DOCUMENT RESUME

ED 311 887 IR 014 011

AUTHOR	Ullmer, Eldon J.
TITLE	Videodisc Technology.
INSTITUTION	National Library of Medicine (DHHS/NIH), Bethesda, Md.
REPORT NO	LHNCBC-89-1
PUB DATE	Jan 89
NOTE	26p.; LISTER HILL Monograph.
PUB TYPE	Information Analyses (070) -- Book/Product Reviews (072)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Allied Health Occupations Education; Authoring Aids (Programing); *Computer System Design; *Interactive Video; *Media Selection; Medical Education; *Optical Disks

ABSTRACT

Developed as a service to the health sciences community, this monograph is intended as an introduction to interactive videodisk technology. It describes both videodisk and compact disk technologies and different videodisk player formats, and discusses some of the major factors that educators considering videodisk adoption should consider. The first chapter introduces videodisk technology and describes its various formats, including electrical capacitance videodisks, optical laser videodisks, videodisk display and interactive features, audio and interactive videodisks, and recordable videodisk technology. The second chapter describes compact disk systems, including compact disk-digital audio (CA-DA), compact disk-video (CD-V), compact disk-read only memory (CD-ROM), compact-disk interactive (CD-I), digital video interactive (DVI), and recordable (WORM) and erasable compact disks (still under development). The third chapter outlines videodisk system selection factors and includes information on choosing a technology format, comparing production processes, authoring tools, and integrated interactive videodisk systems. The final chapter briefly reviews the application of videodisk technology in the health professions. Six appendixes provide lists of selected information sources on videodisk technology, including associations, videodisk and general educational technology periodicals, books, industry guides, and training resource organizations. (14 references) (GL)

Videodisc Technology

The Learning Center For Interactive Technology

Lister Hill National Center for Biomedical Communications

Educational Technology Branch

U.S. DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service • National Institutes of Health

National Library of Medicine

LISTER HILL Monograph
LHNCBC 89-1

VIDEODISC TECHNOLOGY

by
Eldon J. Ullmer, Ph.D.
Educational Technology Branch
Lister Hill National Center for Biomedical Communications
National Library of Medicine
Bethesda, MD 20894

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
National Institutes of Health
National Library of Medicine

January 1989

Ullmer, Eldon J.
Videodisc technology / by Eldon J.
Ullmer. -- Bethesda, MD : U.S. Dept. of
Health and Human Services, Public Health
Service, National Institutes of Health,
National Library of Medicine, [1989]
-- (Lister Hill monograph ; LHNCBC 89-1)

"January 1989."
Bibliography: leaf [20].

1. Video Recording - methods I. Title
II. Series

02NLM: TK 6685 U41v

Organization References and Acknowledgements

Computer and interactive video product development is a widespread enterprise in which many commercial firms are engaged. Some of these firms and some product names are mentioned in this monograph, many others, obviously, are not. The use of a firm or product name does not in any way constitute an endorsement of that firm or product.

Also, many product names are registered trademarks of individual firms while many other terms are simply generally accepted nomenclature in the field. The following list is provided to acknowledge terms known or thought to be trademarks held by particular firms.

Apple is a trademark of Apple Computer, Inc.

CDS Genesis is a trademark of Interactive Technologies Corporation

IBM, IBM InfoWindow System, Personal Computer AT, Personal Computer XT, and Personal System/2 are trademarks of International Business Machines, Inc.

IconAuthor is a trademark of Aimtech Corporation

IV-D is a trademark of Computer Sciences Corporation

LaserFilm is a trademark of McDonnell Douglas Electronics Company

LaserWrite is a trademark of Optical Data Corporation

MS-DOS is a trademark of Microsoft Corporation

OASYS is a trademark of Online Computer Systems

QUEST is a trademark of Allen Communication

Sony and Sony VIEW System are trademarks of Sony Corporation

Foreword

In keeping with a long-standing commitment of the Lister Hill National Center for Biomedical Communications at the National Library of Medicine to develop and support innovative methods for training health care professionals, the Educational Technology Branch conducts research and development in applying computer, audiovisual and multimedia technologies to health professions education. Much of this research and development has focused on interactive educational technology—the delivery of medical education through the combined use of microcomputer technology and videodisc-based images.

The Learning Center for Interactive Technology (TLC) is maintained by the Educational Technology Branch as a "hands-on" laboratory where visiting medical educators and scientists can explore the potential of interactive technology for improving medical education. TLC staff provide tutorials in setting-up and using various hardware systems and in the instructional design alternatives for developing interactive courseware. Our hope is to capture the essence of these tutorials in this series of TLC monographs and thereby create a set of practical handbooks which will guide the reader into the new world of interactive educational technology.

Michael J. Ackerman, Ph.D.
Chief, Educational Technology Branch

Preface

Publications about applying technology to professional education, and to higher education generally, are plentiful. And technological devices suitable for instructional use are everywhere available. Still, lasting innovations in technology-based teaching remain relatively uncommon.

Historically, one reason for this incongruity may be that educators and educational technologists too readily assumed that simply putting new communication media to use would largely solve teaching problems in any discipline or setting. We now know better.

The instructional technologies that now command our attention—mainly microcomputers and interactive video systems—are at once more complex and more powerful than earlier media forms. Their successful use will require extensive technical knowledge, rigorous attention to the principles of instructional design, careful planning and, perhaps, a bit of luck.

This monograph was developed as a service to the health sciences community and is intended as an introduction to interactive videodisc technology. Thus it was written to provide a brief overview rather than a detailed analysis of the field. It is offered with the hope that it will promote interest in applying interactive technology to health professions education and with the expectation that it will be followed by other publications that address specific problems in that undertaking.

Contents

	Page
Introduction	1
I. Videodisc Technology and Formats	3
II. Compact Disc Systems	9
III. Videodisc System Selection Factors	13
IV. Videodisc Use: A Brief Look	17
Appendix	19

Introduction

After Scottish inventor John Logie Baird successfully demonstrated television image transmission using a mechanical scanning disk in 1926, and subsequently devised a means for recording TV signals on a concentric track disk, nearly a half-century would pass before the technological, manufacturing, and marketing developments necessary to make the videodisc a viable instrument for storing, retrieving and dispensing audio and visual information would materialize. Since 1980, however, enthusiasm for videodisc systems has grown immensely among educators and other information management professionals. Indeed, Peter Howsie (1987) recently observed: "A person making a survey of the literature about interactive videodisc could easily conclude that a revolution in education and training had taken place" (p. 5).

Revolutions in education and training are rare, and cautious observers note that there is little credible evidence to justify the cost of widespread videodisc adoption. Hannafin (1985) has suggested that "the compelling face validity of interactive video appears to have preempted the developmental research needed to validate empirically the instructional effectiveness of the technology" (p. 235). But such research is being done, and the volume will no doubt increase as videodisc use increases. And, clearly the videodisc is making significant inroads in some settings. For example, Howsie (1987) reports that it "has been elected by the US military as its future training delivery medium" (p. 5).

Why does the videodisc exhibit for so many what Hannafin calls "compelling face validity?" It appears to be a combination of factors: the basic technological process that the machine represents, the precision engineering it embodies, its enormous information storage capacity, its rapid information access capabilities, its quality sound and video reproduction capability, and its interactive features combine to make the videodisc an intriguing device. But interest has progressed far beyond mere fascination with the machine. The videodisc's potential as a means for storing and managing information, for facilitating the design and delivery of instruction, for conducting research to compare alternate instructional strategies, and for introducing lasting innovations in reaching has caught the imagination of many professional educators.

This increasing interest in the videodisc and its potential has underscored the need for publications that identify the members of this new media "family," explain the underlying technology, and provide the definitions necessary to clarify the differences between *optical* and *electronic* videodisc systems, between *contact* and *non-contact* systems, between *reflective* and *transmissive* discs, between *consumer* and *industrial* machines, between "intelligent" and "dumb" systems, and between the various "levels" of interaction that different videodisc systems afford.

Moreover, the technology has not stood still. Advances in digital technology have resulted in a new family of "compact disc" (CD) machines that, in a few years, has grown to include: *compact disc-digital audio* (CD-DA), *compact disc-read only memory* (CD-ROM), *compact disc-video* (CD-V), *compact disc-interactive* (CD-I), and *digital video interactive* (DVI). And other systems are on the way.

Understanding these new technologies, making wise purchasing decisions, learning how to use interactive video effectively and documenting effective use through rigorous research are problems that now confront educators who seek to improve instruction through technology. A comprehensive treatment of all these problems is beyond the scope of this report. Thus several major concerns—instructional design principles and techniques, instructional delivery management and videodisc research, among others—will be treated in other publications. The purposes of this report are to describe in general terms both videodisc and compact disc technologies, to explain the different videodisc player formats, and to discuss some of the major factors that educators contemplating videodisc adoption should consider.

OPTICAL DISC DEVELOPMENT CHRONOLOGY

1926	In England, J.L. Baird demonstrates a mechanical scanning system for video image transmission. BBC initiates experimental broadcasts to be received by Baird "Televisors."
1930s	Baird's "Phonovision" disk enables broadcast of electronically reproduced video images.
1956	Introduction of videotape technology.
1958	D.P. Gregg develops idea of recording audiovisual information on a plastic disk as a series of pits to be read by optical means and coins the term "videodisk."
1961	3M and Stanford Research Institute (SRI) launch joint research program.
1962	SRI team demonstrates photographic film based videodisc.
1963	3M team demonstrates electron beam recording videodisc.
1970s	MCA, Philips and Thomson-CSF pursue independent videodisc development programs.
1980	LaserVision format videodisc introduced.
1982	Audio compact disc introduced by Philips/Sony.
1983	Panasonic introduces Optical Memory Disc Recorder, an analog video, digital audio, "write-once" system.
1984	Optical Disc Corporation introduces the Recordable Laser Videodisc, first LaserVision compatible recordable unit.
1985	Compact-Disc, Read Only Memory (CD-ROM) introduced.
1986	McDonnell Douglas introduces LaserFilm optical reflective, photographic process player.
1986	Teac introduces "write once" Optical Videodisc Recorder.
1986	Philips and Sony announce Compact Disc-Interactive (CD-I) specification.
1987	General Electric introduces Digital Video Interactive (DVI acquired from RCA, then sold to Intel Corporation).
1988	Erasable CD drives demonstrated at trade shows.

Figure 1.

I. Videodisc Technology and Formats

After Baird's attempt to market his primitive videodisc system in England during the 1920s failed, little significant developmental work was done until after 1956 when the first successful videotape technology was introduced. According to Jarvis (1988, p. 15), D. Paul Gregg, an engineer who worked for both Ampex and Westrex in the late 1950s, deserves the major credit for inventing the laser videodisc and for first using the term "videodisk" in 1958. Gregg, Jarvis explains, was able to develop an optical means of recording motion images and sound on a disc by combining the concept of FM video recording, used in Ampex videotape machines, with the stereo record/playback system developed at Westrex. Gregg subsequently joined the 3M company which, in association with the Stanford Research Institute (now SRI International), launched a sustained research program in the early 1960s (see Rice and Dubbe, 1982). By the early 1970s, N. V. Philips, Thomson-CSF, and MCA each had developed systems that employed laser light sources to record and play videodiscs (p. 283). When videodisc systems eventually became available commercially in the late 1970s, four different system formats based on two fundamentally different technological designs appeared.

The two distinctive technological approaches were called *optical laser* (or optical) and *electrical capacitance* systems. Both employ the same basic principle to store information; etching millions of tiny computer-produced indentations (called pits) onto the surface of a master disc in a continuous, spiral sequence (Mann, 1981). The configuration of this sequence corresponds to the original FM (frequency modulation) signal which represents the recorded program. The difference between the two technologies lies in the way the discs are recorded and read for playback.

Electrical Capacitance Videodiscs

Two electrical capacitance videodisc formats were developed, but one—the capacitance electronic disc (CED) that was developed by RCA—has already disappeared from the market. Like the common phonograph, it employed a grooved disc and a stylus. Unlike the phonograph, however, the disc, while spinning at 450 rpm, was flooded with electricity and, as the stylus rode over the pits in the disc's groove, variations in the electric current enabled reconstruction of the FM signal needed to reproduce a program. This mode of play prohibited random-access and other multispeed functions and so the CED system's abandonment is not altogether surprising. It was, in any case, intended mainly for the consumer market.

The second electrical capacitance videodisc system is known as the video high density (VHD) format. It is marketed in Japan and Europe by JVC, but is no longer sold in the U.S. It is also known as grooveless capacitance because the disc is not grooved. Playback involves a mechanical stylus which, instead of riding in a groove, is guided over the disc's surface by a signal that is distinct from the program signal. This technique is sometimes referred to as "electro-tracking." The VHD format employs a 10.2 inch diameter disc which rotates at 900 rpm during play. It provides one hour of uninterrupted play or 108,000 still frames per side, and offers random access, freeze-frame, slow motion and fast scan functions.

Optical Laser Videodiscs

Optical videodisc systems have been developed in two formats. Both employ a laser beam to read information encoded on the disc. In one format, called *reflective*, light is reflected off the surface of the disc. The other format, called *transmissive*, uses a transparent disc and, during play, light is beamed through the disc.

When a reflective disc is played, the light beam is reflected strongly by the disc's normal surface. However, each time the beam passes over a pit the light is scattered and only weakly reflected. A photodiode senses these strong and weak reflections as on and off signals and transforms the signal pattern it receives into electrical waves which correspond to the original FM signal used to etch pits on the disc. This signal is then fed into a television set which recreates the recorded program.

Because nothing comes in contact with the disc during play, and also because of the disc's protective coating, no wear occurs and the useful life of the disc is virtually infinite.

The standard reflective optical disc is twelve inches in diameter, although there is also an eight inch version. A

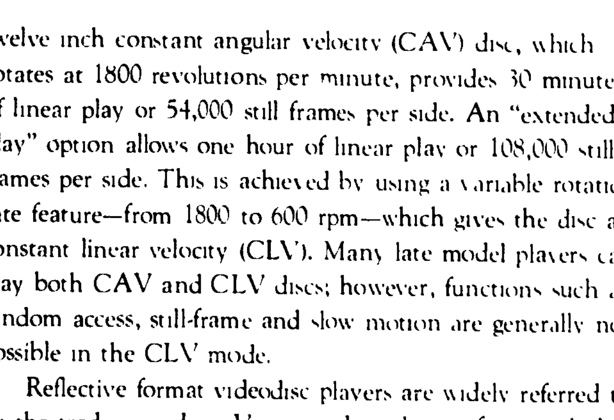
Figure 2. ***A LaserVision Model Videodisc Player (Courtesy of Pioneer Electronics Corporation)***

twelve inch constant angular velocity (CAV) disc, which rotates at 1800 revolutions per minute, provides 30 minutes of linear play or 54,000 still frames per side. An "extended play" option allows one hour of linear play or 108,000 still frames per side. This is achieved by using a variable rotation rate feature—from 1800 to 600 rpm—which gives the disc a constant linear velocity (CLV). Many late model players can play both CAV and CLV discs; however, functions such as random access, still-frame and slow motion are generally not possible in the CLV mode.

Reflective format videodisc players are widely referred to by the tradename *LaserVision*, and marketing firms include Pioneer, Sony, Philips and Hitachi.

McDonnell Douglas Electronics Company, in 1986, introduced its *LaserFilm* system, which is now the only transmissive optical system on the market. (An earlier transmissive player was previously marketed by Thomson-CSF.) Whereas LaserVision technology involves computer-activated etching of pits onto a shiny, hard disc, the LaserFilm system employs a photographic process in which the video information is placed on a transparent film disc as a sequence of dots. This process provides a disc capacity of 32,400 still frames or 18 minutes of motion video.

As one might suspect, duplication processes for the two systems differ markedly. Whereas LaserVision discs are produced by injection moulding, LaserFilm copies are made by photographic processes, a technique for which the manufacturer claims both lower mastering and duplication costs. (Additional information concerning disc production is presented later in this monograph.)



Disc Construction

Figure 3. ***Close-up of Videodisc Construction (Courtesy of Pioneer Electronics Corporation)***

Videodisc Display and Interaction Features

The optical disc's storage capacity is truly amazing, but it is the system's flexible presentation and interaction capabilities that fascinate prospective users. Videodiscs can mix normal video footage and still frames while providing stereo sound. Intermixing and overlaying computer-generated text screens and graphics are possible with some display systems. Other useful features include branching, random-access, freeze-frame, slow motion and fast scan. These are all functional capabilities that heighten the videodisc's potential as an educational medium and challenge educators who seek to exploit that potential to facilitate learning.

To explain the videodisc's varied information presentation and control capabilities, a classification scheme which defines "levels" of interactivity has been devised. A *Level I* system requires only a videodisc player and a television monitor. However, since it has no "memory" or "processing power," the system is limited to linear play altered only by the basic *pause*, *search* and *stop* commands built into the player. (Note: There are printed references to a *Level 0* category to refer to machines that are essentially limited to linear play.)

A *Level II* system is one in which the videodisc player has a built-in microprocessor with programmable memory. The control program is recorded on one of the soundtracks of the videodisc and is loaded into the player's memory when the disc is used, a process commonly referred to as a "digital dump." Level II players allow for some branching and learner response-feedback cycles within a program control mode. Their interactive potential is quite limited, however, because the memory capacity of the typical Level II machine is not great.

A *Level III* system employs a microcomputer with a videodisc player to provide significantly increased presentation and interaction capabilities. This combination allows for extensive branching and learner response analysis and for sophisticated information displays since computer-generated text and graphics can be superimposed over regular video images. The program required to provide this level of flexibility is stored on the computer's disc and must be loaded into the computer's memory. Optional input or interface devices commonly used in Level III systems include keyboards, touchscreens, mouse units, light pens, and barcode readers.

Some new interactive video units, including the Sony VIEW System and IBM's InfoWindow, provide Level III interactivity in a single, integrated system.

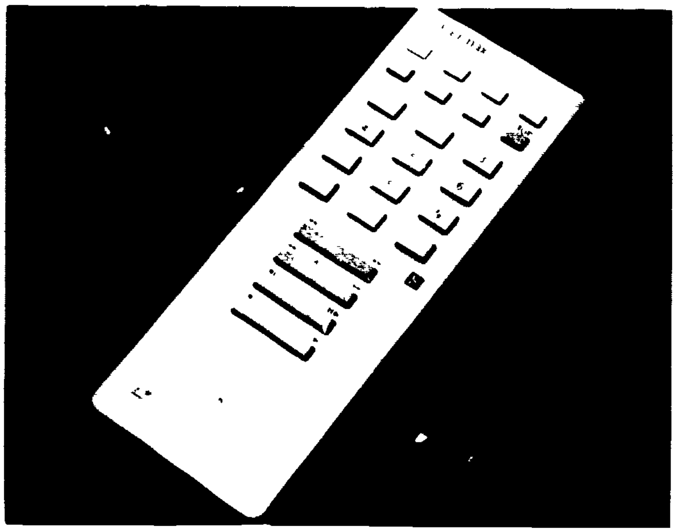


Figure 4. Videodisc Control Keypad (Courtesy of Sony Corporation)

Occasional references to *Level IV* videodiscs have been made, but no widely accepted definition has emerged. But recently a "bona fide" candidate for Level IV designation appears to have arrived. This system embodies all the features of Level I, Level II and Level III discs, but is distinctive in several critical respects. The control program is not stored on a computer disk, as in a Level III system, but instead is recorded on the laser disc itself, as with a Level II disc. But whereas Level II play involves "dumping" the control program into the player's memory, in Level IV the program is downloaded into a separate computer's memory, making the system operable without need of an auxiliary disk. This simplifies program packaging and use since both subject matter content and control information are stored on a single disc. But it also means that the control program recorded on the videodisc cannot be modified, as one stored on a computer disk could be.

Audio and Interactive Videodiscs

As prescribed by the North American Standard (NTSC), the video picture seen on a television set or monitor is composed of thirty still pictures or frames per second. As was mentioned earlier, the standard videodisc with a capacity of 54,000 frames can therefore provide either 54,000 "stills" or 30 minutes of continuously running video. In practice, of course, a typical instructional videodisc is a mix of still frames and motion sequences. Using only a fraction of the disc's total capacity for still-frame displays enables the lesson designer to incorporate many branching opportunities for learners of different knowledge levels and learning styles. However, the teaching effectiveness of still-frame displays is limited by a fundamental problem—providing audio accompanyment.

A videodisc has two audio tracks which, taken together, provide for 60 minutes of audio information, but only in the linear play mode. Thus designing videodisc systems that provide adequate audio with still-picture displays has been a major technical challenge.

One way to add substantial audio capacity to a videodisc system is to digitize the audio signal and store it on a peripheral device, such as a computer hard disk or an audio compact disc. But this means that the peripheral equipment, including suitable control devices, must be added to the instructional system, a cost and operational drawback.

What some see as a more promising approach involves using "compressed audio." In this technique, the audio signal is converted into a video signal, compressed, and stored on the videodisc itself. In a typical system, each video frame of a disc can store about four seconds of audio data, and thus a standard videodisc has a potential capacity of about 60 hours of audio. So, programs that combine several thousand still frames with extensive audio accompanyment are now possible, although the recording process is neither simple nor inexpensive.

But a little arithmetic clearly demonstrates the advantage of this technique for information delivery. If a designer desires an average of 12 seconds of audio for each still frame, the audio information will require three frames (12/4). Adding one frame for the video signal gives a total of four frames used for each still image. Then, if half of a disc is devoted to motion video (15 minutes) and the other half to still images, space for 6,750 still-frames (54,000/2/4) with accompanying audio is available. Needless to say, this provides the program designer with enormous capacity and flexibility in creating an instructional program.

Levels of Interactivity

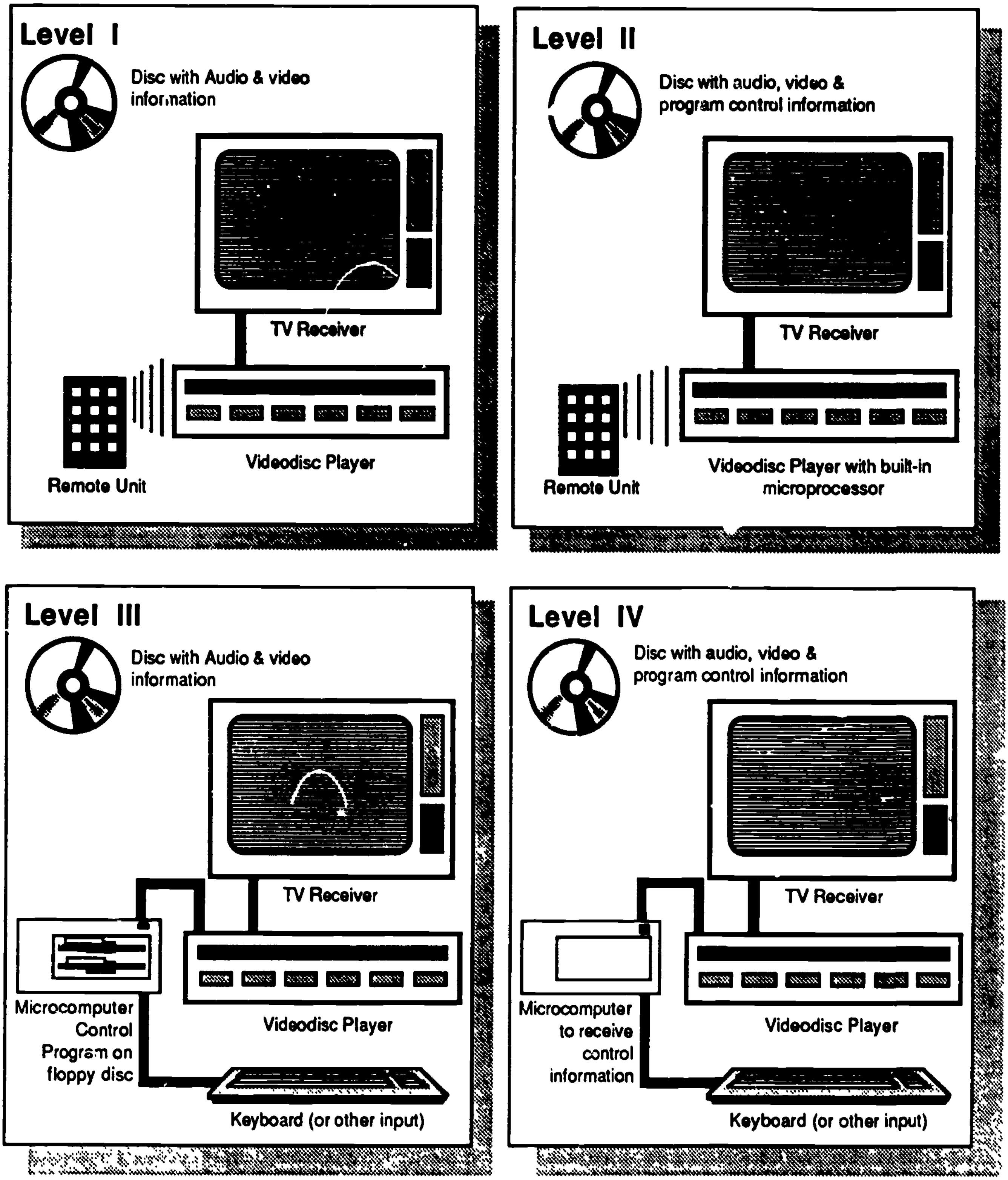


Figure 5.

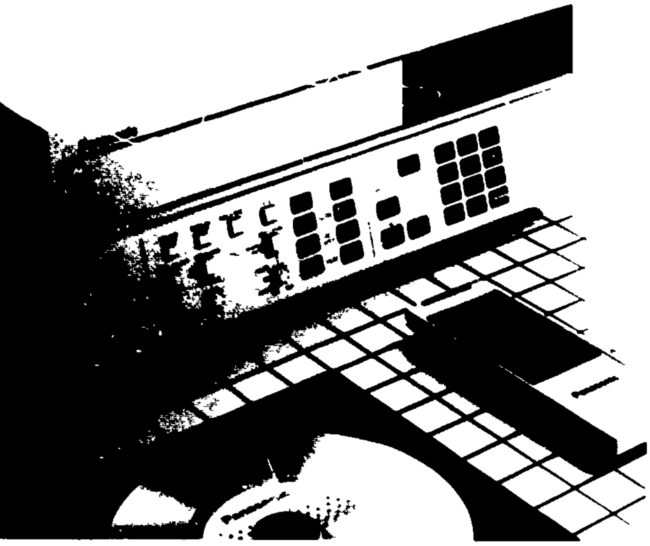


Figure 6. Optical Disc Recorder
(Courtesy of Panasonic Industrial Company)

The LaserFilm disc, if used in this manner, would provide about 4,050 still frames with audio. The LaserFilm player, however, has built-in compressed audio circuitry which, the manufacturer claims, makes the system "easier to implement than some of the earlier compressed audio systems" (Laser-Learn Report, 1987, p. 5).

Recordable Videodisc Technology

A recordable videodisc system enables a user to record a playable videodisc without going through the standard, and expensive, process of creating a "master disc" from which replicas can be made. This technology is usually referred to by the term DRAW, for Direct Read After Write. A DRAW disc may represent a stage in the standard videodisc production process; in this case it is commonly referred to as a "check disc" because its principal use is for checking the disc's format and content before the master copy is made. But DRAW discs have other uses, as well. One is for low volume production, another is as an editing tool, and a third is for use in videodisc development training courses where immediate playback is a necessity.

The recording process for a DRAW disc is similar to that used for producing a standard disc. Audio and video information is carried as an FM signal which activates a blue argon laser which does the "writing" on the disc's surface. The data track is a series of pits etched in spiral fashion from the inside to the outside of the disc. When the disc is played, the sequence of pits and non-pits, which is the physical representation of the disc's information, is "read" by a red helium-neon laser in the manner common to other reflective optical videodiscs.

Videodiscs produced with DRAW technology generally do not have the image quality of a "standard" disc, that is, one duplicated from a master. Thus the principal value of a DRAW system to the organization that owns one derives from the real time recording and continuous updating capabilities that the technology affords.

To date, three firms are known to offer recordable videodisc systems. Optical Disc Corporation introduced its Recordable Laser Videodisc (RLV) model in 1984, calling it the first "LaserVision Standard compatible optical medium." The company has recently announced a new disc design (the Mark II) which, it claims, offers significant improvements in recording and playback quality. Panasonic markets its Optical Memory Disc Recorder (OMDR) which uses an eight inch disc that provides about 13 minutes of motion video. It is not LaserVision disc compatible, however. Reportedly, a twelve inch OMDR model will be available in late 1988. And, TEAC Corporation of America has introduced its LV-200 recordable system, which it calls "the first desktop 12-inch videodisc recorder."

Recordable disc systems that employ digital technology and "compact disc" formats will be discussed in the next chapter.

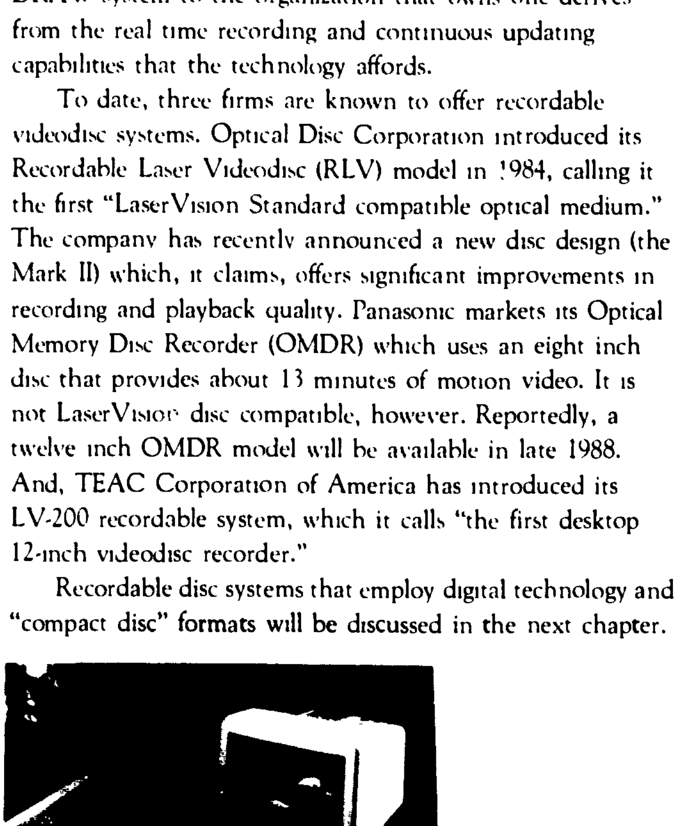


Figure 7. Computer Controlled Image Storage System Using an Optical Disc Recorder/Player (Courtesy of Panasonic Industrial Company)

II. Compact Disc Systems

Since 1982, when compact disc audio players were introduced, the "CD family" has grown by several members and, although some of the formats are aimed primarily at the consumer market, many believe that the technology holds much promise for educational and information management applications. The term "compact" derives from the 4.72 inch disc that most formats use. Beyond that, all compact formats share certain basic technical characteristics: all are reflective laser, optical disc systems; all use digital technology to encode audio and video information on the disc; all are constant angular velocity (CAV) players; and, generally, all follow the "High Sierra" standards (named for a Lake Tahoe hotel at which an ad hoc standards group first met in 1985) for compact disc hardware and software configuration. There are, however, major technical differences among the various systems, differences which greatly affect each system's utility for professional applications.

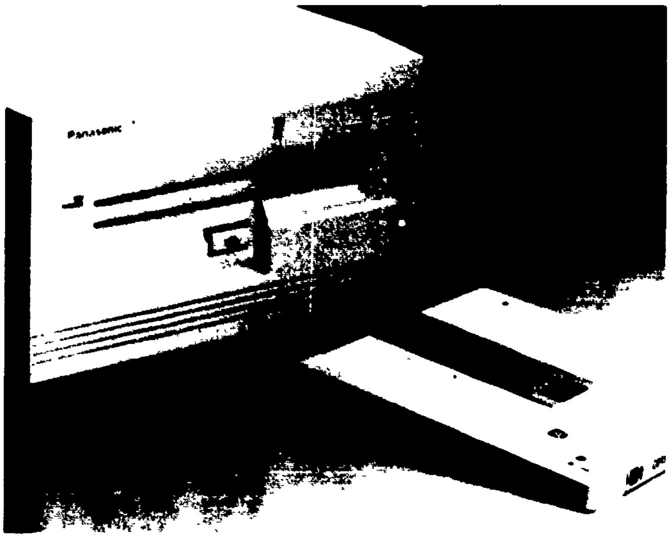


Figure 8. A WORM Optical Disc Drive (Courtesy of Panasonic Industrial Company)

Compact Disc-Digital Audio

The compact disc-digital audio (CD-DA) player was introduced in 1982 by Philips and Sony as a high quality sound medium for home use. It provides up to 70 minutes of 2-channel audio and the disc cannot be erased or rerecorded. The format follows the so-called "Red Book" standards set by Philips and Sony. The player's vigorous sales performance prompted one writer to label its introduction as "the most successful in the history of consumer electronics" (Sayers, 1987, p. 4).

Compact Disc-Video

A recently developed variation of the audio compact disc is compact disc-video (CD-V) which offers 20 minutes of digital audio and five minutes of full-motion, analog video. Except for its size, however, this is not a *true* compact disc because it does not follow exactly any of the High Sierra standards. In any case, most apparently see this format as a "music video" medium that offers little potential for education and training. CD-V discs are also to be offered in eight inch (Extended Play) and twelve inch (Long Play) sizes to provide longer playing times.

Interactive Compact Video Disc

Mattel Toys is introducing a new system that combines interactivity with digital audio and analog video play modes. Called Interactive Compact Video Disc (ICVD), the system is the result of a licensing agreement between Mattel, SOCS Research and Interactive Video Systems, and it is reported to be "a new format separate and distinct from not only conventional CD-audio but laserdiscs as well" (CD-I News, October, 1987, p. 10). Two versions will be available: A standards CAV play mode providing up to 10 minutes of video and a CLV extended play model for up to 20 minutes of video.

But the three compact disc formats that appear to hold the most potential for education and other professional applications are Compact Disc-Read Only Memory (CD-ROM), Compact Disc-Interactive (CD-I), and Digital Video Interactive (DVI). Their distinctive features illustrate the range of technical and information management capabilities that derive from a single technology.

Compact Disc-Read Only Memory

The one compact disc technology that is available now and has at least a modest history of professional application is CD-ROM. Briefly stated, CD-ROM is a read-only, mass information storage and retrieval device that functions as a computer peripheral. The format was introduced in 1985 by Philips and Sony, who published the relevant standards in the so-called "Yellow Book." The medium's flexibility to serve different database and archival applications, according to the setting and associated computer software, makes it a tool with potentially wide usage in business, education and library operations. Because the CD-ROM disc can store up to 550 megabytes of data, it is especially valuable for large databases and similar information collections.

Compact-Disc Interactive

Compact Disc-Interactive (CD-I) was announced in 1986 by Philips and Sony as a medium intended to integrate audio, video and text on a single disc using digital technology. The international standards for CD-I, published in what is called the "Green Book," specify audio and image capabilities for the format and specifically state that CD-I players must have a Motorola 68000 series microprocessor with a CD-RTOS (compact disc-real time operating system), so that it operates as a "stand alone" machine. This means that all information for audio, video, text and program code can be stored on a single disc. Although the medium is intended primarily to serve as a home information and entertainment system, many see the possibility for extensive educational use, especially in continuing education. Prototype systems have now been successfully demonstrated and commercial units are expected to be generally available by mid-1989.

Digital Video Interactive

While the CD-I format was evolving from "vaporware" to hardware, that is, from a specification to an actual player, the General Electric Company introduced another CD-based technology called Digital Video Interactive (DVI). DVI was developed at the David Sarnoff Research Center (formerly RCA Laboratories) in Princeton, New Jersey, using the CD-ROM "Yellow Book" standard and, when first demonstrated in March, 1987, was seen by many as a breakthrough in compact disc technology. By employing sophisticated data compression and regeneration techniques, the system can offer more than an hour of full motion, full-screen digital video from a standard CD-ROM configuration disc. The video may include still images, motion images, graphics, text, or computer data.

The heart of the DVI system is the Video Display Processor (VDP), a two chip set that includes a pixel processor and an output display processor. Software runs under the MS-DOS operating system as found on a standard IBM PC AT computer and other compatibles.

The impressive display capability that first-version DVI systems afforded was not achieved without cost, however. The data compression-regeneration process resulted in a video picture of relatively low resolution, and while this may not be a significant factor in some teaching applications, it is often a serious concern in medical instruction. And, on the production side, the cost of encoding an original disc was very high. A regular television signal contains about 500 kilobytes of information per frame, which is compressed to about 5 kilobytes per frame, a 100:1 compression ratio. Originally this process required a great deal of computer time—about 30 seconds per video frame using a VAX 8800 computer. Now, however, major improvements in the technology have been reported by the developer. By using an advanced parallel-processing computer, compression time for motion video has been reduced to near three seconds per frame. Real-time motion video compression is also possible using what is called Edit-Level Video (ELV), a technique that facilitates program authoring. And the ability to produce high resolution still images suitable for medical applications by using compression ratios between 2- and 3-1 is also claimed. Thus, while the safe prediction is that the interactive videodisc, which is an analog device, will remain the most efficient means for providing interactive, motion video for instructional purposes in the near future, digital technology systems, such as DVI, may become practical options sooner than most expect.

DVI technology is now owned by Intel Corporation which recently acquired it from General Electric. GE had acquired DVI when it purchased RCA in 1986 and subsequently promoted the technology as "an exciting new platform, one which can have a tremendous impact on the ways we create, communicate, educate and entertain" (Interactivities, 1987, p. 1).

Indeed, videodisc and compact disc systems, with their impressive storage, presentation and interaction capabilities, appear to have the potential for changing education in ways that earlier media forms did not. However, the history of media use in education has made one lesson painfully clear: realizing the potential inherent in "level III" and "level IV" instructional systems cannot be accomplished with "level I" planning and design.

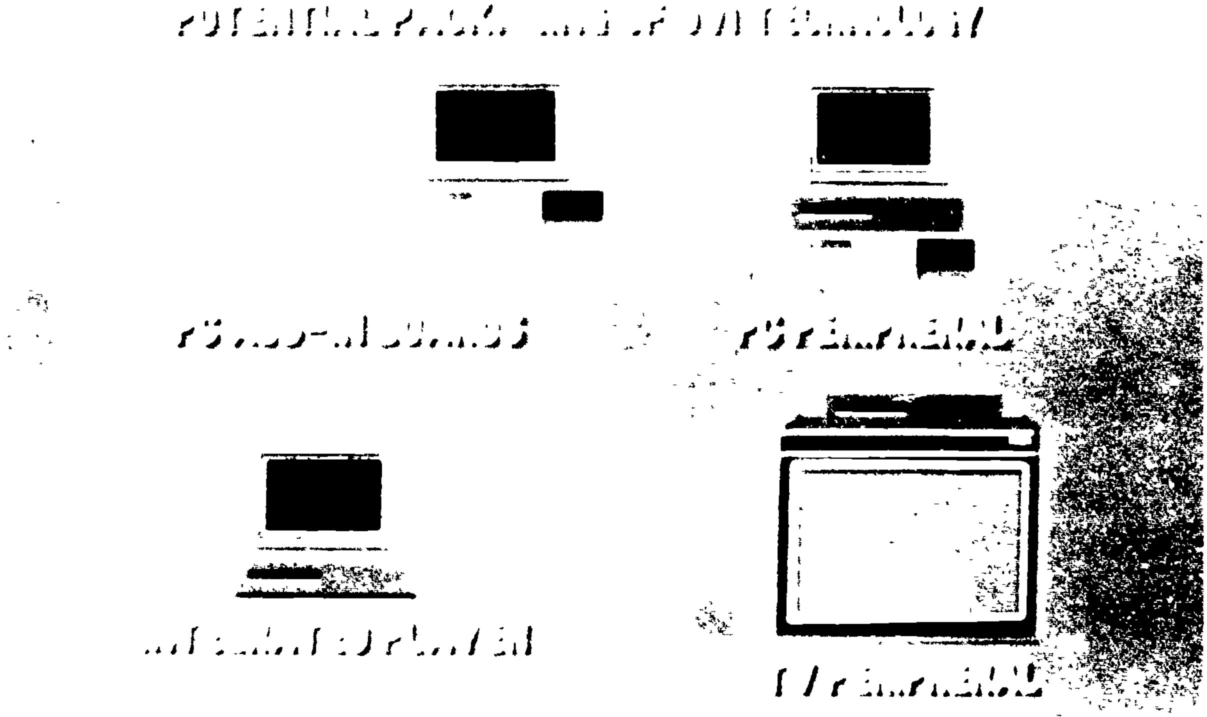


Figure 9. Potential DVI System Assembly (Courtesy of Intel Princeton Operation, DVI Technology)

Figure 10. A DVI Surrogate Travel Program Frame (Courtesy of Intel Princeton Operation, DVI Technology. Photo copyright 1986, Bank Street College)

Recordable and Erasable Compact Discs

Several manufacturers, including Panasonic and Pioneer, now offer recordable optical disc drives that employ the digital technology associated with compact discs. Called WORM drives, for Write-Once, Read-Many, they enable the user to write on the disc as well as read from it. These systems are mainly intended for text and data storage and retrieval, and typically use a 5.25 inch disc.

The utility of current "write once" recordable disc systems for maintaining files and databases is limited by the fact that information, once recorded, cannot be erased and updated. Thus the erasable disc has become a highly anticipated technical advance. Several erasable systems have been demonstrated at trade shows, although most are not yet available. Tandy Corporation recently announced development of one system that employs "thermal optic technology" to allow creation and erasure of pits on a heat-sensitive layer of a CD format disc (Newsline, 1988, p. 3). Sony, Sharp, Eastman Kodak and Olympus Optical are reportedly to have systems on the market soon. And Advanced Graphics Applications, a New York based firm, has developed what Strukhoff (1988, p. 24) describes as "the first commercially available erasable optical subsystem." The AGA system uses an Olympus drive and a 5.25 inch disc with a capacity of 325 megabytes per side.

All such systems employ digital technology and therefore are not compatible with any of the analog videodisc formats described earlier. WORM and erasable drives, like the basic CD-ROM, likely will be used mainly as computer peripherals; however, their distinctive capabilities suggest that each will play a different role in information management. CD-ROM is widely regarded as a "publishing medium" whereas WORM and erasable units are expected to find wide application as "local storage" information systems.

Interactive Video Technology

Disc Technology	Electronics Technology	
	Analog (*Videodisc*)	**Digital** (*Compact Disc*)
Indelible Storage Read Only	LaserVision (*optical reflective*) LaserFilm (*optical transmissive*) Video High Density (VHD) (*electrical capacitance*) Capacitance Electronic Disc (CED)	CD-ROM CD-I DVI other
Indelible Storage Write Once, Read Many	DRAW Systems (Manufacturers) Optical Disc Corp. Teac Panasonic	WORM Drives (Numerous Manufacturers)
Erasable Storage Write Many, Read Many	(None)	Three Formats magneto-optical phase-change thermal-optic

Figure 11. Analog and Digital Technology Disc Formats

III. Videodisc System Selection Factors

Chapters One and Two presented brief descriptions of technologies now available or under development with which videodisc-based teaching systems can be constructed. In this chapter, other factors that are relevant to selecting and using such systems in health professions education are examined.

When purchasing a videodisc system, what you see is only part of what you get. You see an assemblage of electronic components: a player, a monitor, a control device (e.g., a computer), an input device (e.g., a touch screen), and, of course, a disc. But, more than that, each system has distinctive technical features that dictate certain design, authoring and production requirements in creating useable programs. Thus each basic disc technology must be considered not only on its technical merits but also in relation to the developmental processes its use requires and the practical, curricular and human implications of a particular system's adoption.

Between making the videodisc a major instructional delivery medium—as the US Army reportedly has done—and ignoring it altogether, there are intermediate levels of involvement. Each organization must determine for itself what resources it wishes to commit to acquire the technology and to support its use. One institution may elect merely to buy a player or two, another may decide to build a videodisc learning center as an integral part of its curriculum delivery apparatus. Either way, important choices must be made.

These choices are examined here in relation to four elements: technology format, production processes, authoring tools, and the case for integrated videodisc systems.

Choosing A Technology Format

Recent activity in the videodisc marketplace has produced a condition that is decidedly uncommon in the electronics field: the available choices seem to be diminishing in number. The Thomson/CSF transmissive optical format and the RCA capacitance electronic disc (CED) disappeared from the market some years ago. Now, reportedly, the JVC video high density (VHD) capacitance format has been withdrawn from the American market, although it is still offered in Europe and Japan. This narrows the field to the two remaining optical disc formats: the reflective optical videodisc, commonly called LaserVision, which is marketed by several firms, and the transmissive optical LaserFilm format, which is a trademark of the developing firm, McDonnell Douglas.

There is, of course, another option (as of mid-1988): purchase none of the above and wait to see what the much-publicized CD-based, digital technology formats, namely CD-I and DVI, eventually will offer in the way of educational/industrial units. Although that could be a long wait, these technologies do bear watching. However, for the immediate future, the analog, optical videodisc formats seem to be the only practical choices.

The VHD format, according to published sales figures, never enjoyed wide distribution in the United States. So even if it were still available, this would be a serious concern in a field such as health professions education where use of programs acquired from diverse sources is virtually a practical necessity.

The McDonnell Douglas LaserFilm system has been available for a relatively short time and thus its future is difficult to predict. Also, current reports indicate that the manufacturer has not been aggressively marketing the system of late and has been seeking a buyer for the product line. However, because this technology's photographic process reportedly allows for quicker and less expensive disc mastering and duplication, the format may find wider application in the future.

Clearly, the most widely used videodisc technology format is the LaserVision optical reflective player, for which Pioneer, Sony, Hitachi and Philips are major distributors. All such players conform to the so-called LaserVision standard for encoding information on the disc, and thus any such disc can be played on any of the LV players. Many in the field now consider this format to be the industry standard. LaserFilm and Video High Density discs, of course, can be played on those respective systems only.

Literature explaining the technical specifications of the various disc players and associated equipment is readily available from the manufacturers. It is important to remember, however, that these specifications must be weighed against the design, authoring, production and program acquisition factors associated with each technology.

Comparing Production Processes

A 3M company monograph advises that "the production of optical videodiscs is a demanding and exciting process that requires good teamwork at each stage—from the earliest conception and planning through production to post production, premastering and replication" (Premastering, 1981, p. vi). Probably no one who has gone through this process will challenge that assessment, or argue that the available technology makes disc development easy. However, the production processes associated with the different technology formats are potentially important factors in the selection process.

The development and production process for optical LaserVision standard discs includes several activity phases. First is the instructional design stage in which an insructional treatment is prepared along with objectives, test items, storyboards, and a script. This process has much in common with instructional design for other media forms except, of course, that for interactive video it is necessary to create a flowchart that displays the options and alternative paths through the disc's content that the program design is to afford. Second, all filmclips, video sequences and slides needed for the program must be shot or acquired. The third phase, usually called *premastering*, involves transferring all source materials onto a videotape that meets prescribed standards for tape format, cue insertion, and other technical details required for creating the master disc. In the fourth and final stage, the master tape is used as a source medium for making the master disc, which in turn is used to replicate copies as required by the user.

The instructional design phase, the first step in the process outlined above, does not differ significantly from one technology format to another. Later production steps do, however, and a comparison of LaserVision versus LaserFilm development makes this especially evident.

The major components of the McDonnell Douglas LaserFilm production system are called the *formatter*, the *recorder*, and the *autoprinter*. The formatter receives source material—video, audio, slides and digital data—and program flow instructions and produces what is called the *disc image tape*. The recorder uses this formatted disc image tape to produce a *master disc*. The autoprinter is used to duplicate discs using a photographic process. A printing rate of up to 200 discs per hour is possible, according to the manufacturer, who also claims that duplication costs are lower for this process than for reflective (LaserVision) disc duplication.

Authoring Tools

The term *authoring tools* refers to a variety of instructional design and programming aids in two general categories: *authoring languages* and *authoring systems*. As the name implies, an authoring language is a computer programming language that has been designed specifically to issue the commands required in interactive lesson designs—commands related to visual display control, program sequencing and branching, student response assessment, and so on. An authoring system, on the other hand, is a software form that incorporates or "packages" a predetermined set of command functions and thus essentially eliminates the need for a designer to know language executed programming. The capabilities of available authoring systems vary widely, but the basic idea is to provide the user with the necessary tools, e.g., templates, menus, prompts, to facilitate interactive lesson design.

Available authoring software systems also vary widely in cost and features. The LaserWrite unit from Optical Data Systems, which Haukom and Malone (1987, p. 105) describe as "a simple, easy to use authoring language for Apple computers," has reportedly sold for as low as $75. Among units in the $5000 range is IBM's InfoWindow Presentation System. It consists of two integrated software modules, one an "authoring" program and the other a "presentation" program used to deliver InfoWindow lessons. Other widely advertised systems include Aimtech's IconAuthor system, Computer Sciences Corporation's IV-D system, Online Computer Systems' OASYS unit, Interactive Technologies Corporation's CDS/Genesis, and Allen Communication's QUEST authoring system. The thrust underlying the development of such systems is to provide tools that can guide the creation of complex interactive lesson designs that may incorporate disc recorded video material, overlaid graphics, graphics animation, dual-track audio, information from a

Figure 12. Authoring with Sony VIEW System (Courtesy of Sony Corporation)

peripheral device, such as a CD-ROM drive, and yet be easy to use. Numerous authoring system producers are claiming success in meeting this challenge, thus making the choice of an authoring system itself a challenge for health professions educators and those who support them in videodisc design activity.

Some authoring system producers claim as an advantage of their product that it offers "portability" among various leading interactive videodisc systems. This means that an interactive program created for a particular integrated system can be "converted" to run on one or more other systems. This feature, of course, can be an important consideration in a field in which programs are to be exchanged among several institutions. And it also raises two basic questions: What is an integrated videodisc system? What advantages does it offer the user?

Integrated Interactive Videodisc Systems

One solution to dealing with the varied array of videodisc players and associated products now on the market is to choose one of the "integrated" videodisc systems which several well-known firms presently offer. In this way the user acquires a "ready-to-run" system with compatible components. The key components of such a system are the videodisc player, a monitor and a computer. Compatibility problems still arise *among* integrated systems because of differences in computer operating systems, in electronic circuitry used to overlay graphics onto video images, and in interface equipment. Thus individual manufacturers have sought to overcome these problems by producing what each sees as the "ideal delivery system" for videodisc instruction.

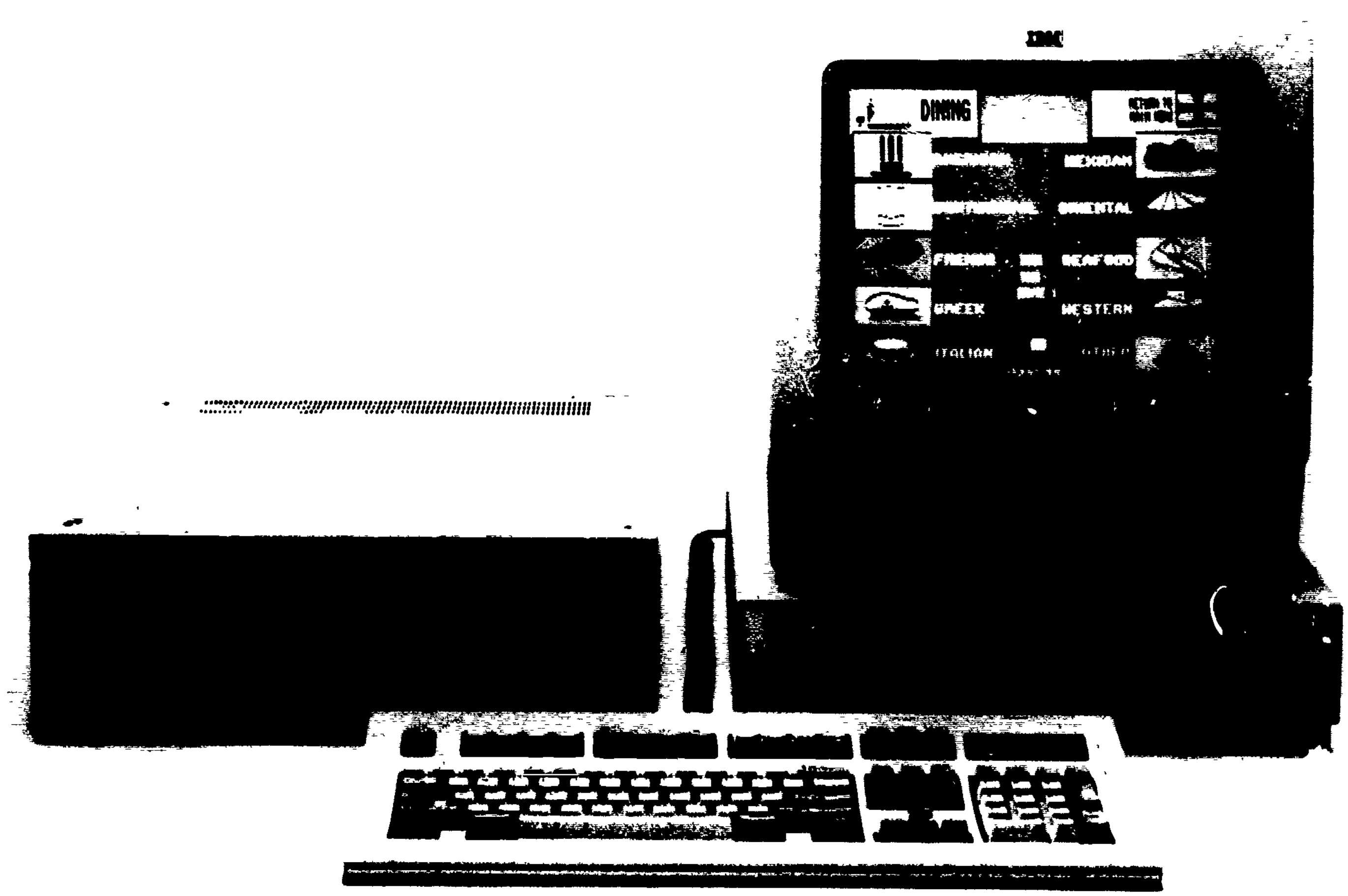


Figure 13. IBM InfoWindow System
(Courtesy of International Business Machines Corporation)

For example, in 1987, Hane Industrial Training, Inc., in collaboration with McDonnell Douglas, undertook development of a system for which the "key ingredients" were listed as: 1) A CAV videodisc player, 2) Sound over still capability, 3) An IBM AT compatible computer with 20 Meg hard disk drive and 640 K RAM, 4) A color monitor, 5) A touch screen, 6) A video overlay card, and 7) An ergonomic workstation (LaserLearn Report, 1987, p. 3).

The thrust for standardization among videodisc systems was given considerable impetus recently when the US Army issued its Electronic Information Delivery System (EIDS) specifications, and awarded a major contract for hardware systems to Matrox Electronics Systems of Canada. These specifications prescribe a front-loading videodisc player with a three second maximum search time and built-in still-frame audio capability, an MS-DOS computer with a 16-bit microprocessor and 256K memory (expandable to 512K), two 3.5 inch disk drives and an RS-232 port. Other operational requirements relative to presentation and feedback management are also specified. The sheer volume of the Army's requirement for these systems will likely make the EIDS specifications a significant factor relative to technical standards in the field.

But there are presently several other integrated interactive videodisc systems on the market, some EIDS compatible and some not.

IBM's InfoWindow System is a touch screen unit that combines an IBM InfoWindow Display device, an IBM personal computer (or one of many compatible "clones"), and, as a usual but not necessary option, a LaserVision model videodisc player. Compatible IBM brand computers include models from the Personal Computer AT, Personal Computer XT, and Personal System/2 lines. Touch screen systems of course, are easy to use and the IBM unit offers up to 60 "touch points." Also, the IBM InfoWindow Display unit contains its own microprocessor and thus the terminal itself can control audio, video, and other functions.

The Sony VIEW system uses a Sony SMC-3000V microcomputer and either a Sony LDP-1500 or LDP-2000 videodisc player to form integrated systems of differing levels of sophistication, depending on the player chosen. Sony's advanced system provides a still-frame audio option while both systems provide graphics overlay capability. The SMC-3000 computer has two built-in display modes and the high resolution mode provides for display of 256 colors simultaneously, chosen from a palette of 4,096 available colors. Full-screen resolution is 672×496 pixels.

Other firms that now market integrated interactive systems include Pioneer, Online Computer Systems, Inc., NCR, and Visage Inc. And, while different systems may use similar disc players as the main information source, differences in other components—microcomputers, input devices, graphics units, and authoring systems—make the choice of an integrated system for educational applications a decision that requires careful analysis. This analysis should also include consideration of educational needs, potential program sources, and "human factors" associated with learner use.

IV. Videodisc Use: A Brief Look

Veteran educational practitioners in all settings have been witness to many technological revolutions promised but not delivered. Presently, the interactive videodisc, having, by all appearances, assumed the status of the "cutting edge" educational technology of the 1980s, is generating hope anew. The fact that other educational media forms—film, television, programmed instruction—have generally failed to fulfill the predictions once made for them does not seem to have dimmed the enthusiasm which many hold for interactive video and related technologies. Indeed, optimistic observers seem convinced that the mesh of computers, interactive disc systems, and information transmission via telecommunications channels will, in the not too distant future, produce the revolution in teaching that previous technologies did not. It is still too early to judge whether or not such optimism is justified. But it is clear that videodisc use is growing steadily in several major sectors, including business, education, the military and the health sciences.

Applications relevant to health professions education have been among the most interesting developments involving videodisc technology. For example, The National Board of Medical Examiners (NBME) began the final phase of its Computer Based Examination (CBX) development project in 1983. During this phase, the NBME developed several generations of the CBX simulations system in a microcomputer environment. A presentation system for multiple choice questions and patient management simulations was developed and medical images to support the system were collected and stored on a videodisc. An extensive field test was undertaken in early 1987 to assess logistic and measurement issues—the Computer Based Testing (CBT) Pilot Examination. The results indicated that the simulation system could be successfully used to assess clinical competence. The NBME CBX system is now being readied for wide distribution to U.S. and Canadian medical schools. This will lead to its eventual adoption as the examination for medical certification as well as to continued use in medical education.

Interactive teaching programs for the health professions are being developed by individual schools, by cooperative groups, by professional associations, by private firms and by government units such as the US Navy and the National Library of Medicine. In short, despite reservations about cost, compatibility and other concerns, considerable progress is being made. Powerful and reliable interactive videodisc technology is available now!

But history shows that an educational technology is not likely to succeed on its technical merits alone. Fortunately, optical disc technology has more than its technical features in its favor. The important point, it can be argued, is that for any education related application, whether it be teaching, testing, publishing, or database management, the ideal system is probably one in which an optical disc device—either analog or digital—is an integral part. Choosing the ideal system for each particular application is now one of educational technology's major challenges.

Not long ago an enthusiastic proponent of educational technology wrote that "A new combination of existing products—microcomputers, compact discs, adaptive tests, satellite communications and artificial intelligence—will produce the first technological revolution this century that educators will be unable to ignore" (Frankel, 1986, p. D-3). If such a teaching revolution does come about, hopefully it will be produced not so much by a "new combination of existing products" as by new visions of the role of technology in education and a new inventiveness in designing instructional systems that adapt to different learners and learning requirements. Human aspirations, not product potential, should motivate revolutions in health professions education, as elsewhere.

References

CD-I News. (1987, October). Author.

Frankel, S. (1986, November 23). Finally, the revolution in teaching. *The Washington Post*, p. D-3.

Hannafin, M.J. (1985). Empirical issues in the study of computer assisted interactive video. *Educational Communication and Technology Journal*, *33*, 235-247.

Haukom, R., & Malone, E. (1987). A survey of level III videodisc delivery systems. In S. Lambert & J. Sallis (Eds.), *CD-I and interactive videodisc technology* (pp. 93-115). Indianapolis: Howard W. Sams.

Howsie, P. (1987, July). Adopting interactive videodisc technology for education. *Educational Technology*, pp. 5-10.

Interactivities. (1987, July). David Sarnoff Research Center.

Jarvis, C.S. (1988, May). 1988: The 30th anniversary of the videodisc. *The Videodisc Monitor*, p. 15.

LaserLearn Report. (1987, September). Hane Industrial Trainirg.

Mann, C.C. (1981, October/November). How it works: Videodisc. *Technology Illustrated*, pp. 102, 103.

Newsline. (1988, May). *The Videodisc Monitor*, p. 3.

Premastering/Post Production Procedures. (1981) St. Paul, MN: Minnesota Mining and Manufacturing Company.

Rice, P., & Dubbe, R. (1982). Development of the first optical videodisc. *SMPTE Journal*, *91*, 277-284.

Sayers, J. (1987, January/February). Optical disc cornucopia. *Medical Disc Reporter*, p. 4.

Strukhoff, R. (1988, September). Getting the whole picture. *CD-ROM Review*, pp. 24-26.

Appendix

Selected Information Sources on Videodisc Technology

A. Associations

1. Association for the Development of Computer-Based Instructional Systems (ADCIS).
   Miller Hall, Room 409
   Western Washington University
   Bellingham, Washington 98225
2. Association for Educational Communications and Technology
   1126 Sixteenth St. NW
   Washington, D.C. 20036
3. Health Sciences Communications Association (HeSCA)
   6105 Lindell Blvd.
   St. Louis, MO 63112
4. International Interactive Communications Society (IICS)
   2120 Steiner Street
   San Francisco, CA 94115

B. *Periodicals: Specific to Videodisc Technology*

1. CD-I News
   Emerging Technologies Publications
   LINK Resources Corporation
   79 Fifth Avenue
   New York, NY 10003
2. CD Publisher News
   Meridian Data, Inc.
   4450 Capitola Rd., Suite 101
   Capitola, CA 95010
3. CD-ROM Review
   CW Communications/Peterborough Inc.
   80 Elm Street
   Peterborough, NH 03458
4. Medical Disc Reporter
   Stewart Publishing, Inc.
   6471 Merritt Court
   Alexandria, VA 22312
5. The Videodisc Monitor
   Post Office Box 26
   Falls Church, VA 22046

C. *Periodicals: General Educational Technology*

1. Educational Technology Magazine
   720 Palisade Avenue
   Englewood Cliffs, NJ 07632
2. Instruction Delivery Systems
   50 Culpeper Street
   Warrenton, VA 22186
3. Tech Trends
   AECT
   1126 Sixteenth St. NW
   Washington, D.C. 20036
4. T.H.E. Journal
   Information Synergy Inc.
   2626 S. Pullman
   Santa Ana, CA 92705
5. Videography
   Media Horizons, Inc.
   50 West 23rd Street
   New York, NY 10010

D. *Books*

1. DeBloois, Michael L. (1982)
   Videodisc/Microcomputer Courseware Design
   Educational Technology Publications
   720 Palisade Avenue
   Englewood Cliffs, NJ 07632
2. DeBloois, Michael L. (1988)
   Use and Effectiveness of Videodisc Training
   Future Systems, Inc.
   P.O. Box 26
   Falls Church, VA 22046
3. Iuppa, Nicholas (1984)
   A Practical Guide to Interactive Video Design
   Knowledge Industry Publications
   701 Westchester Avenue
   White Plains, NY 10604

4. Iuppa, Nicholas, and Anderson, Karl (1987)
Advanced Interactive Video Design
Knowledge Industry Publications
701 Westchester Avenue
White Plains, NY 10604

5. Lambert, Steve, and Sallis, Jane (Eds.) (1987)
CD-I and Interactive Videodisc Technology
Howard W. Sams & Co.
4300 W. 62nd Street
Indianapolis, Indiana 46268

6. Schwier, Richard (1988)
Interactive Video
Educational Technology Publications
720 Palisade Avenue
Englewood Cliffs, NJ 07632

7. The Educator's Handbook to Interactive Videodisc (1937)
Association for Educational Communications and Technology
1126 Sixteenth St. NW
Washington, D.C. 20036

E. Industry Guides

1. Videodiscs in Healthcare (1987)
Stewart Publishing, Inc.
6471 Merritt Court
Alexandria, VA 22312

F. Training Resource Organizations

1. Bloomsburg University, Bloomsburg, PA 17815
(Instructional Technology Degree Program)
(Interactive Video Workshops)
Contact: Dr. Harold Bailey (717) 389-4528

2. Nebraska Videodisc Design/Production Group
(Annual Symposium and Videodisc Workshop Series)
KUON-TV, University of Nebraska
Lincoln, NE 68501

3. Society for Applied Learning Technology (SALT)
(Conferences and Tutorial Sessions)
50 Culpeper Street
Warrenton, VA 22186