or by type.

Several organizations, including the Voyager Company (see p. 11) and Videodiscovery (P.O. Box 85878, Seattle, WA 98145–1878), have produced interactive video components to complement the *National Gallery of Art* laserdisc. These are designed to be used with a Macintosh, HyperCard software, and a special HyperCard stack that each organization sells. With a single cable, the Macintosh can be linked to one of several disc players in the Pioneer or Sony series. The character of the stacks developed varies somewhat, but essentially they all allow instructors and students to access, analyze, and comment upon the art in different ways through control of the laserdisc and its frames.

Similar specialized stacks have been created for use with scientific discs by the Optical Data Corporation (30 Technology Drive, Warren, NJ 07060). Discs and correlated stacks are available for such sample areas as earth science, life science, and physical science.

Project Interact

At North Carolina State University, Department of Curriculum and Instruction, Project Interact is designed to help teachers transfer interactive video technology into classroom applications across all subject areas and grade levels. It is based on the philosophy that all technological tools should function as extensions of the teacher, rather than vice versa; that these tools need to prove their worth through enhancement of the required curriculum rather than through enrichment; and that the effective use of technologies in instruction should require minimal technical and programming expertise.

For many of the reasons discussed earlier, Project Interact is based on disc applications. Teachers primarily repurpose commercially prepared discs. The reasons for this are economy and efficiency, and because in many aspects the process of repurposing simulates the way in which creative teachers have for centuries repurposed other media for teaching. While teachers are introduced to several computer systems, interface devices, and authoring tools—primarily for purposes of comparison and insights into the strengths and limitations of different interactive video systems—the chief focus is on HyperCard applications with a Macintosh.

In Project Interact teachers are assisted in identifying for repurposing suitable videodisc material for important curricular objectives. No prior computer or laserdisc experience is assumed. Apart from introducing HyperCard applications, including stacks, cards, and buttons, the only authoring tools presented are the special stacks in the HyperCard Videodisc ToolKit provided without charge by Apple and the Voyager VideoStack sold by the Voyager Company.

EFFECTIVENESS OF INTERACTIVE VIDEO SYSTEMS

Since interactive video is a relatively new instructional tool and because it straddles two different technologies, there is not a definitive body of empirically tested generalizations concerning its use (9, 19, 27, 29, 62, 63). Nor has a definitive agenda of research questions concerning its efficacy been established. There is, however, a growing body of research data that undergirds computer applications in instruction. An increasing number of recent individual studies have claimed results supporting the effectiveness of interactive video instruction in some way (8, 12, 20, 21, 22, 28, 32, 39, 42, 45, 47, 58, 59, 64).

Research on Computer-Based Instruction

Studies of computer-based instruction generally report positive findings with respect to achievement gains and attitudes toward the learning process (4, 13, 14, 40). These findings show that this form of instruction typically reduces the amount of time required for learning (13). In comparison with younger learners, middle grade and secondary students appear to benefit more from computer-based education (4, 40). Further, disadvantaged high school students benefit especially from this instruction, more so than do those who are academically talented (4).

Such effects are reported across subjects, but mathematics and reading/language arts were the dominant areas of instruction studied (4, 40). This suggests an important qualification for subjects such as science and social studies, which often employ a great deal of imagery in instruction. Computer-based software for these subjects, even with excellent graphics components, typically is high in symbolic content (46).

The results derived from studies of computer-based instruction, however, cannot be generalized to interactive video. As a related but different medium of instruction, it presents its own agenda of research issues. Whether further research into this area yields results that mimic those found for computer-based instruction remains to be seen (15, 17).

Research on Interactive Video

Two reviews of studies involving interactive video were recently completed. Bosco (6) examined 28 reports of evaluations of the use of interactive video that spanned the period 1980–1985. These involved both formative and summative evaluations and both disc and tape systems. Sample sizes ranged from 5 to 700 and the treatment duration generally was a few days. Bosco's analysis provides a useful profile of each of the studies but draws no firm conclusions about the efficacy of interactive video as a medium of instruction.

In his review of the studies of interactive video, Smith (63) concluded that procedures and guidelines for the development of interactive video instruction do exist, but that for the most part they were untested. Like Bosco, he drew no firm conclusions about the medium's efficacy in promoting learning.

Using a different approach, Hannafin (27) extrapolated a series of empirically based findings from areas of information processing and presentation technologies research. He examined relevant research related to orientation, presentation, sequencing, encoding, and retrieval strategies. He then suggested this set of research findings from related areas might be generalized to the instructional applications of interactive video.

One of the interesting research questions related to the use of interactive video concerns the issue of time. One question addresses the relative effects of access times of videodisc compared to those of videotape systems. Conventional wisdom suggests that faster access times provide for more effective learning (27). In sum, faster is better. A recent study by Schaffer (58) challenges this assumption, however. Using five treatment groups and simulating different access time rates for different groups of users, he found no significant differences between learning, acquisition rate, or attitude scores for different access times.

A second time issue concerns whether interactive video instruction takes more or less time than competing forms to achieve common objectives. Carlson and Falk (12) tested this proposition in a study involving elementary pre-service teachers. They found that a deductive videodisc treatment group finished in less than half the time required by students in the alternative conditions. The instructional treatments consisted of materials designed to teach students about cooperative goal structures. Carlson and Falk also found that students who used videodisc treatments scored significantly higher in information acquisition related to cooperative learning than did students in a reading/lecture/discussion group.

However, Schaffer and Hannafin (59) found that, while interactive video instruction produced greater learning than two alternative video instructional treatments, it also took more time. Their study involved high school students; the information taught dealt with television graphic special effects.

In addition to time, another important issue related to interactive video is the extent to which variations in levels of control affect learning. Hannafin and Colamaio (28) investigated the comparative effects of linear control, learner control, and designer control in a set of materials assigned to teach basic principles of cardiopulmonary resuscitation (CPR). The linear control was a traditional linear video presentation: the other two treatments were interactive video under the control of the designer or the student.

In the instructor control treatment, all branching to video segments was predetermined by the designer and was done in response to student answers. In contrast, the learner control treatment allowed the student to determine all choices at the same points that the designers had made their decisions in the alternate treatment. Both the learner and designer control groups performed better than the linear control group. No significant differences were found between the two interactive video treatments, however. The study also found that factual, procedural, and problem-solving questions embedded in the three sets of treatments had a significant effect on learning factual and problem-solving material.

In a study that compared the effects of two different interactive video instructional strategies and a conventional linear videotape unit on ninth graders' learning of economic principles, Dalton and Hannafin (22) reported mixed results. On a recall subtest there were no significant differences among the three treatments. On an application subtest, however, students who received the context strategy, an interactive video unit that used application examples rather than mere factual information, did significantly better than students in the other two groups.

An Agenda for Future Interactive Video Research

As Hannafin (27) has noted, the absence of clear, operational definitions of interactive video has probably retarded the development of a cumulative body of research. The lack of a common, specific referrent in studies often makes comparisons and syntheses difficult (9, 20, 55). Hannafin (27) has observed, that "a variety of levels of interactivity are available, ranging form learner-directed sequencing of instruction, to essentially linear video, to fully interactive response-dependent instruction featuring embedded questions, response feedback, conditional branching with the lesson" (p. 236).

Thus, a starting point for a research agenda is a call for more precision in specifying the variety and degree of interactivity. Hannafin (27) has also provided a useful framework for a serious research agenda; he suggests 12 propositions that lend themselves to empirical investigation. Among these are issues such as the following:

1. How interactive video compares in effectiveness to alternate forms of instruction
2. Under which conditions interactive video proves to be most effective; e.g., whether the inclusion of embedded questions, advance organizers, and other orienting strategies improves comprehension or recall and which types of questions are most effective
3. For which range of learners, topics, and subject area interactive video is most effective
4. How interactive video instruction affects student attitudes toward a variety of objects such as the subject matter being taught, learning, and the technology.

Seal-Wanner (62) has suggested some additional related issues for the research agenda: How progressively more interactive video instruction and greater and richer interactive environments affect learning yields, and whether mastering an interactive video environment encourages students to take a more active part in their own education.

FUTURE DEVELOPMENTS

We are entering an era in which the lines between elements of technology are becoming blurred. Integrated sound, still and motion images of all types, and computer-generated graphics with touch-screen and mouse-activated interface devices—all regulated by microcomputers of increasing capabilities and speed—loom on the horizon (65).

Technologies of the Future

Where computers with 16k memories were considered acceptable for many software applications only a few years ago, one-megabyte machines are now recommended for many basic operations. Both the memory and storage capacity of computers continues to grow, even as they shrink in size. High capacity hard drives now are relatively inexpensive and readily available for all major computers, even laptop versions.

CD-ROM (Compact Disc-Read Only Memory) units that permit the storage of entire libraries on a few discs are now a reality; their applications are growing and finding their way into schools. We are rapidly approaching the point where such units will be standardized, will easily access and serve as storage devices for a mixture of media and computer data (5). Several exciting applications of this technology to the storage of multimedia material and computer programs are already a reality. For example, now available in CD-ROM are *Grolier's Encyclopedia, Books in Print, Dissertation Abstracts, ERIC, Reader's Guide to Periodic Literature.* Phillips/Polygram (The Record Group) also has developed a program called *The Time Machine* that includes geopolitical maps of the world over time. Similarly, XIPHAS has developed *Time Table of History: Science and Invention*, a collection of key events in the history of science and technology. *Bookshelf* by Microsoft provides 10 major reference works on a single CD-ROM disc.

Videodisc units that can *record*, as well as play video data, will increase in use as the technology develops and costs per unit drop (69). This new generation of player/recorder systems will also store computer digital data, permitting computer functions and graphics to be read from the videodisc. Once disc recording techniques approximate the ease and cost of current tape-based technologies, the advantages of discs cited earlier are likely to make them the dominant medium for interactive video. Gradually, too, technological advances will be easier for teachers to apply and incorporate into their instruction. The ubiquitous telephone will become the standard of technological "user friendliness" that newer computer-based tools emulate.

Interactive video that can incorporate all the developing technologies will be increasingly used in many sectors of our lives, from shopping to job training to preparation of military personnel, and in classrooms. It is also likely to be a major part of our leisure-time activities. For example, arcade games such as *Dragon's Lair* add interesting features to simulations that traditional linear activities lack. Plays and films, as well as games, can have multiple options for endings or scenes.

Along the lines of the Education Testing Service's future plans for using interactive video to test prospective teachers, mentioned earlier, other organizations are also likely to find it a useful tool for screening employees. Interactive-video-based tests more realistically simulate both the conditions being tested and the testee's preferred response. Such forms of testing also reduce the respondent's verbal burden in cases where it is more important for an employee to be able to identify or model correct behavior than to verbalize it.

CONCLUSION

What role will interactive video play in the schools of the twenty-first century? At the outset we underscored the challenge that faced U.S. schools with respect to technology transfer. The nub of the issue is to reduce the increasing lag that exists between technological innovations that are available in the governmental and commercial sectors and the application of these cutting-edge tools to instructional ends in schools.

The generation of teachers now entering our schools entered adolescence in the midst of the video explosion and emerged into the microcomputer revolution. These teachers have spanned the explosion of two technologies that have transformed in significant and enduring ways the means by which information is constructed and shared throughout the world. In their worlds outside the schools they interact comfortably and frequently with these twin technologies.

To incorporate these tools, through interactive video, into their classroom activities as an extension of their lesson planning they require both pre-service and in-service training programs, developmental support, successful curricular models, and equipment resources. All the signs from research and other reports suggest that these elements are increasingly emerging in schools and educational centers across the country.

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