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ABSTRACT

Hypermedia is not a single technology; it is an integrated electronic environment that combines text, audio, and video into one large file. Users can explore information about a subject using several technologies at the same time. Although the technical foundation for hypermedia was established in the early 1970s, it was not until the late 1980s and early 1990s that the hardware for supporting hypermedia became readily available. In a hypermedia system, each component of stored information is a node, and the nodes are connected by paths. The paths that a user travels are determined by interest, experience, and need. Hypermedia systems have many classroom applications, and can revolutionize a student's view of learning with the hardware and software currently available. As hypermedia technology develops, the educational environment will advance beyond lectures, notetaking, and other common forms of learning. "Edutainment," the combining of education and entertainment, and virtual reality are extensions of hypermedia that promise to improve the learning environment. A 13-item resource list cites the names and addresses of organizations and journals that provide information about hypermedia. (SLD)

FASTBACK

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Hypermedia: The Integrated Learning Environment

Dan H. Wishnietsky

PHI DELTA KAPPA
EDUCATIONAL FOUNDATION

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Hypermedia: The Integrated Learning Environment

by
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Introduction

During the 1980s, schools, colleges, and universities spent millions of dollars to install computer hardware and software, hire computer coordinators, and provide inservice computer training. These initial computers were quite primitive by today's standards. The systems usually had one floppy disk drive and, at most, 64 kilobytes of internal or random access memory (RAM). In addition, school computers usually were isolated from each other or connected with only the other computers in the same room.

The first educational software products were equally basic. Most instructional software consisted of drill-and-practice sessions or tutorials. A few of these programs included sound or graphics, but these extras were rudimentary; the monochrome monitors and limited sound capabilities of these early computers did not permit anything more.

By 1990 computers and their accompanying technology had become much more sophisticated. Instead of only one floppy disk drive for reading and storing limited amounts of data, current computer systems include hard disks, CD-ROM players, and optical disc players, which can store and retrieve vast quantities of audio, video, and text. Monitors now are capable of displaying more than 250,000 shades of color in a high-resolution display that rivals that of photographs. Audio capabilities now include lifelike stereo reproductions of almost any sound, including speech and music. And the average computer's internal memory has increased in size from 64 kilobytes to 4 megabytes or more. This is the equivalent of increasing the computer's internal memory capacity from approximately 16 pages of information to more than 1,000 pages.

The development of more powerful and flexible computers has provided new opportunities to enhance teaching and learning. Computer-assisted instruction has advanced far beyond drill-and-practice and tutorial programs to simulations, problem solving, and discovery learning. Developers of educational software have used each upgrade in technology to deliver a more realistic educational program.

Today's school computers also are connected with such other technologies as video sources, audio sources, and telecommunications. The technologies used in education are so varied that the term "computer literate" has been replaced by "technology literate."

This fastback will examine how these varied technologies can be integrated into a connected educational delivery system using hypermedia. Hypermedia is not a single technology. It is an integrated electronic environment that combines text, audio, and video into one large file. Thus users can explore information about a subject or subjects using several technologies at the same time. The following chapters present a history and current overview of hypermedia, describe the hardware and software required for a hypermedia system, examine current hypermedia applications, and attempt to predict the future direction of hypermedia.

Hypermedia Overview

A major goal of educators is to provide students with a creative and meaningful learning environment. Technology has been an important part of this process. Early technological innovations used by teachers include the overhead projector, record player, film projector, filmstrip projector, and television. More recently, computers and computer-related technologies have appeared in the classroom.

An innovation that connects and integrates computers with other technologies is hypermedia. Hypermedia allows students to access information from many audio, video, and textual sources. Not only can students access various information sources, they also can create and control their own learning environment. This section will introduce the concept of hypermedia by presenting its history, definition, and implementation.

Historical Background

The concept of hypermedia was described in 1945 by Vannevar Bush, the director of the U.S. Office of Scientific Research and Development during World War II. In an *Atlantic Monthly* article, Dr. Bush described a device that could complement a person's memory. This imagined invention, called a "memex," stored and managed information quickly and easily. The memex had the internal memory of today's computers but accessed information the way the human mind does, by association. Just as the synapses in the brain form the complex paths of human thought, the memex contained intricate passages that enabled one topic to instantly change to another related topic as association would suggest.

While a student at Harvard University in 1965, Ted Nelson began work on a system that would logically link the materials from one class with materials from other classes. Nelson called that system "hypertext," a term defined as non-sequential writing. Nelson conceived of a computer system in which text would be displayed on an interactive screen that provided readers the option of branching to other appropriate texts. In 1968, a hypertext system created by Nelson and Andries van Dam was used to link documents for the Apollo moon missions. Another hypertext system, developed in 1968 by Douglas Engelbart, was used at Stanford Research Institute to link computer files.

The power of hypertext can be illustrated by visualizing this fastback on a computer screen. The reader requests the fastback, *Hypermedia: The Integrated Learning Environment*, and in a short time the Table of Contents fills the screen. After selecting the desired section, the designated text appears on the screen. If the reader encounters an unfamiliar word, such as *videodisc*, he can select the word and transfer to a glossary without leaving the computer to consult a dictionary. The information is connected to the fastback text by a logical pathway.

If the glossary definition is not sufficient, there is another pathway that leads to a list of articles about videodiscs. The chosen article appears on the screen and states the importance of having a high-resolution monitor. By selecting *high-resolution monitor*, the reader now accesses information concerning monitors. At any time, previous steps can be retraced or the person can return directly to the fastback. Hypertext presents the reader with choices. There is no requirement that the fastback be read in the step-by-step fashion outlined by the author. It is the user who controls the learning environment according to his interests.

Hypermedia is comparable to hypertext, except the pathways lead to video and sound in addition to text. Ted Nelson, who defined hypertext, also defined hypermedia. He envisioned a technology that linked the personal computer with film, video, graphics, sound, and text in an integrated system. The "hyper" part of hypermedia means "beyond," and "media" means "channels of communication." In a hypermedia environment, the user is able to proceed beyond text and access many media of information.

Hypermedia requires powerful computers and extensive data storage capacity. Although the technical foundation for hypermedia was established by the early 1970s, the cost of the technology restricted its use. A few companies and universities developed and incorporated hypermedia systems, but it was not until the late 1980s and early 1990s that the computer hardware for supporting hypermedia became readily available. Currently, there is extensive development of hypermedia applications; and many researchers believe that before the year 2000, hypermedia systems will be in many homes.

Definition and Purpose

Hypermedia is a system that uses computer hardware and software to link information stored on multiple types of media. Each component of stored information is called a *node*, and these nodes are connected by paths. There is no set path that users have to travel. The order in which a person proceeds from one segment of information to another is determined by interest, experience, and need.

To guide users among the different nodes, a hypermedia system must provide a map of the paths connecting the nodes and a method to travel these routes. This is accomplished by using on-screen *buttons*, which are *icons*, or drawings, that are activated by a cursor that is moved by a *mouse*. When the cursor is moved to one of the buttons and the mouse button is clicked, the hypermedia system displays the requested information. Each information node has several more buttons, which provide access to other units of related information.

A goal of hypermedia in education is to provide students with the capability to access information in a way that parallels the thought process. For example, an English student chooses to study the plays of Shakespeare on a hypermedia system. She enters the system and requests Shakespeare. In a few seconds, a picture of Shakespeare appears on her video screen with several labeled buttons. The student remembers that a movie she had seen, *West Side Story*, was derived from *Romeo and Juliet*. She uses the mouse to click the button for *Romeo and Juliet*, and in a few seconds a list of choices about the play appears.

The student decides to request the text of the play and to have the computer find the familiar line, "O Romeo, Romeo! Wherefore art thou Romeo?" Almost instantly, the screen displays the text of Act II, Scene ii, line 33. After reading for a few minutes, the student decides to request a video of Act II, Scene ii. After reading the text and watching the video twice, the student requests a commentary to help her understand the scene. The commentary mentions that *Romeo and Juliet* contains bawdy and suggestive dialogue. Thinking that this would be a provocative topic for her English paper, the student requests a list of lines from the play with these words and decides to print them for future reference. Again remembering *West Side Story*, she requests the soundtrack from the movie and relaxes for a few minutes. The interaction between student and hypermedia system continues until the student is finished. The hypermedia system has provided an extensive number of choices and placed the student in control.

Hypermedia in the Classroom

Since the early 1980s, educators have used computers to enhance learning. Computers continue to be used for reinforcement, remediation, enrichment, and classroom instruction. However, research indicates that poorly designed instructional software detracts from learning. Educators must evaluate software to determine if it is pedagogically sound. Well-designed instructional software involves students in the learning process, develops and improves thinking skills, simulates a process, and provides feedback. Hypermedia systems provide a learning environment that does all these things. In addition, hypermedia allows students to control their learning environment.

Teachers have incorporated hypermedia into the curriculum to improve the reading and writing ability of their students. In one activity, students are given information on characters and settings. The students then determine the direction of the story by making decisions for the characters. By determining what happens next, the students control the learning environment and become both readers and authors.

Other activities incorporate text, graphics, speech, and sound effects to involve the student in the storybook world. In one activity for elementary students, students select a character or object from a story. They can then explore the relationship between the chosen character or object and other characters or objects in the story.

As with other forms of computer-assisted instruction, the instructor must plan and evaluate the hypermedia system before implementing the application. In addition, information must be collected and organized into nodes; and the appropriate technology for accessing the different nodes must be organized and linked using a hypermedia authoring program.

The hypermedia authoring program is the electronic tool box of the hypermedia system. Its components – a database, word-processor, and graphics package – enable the developer of a hypermedia presentation to link and control nodes. The authoring program can interface the computer with compact disks, videodiscs, and any other type of information that the computer can digitize and store.

There are several authoring programs currently available for developing hypermedia systems. Most teachers and students discover that they are easy to use, and they provide an extensive variety of functions and visual effects.

The programs usually are organized in four major elements: page or card, folder or stack, button, and base page. The page or card is the fundamental unit of information. It is one screen of data and can include text, graphics, and buttons. The folder or stack is a group of pages that usually reflects some common theme. A button is the computer hot spot that, when activated by the cursor, connects pages, graphics, sound, and video. The base page, sometimes called "home," is the central screen that contains buttons that lead to every stack.

Using hypermedia applications in the classroom provides more information than using only printed text. A middle school teacher presenting a lesson about Alaskan wildlife can begin with a computer-generated map of Alaska. The students then see on the computer screen a list of Alaskan animals. By selecting the name of an animal, the class accesses pictures and videos of the animal. For example, the teacher may choose a Kodiak bear; and the computer will display the bear's picture with the appropriate text. By clicking another button, the hypermedia system presents a video of the Kodiak bear foraging for food. At the same time, the computer can play the growling sounds made by the Kodiak bear or any other appropriate audio presentation.

Instead of assigning term papers, teachers in schools with hypermedia systems can have their students develop hypermedia applications. For example, a class studying Renaissance art would create folders containing paintings by Ghiberti, Verrocchio, Michelangelo, and other Renaissance artists. These folders would be connected to folders containing analyses of the artist's paintings, which in turn can be connected to a laser disc and an audio digitizer that provides Renaissance music. This hypermedia program can become a part of the curriculum used and modified by future students.

All these multimedia peripherals are not necessary to develop hypermedia applications. For example, a hypermedia system that does not have a sound digitizer will not have an audio component; but it still can be an effective lesson delivery system. If at a later time the school acquires audio equipment, teachers or students can modify the presentation for sound using the authoring program. Educators, with just a computer and an interactive videodisc, have created and presented insightful and compelling hypermedia presentations.

Hypermedia Hardware

Effective hypermedia presentations do not just happen. Careful planning is required not only for developing presentations but also when acquiring the technology for a hypermedia system. This section will describe the principal computer hardware and peripherals needed for equipping a hypermedia lab. The emphasis is on providing information about the different functions and features; products of specific vendors are not evaluated. Because technology is changing so rapidly, all information and recommendations should be verified for timeliness. One never knows when a technological breakthrough will occur and render a type of equipment obsolete.

The Central Processing Unit

Inside the computer is its central nervous system, or *motherboard*. This is the main circuit board that contains the computer's memory chips, control circuitry, and expansion boards for connecting peripheral equipment. Also located on the motherboard is the central processing unit (CPU). This device, also known as a microprocessor, controls the computer and peripherals, processes information, and performs calculations. To evaluate the power of a computer and its ability to control a hypermedia system, the user must ascertain the CPU's register size, data bus size, speed, and memory capability.

The purpose of a CPU's register is to hold temporarily the information that is currently being processed. Registers are sometimes referred to as the "scratch pads" of the computer. The larger the scratch pad, the more information it can hold and the more powerful the computer. The size of the register is measured in *bits*. A bit is a single binary digit; and it takes eight bits, called a *byte*, to store a single character or a number from 0 to 255. For a hypermedia system, microprocessors with 32-bit registers are recommended. The 32-bit registers process more data at one time than the smaller registers, thus minimizing the time it takes to access and display information.

Another measure of the CPU's processing power is the size of the data bus. In a computer system, a bus is the set of pathways that connect the microprocessor to the computer's memory and its other components. The data bus is the connection that channels instructions and data between the CPU and the internal memory. Data bus size, like register size, is measured in bits and determines the amount of data that can be transferred at one time. For example, an 8-bit data bus is able to transfer one character at a time; a 32-bit data bus can deliver four characters at once. A 32-bit data bus is recommended for a hypermedia system.

The speed at which a microprocessor operates also will influence the performance of a hypermedia system. A CPU's speed is determined by its internal design and the speed of the system clock. The system clock is a crystal that vibrates several million times per second. It is connected to the microprocessor and coordinates the operation of the computer components. Every computer operation requires a certain number of clock ticks; therefore, the more ticks per second, the faster the computer can operate.

The computer's speed is measured by the number of times the clock vibrates per second. Vibrations are measured in *hertz* (Hz); one hertz equals one cycle per second. Because system clocks vibrate several million times per second, their speed is measured in *megahertz* (MHz), or millions of cycles per second. For a hypermedia system, a clock speed of at least 20 MHz is suggested, and a speed of 33 MHz is recommended.

Associated with each microprocessor is a maximum *random access memory* (RAM) size. The computer temporarily stores and retrieves needed instructions and information in its RAM. The larger the RAM, the more information the computer has immediately available.

Most modern microcomputers associated with hypermedia measure RAM in megabytes (Mb). One megabyte of RAM enables the CPU to instantly access more than one million characters. All microprocessors that meet the recommended speed, bus size, and register size for hypermedia can incorporate 16 or more megabytes of RAM. The minimum amount of RAM recommended for a hypermedia system is 4 Mb.

Storage Devices

Although RAM allows immediate access to information, it is limited in size and loses its data when the computer's power is turned off. To provide a permanent place for storing programs, presentations, and data, hypermedia systems use external storage devices. The major storage devices on a hypermedia system include floppy disk drives, hard disk drives, and optical disc drives. These devices provide almost unlimited room for data, since more storage devices can be added and the stored information remains unaltered until the user directs the computer to make changes.

All personal computers have a floppy disk drive that reads and writes the information stored on floppy disks. In the early 1980s, the floppy disk drive was the only storage device on personal computers. This limited the power of computer applications, since the first floppy disks could store only 140 kilobytes of data. Even if the computer had two disk drives, the disk in the second drive usually stored only the application's data files.

Most of the current computers use high-density floppy disks that can store up to 1.44 megabytes of information. In addition to the floppy disk, today's machines also have a hard disk drive for storing information. In a hypermedia system, the purpose of the floppy disk drive is to install the required programs and data onto the hard disk drive. After the information is installed, the floppy disks are stored in a safe place as a backup in case the data on the hard disk is destroyed.

The computer's hard disk drive provides the needed storage capacity for applications that require large amounts of data. Even the smallest hard disks store 20 megabytes of data, and disks that store more than 160 megabytes are available. In addition to providing more storage space, a hard drive maneuvers data faster than a floppy disk drive. Hard disks are made of more rigid material than floppy disks, so they can be rotated at a faster speed. This faster speed enables the hard disk drive to access and transfer the required data faster than the floppy disk drive. For a hypermedia system, a minimum of a 40 megabyte hard disk drive is recommended.

More recent storage devices used in hypermedia systems are optical disc drives. Optical discs are capable of storing in excess of 500 million bytes of information, the equivalent of 250,000 pages of text.

There are several types of optical drives, including compact disc read-only memory (CD-ROM); write-once, read many (WORM) discs, erasable optical discs, and compact disc-interactive (CD-I).

Introduced in 1985, the CD-ROM is a 12-centimeter disc that allows the user to read previously recorded information. To store information on a CD-ROM, a laser beam burns dimples of information into its surface. When the disc is placed into an optical disc drive, another laser reads the information from the disc. Many people are familiar with optical discs from the digital music recordings on compact disc (CD) or movies recorded on laser discs. As with music compact discs, once the disc is encoded with information by special laser equipment, the data cannot be erased or changed. A large variety of references have been published on CD-ROM, including encyclopedias, education indices, journals, almanacs, art, and many others. Most hypermedia systems include at least one CD-ROM drive.

Write-once, read-many (WORM) discs allow users to permanently record their own data on an optical disc. WORM disc drives are similar to CD-ROM drives except the WORM drive laser is powerful enough to write data by indenting the recording surface of the disc. These indentations are permanent, so the information recorded on the disc cannot be removed.

The major disadvantage of CD-ROM and WORM discs is that the information cannot be erased or changed. Erasable optical discs overcome this limitation by combining a laser and an electromagnet. The laser heats a spot on the disc that is then magnetized. These disks store more than 500 megabytes of programs and data, and some hold more than 900 megabytes. Erasable optical discs are an effective way for users of hypermedia to store information that will need to be updated.

One problem with erasable optical discs and WORM discs is the amount of time required to access data. With current technology, it takes eight times as long to access information from erasable optical discs and WORM discs than from a 160Mb hard disk. Future technological advances should reduce the information access time for these types of disc.

The optical storage medium most useful for hypermedia is compact disc-interactive (CD-I). With CD-I, the user is able to travel freely through databases that include full-motion color video, stereo sound, animation, and text. The CD-I disc player is able to access a single frame or track of information and begin at that point or freeze it on the monitor. If the frame is a picture, it appears frozen on the screen. With a high-resolution monitor, the pictures rival photographs; and the full-motion video provides a clearer picture than home VCRs. Icons on the screen enable the disc player to jump to any logically connected track on the disc, providing a complete hypermedia environment.

There are CD-ROM drives available that will read all the types of optical disc described above, and they even will play audio compact discs. Many vendors sell these drives as a package that includes the CD-ROM reader, stereo speakers, stereo headphones, and several of the CD-ROM interactive software titles described in the "Available Hypermedia" chapter of this fastback. The packages also include installation diskettes and all necessary cables. Before buying one of these packages, users should be certain that their computer satisfies the system requirements of the CD-ROM system and the included software. The system requirements usually are listed on the outside of the packaging.

Screens and Sound

In a hypermedia environment, the monitor displays the text and other images. Monitors are similar to television screens. They use cathode ray tubes to fire electronic beams at phosphorescent dots, or pixels, on the inside of the monitor screen. Energy from the beams excites the pixels, causing them to glow. By sweeping back and forth across the screen, the beams continually excite the pixels to create the desired image.

There are three basic considerations in choosing a monitor for a hypermedia system: color, sharpness, and size. As with televisions, monitors come in monochrome or color. However, a color monitor can display as few as two colors or as many as 250,000 different shades of color.

Measures used to evaluate the sharpness of a monitor are *dot pitch* and *resolution*. Dot pitch, or the density of the pixels, is the distance from the center of one pixel to the center of an adjacent pixel. The shorter the distance between pixels, the sharper the image. Resolution is the total number of vertical and horizontal pixels on a screen. Usually expressed in a form such as 320 X 200, this number describes a screen with a matrix of 320 horizontal pixels by 200 vertical pixels.

The most common monitors have screens that range from 9 to 19 inches, measured diagonally. As a rule, smaller monitors present sharper images, but the text and pictures are smaller. Since the density of the pixels is determined by the number of pixels per unit area, a larger screen size with the same resolution as a smaller screen will display larger images, but they will be more grainy.

When choosing a monitor for the classroom, a minimum size of 16 inches is recommended. The resolution of the monitor should be 640 X 350 or higher, with the ability to display a minimum of 256 colors. When the monitor is not able to display 256 or more colors, some full-color graphics from CD-ROM databases cannot be shown.

The computer used in a hypermedia system also should include sound input and output ports. With the sound input port, a person can connect a microphone or a stereo plug to record self-created sounds or sounds from such sources as a compact disc or audio cassette. The sound output port enables the user to connect speakers, amplifiers, headphones, or other audio output devices to the computer. Most sound ports accept standard stereo plugs found on headphones and cassette players.

Video and Audio Equipment

Teachers who intend to put together original hypermedia presentations will need scanners, video cameras, audio equipment, and digitizers. Scanners read text and graphics directly from a document and store them on a computer disk, where they can be edited by a standard word-processing or graphics program. Video cameras, audio equipment, and digitizers enable teachers and students to integrate original pictures and sounds into their presentations. The digitizers convert the pictures and sounds into a digital code that can be stored in the computer. At any time, the hypermedia system can access the code and present the pictures and sounds.

Hypermedia authoring programs offer educators a choice. They may assemble information for their presentations from prerecorded sources or generate it themselves. The hypermedia presentations should be more than flashy videos that only imitate video games. The presentations should impart knowledge. Properly designed hypermedia programs incorporate the principles of cognitive psychology, providing the student with both an exciting and instructive environment.

Available Hypermedia

The growing popularity of hypermedia has helped increase the demand for databases stored on optical discs. Using the extensive library of programs available on CD-ROM or CD-I, educators and students are able to instantly access and display volumes of information on their computer screens. Databases currently available include encyclopedias, atlases, literary study guides, almanacs, literary works, and many other publications. This chapter describes examples of the different programs available on optical disc and how educators are using them in hypermedia presentations.

CD-ROM Databases

Advertised as the CD-ROM product of the year, the entire *Academic American Encyclopedia* is on one 12-centimeter optical disc. The database includes more than 10 million words, 2,000 color graphics, and audio recordings. The desired text is accessed by article name, article subject, or by a word search. For example, students who are interested in John Kennedy can access all the articles that include a reference to the 35th president just by typing his name. The students also can access Kennedy's photo and hear a quote from his inaugural address. When the desired information is located, it can be printed or inserted into the hypermedia authoring program.

Atlas databases available on compact discs provide graphics for hypermedia systems. Most have full-color maps of all 50 states and almost every country. In addition to the maps, the atlases include a variety of statistical information concerning geography, people, government, and economy. Students can locate any city, state, or country by just typing the name. When used with a hypermedia authoring program, the atlas' maps can illustrate the countries involved in the Middle East crisis or provide a tour of the United States. One music class even used hypermedia to link each country's map with its national anthem.

Dictionaries are an essential reference on hypermedia systems. For example, medical students at Cornell University Medical College study the case histories of their patients using a hypermedia system. Instead of consulting a medical dictionary when confronted with unknown terminology, a student clicks the word and its definition from an illustrated medical glossary appears on the screen. From the dictionary, students have the option of returning to the patient's case history or accessing other available databases. Similar applications are used in other professional schools.

For hypermedia applications designed for undergraduate and secondary levels, *Webster's New World Dictionary and Thesaurus* is available on CD-ROM. The dictionary provides the complete definition of more than 170,000 words. In addition to the definition, the dictionary provides grammatical classifications, syllable breaks, usage rules, and usage examples. The thesaurus database enables the student to locate more than 300,000 synonyms and antonyms for selected words. If students require additional help with writing, they can access the CD-ROM's style guide or usage manual.

Another dictionary on CD-ROM is *Webster's New World Dictionaries of Quotable Definitions*. This database lists more than 1,500 notable quotations. With a hypermedia system, the quotation does not have to remain in text form. One secondary school history class developed sound recordings of needed quotations. Using a microphone connected to the computer's sound input port, students recorded quotations and stored the audio on the system. The quotations then were

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linked to the authors with an icon from the authoring program. A person researching Herbert Clark Hoover could access the pertinent articles from the encyclopedia, click an icon, and hear a passage from his New York campaign speech, his speech to the 1944 Republican National Convention, or any other prerecorded message.

Other examples of references on CD-ROM include the *Time Almanac*, a magazine rack, United States history, and a literary library. The *Time Almanac* CD incorporates the text of nearly 5,000 *Time Magazine* articles from 1923 to the present. Also included on the CD are 400 tables from the *U.S. Statistical Abstract*, U.S. historical documents, and the *Congressional Directory*. Magazine racks on compact discs include articles and abstracts from hundreds of magazines, journals, or newsletters. Many disciplines have their field's journals recorded on compact disc, thus reducing research and writing time.

The *United States History* CD includes the complete text of more than 100 U.S. history books, including photographs, maps, charts, and illustrations. To access the information, the user enters a topic, name, word, or phrase. On the *Literary Library* CD is the complete text of more than 450 titles from literature, philosophy, drama, poetry, science, and religion. These works also are retrieved by typing a word or a phrase. If the reader does not understand the literary work, the complete text of the *Monarch Notes* literary study guides is available on CD-ROM.

CD-I Databases

Introduced in 1991, compact disc-interactive (CD-I) offers advanced adaptability and simplicity of use compared to previous optical disc technology. The disc features its own operating system, which provides more than just a database. By connecting audio and visual features with computer data, CD-I has the components of a complete hypermedia presentation on an optical disc. The classroom teacher has the option of using CD-I presentations individually or integrating them into a larger hypermedia system.

Organizations producing interactive compact discs include the Smithsonian Institution, Children's Television Workshop, National Geographic, Rand McNally, and many others. National Geographic's *Mammals Multimedia Encyclopedia* is a fully developed hypermedia presentation. The database contains information on more than 200 mammals, including 700 photographs, 155 animal sounds, 45 full-motion movie clips, habitat maps, and more than 600 pages of text. From the main menu, the user selects the name of one of the mammals. The program then displays the mammal's name, its picture, and facts about the mammal. This screen also contains icons that allow the user to interact with the program and navigate through the data. If the sound icon is clicked, the computer simulates the animal's voice. Click the camera or film icon and watch color photographs or a video. The application also pronounces complicated words when they are selected.

Perhaps the hypermedia application that most excites educators is electronic textbooks on interactive optical discs. When literature classes study John Steinbeck's *The Grapes of Wrath*, they can use hypermedia on CD-I to link sections of the book to related information. These include Woody Guthrie songs, fireside chats by Franklin Roosevelt, newspaper articles, and other works that help students experience the Great Depression.

Stanford medical students are using an electronic textbook to study the human body. Starting with the full skeleton, a student can examine a particular joint or nerve. By electronically stimulating the nerve, the program illustrates how the nerve affects other body parts. Also at Stanford, students of Shakespeare use hypermedia to attend play rehearsals, investigate wardrobe and prop rooms, and compare different scenes from the plays.

Classroom Presentations

The *Intermedia* writing environment at Brown University allows students to connect information, annotate texts, and find other references when writing papers. For example, students in an English literature class are able to link English poets to information about their surroundings, works, and beliefs. Students and teachers at Brown University reported better understanding, writing, and class discussions as a result of using *Intermedia.*

Another writing environment is *Project Jefferson* at the University of Southern California. This project emphasizes writing related to constitutional rights and reference skills. Students navigate through such resources as a camera, notebook, note pad, encyclopedia, and citations. Once the information is acquired, students use the project's authoring tools to organize and write their papers.

At the George Peabody College for Teachers at Vanderbilt University, hypermedia programs are used in the preparation of preservice teachers. Mathematics and science educators at Vanderbilt University designed a set of video demonstrations that illustrate certain teaching skills and strategies. Initially the segments were placed on videotape to supplement classroom lectures. However, instructors reported that the tapes were difficult to use, because they could not be varied for different class activities. By recording these video demonstrations on an optical disc, faculty could instantly access any frame on the disc and change the order for displaying the frames; but their use still depended on classroom lectures or notes. To overcome this limitation, instructors used a hypermedia authoring system to link video segments to a descriptive text. The students now have a learning tool that is independent of the classroom activity or lecture.

One of these hypermedia presentations analyzes an activity lesson of a beginning and an experienced teacher. Video segments that illustrate the differences between these lessons are linked to teacher self-analysis, literature citations, and comments. The students control the learning environment by selecting the information they need to compare the different lessons. After using the hypermedia applications, students indicate that educational research and theory have more significance.

Future Directions

When the first personal computers were announced in the 1970s, few people recognized the profound effect this machine would have on society. Not only did microcomputers proliferate into all areas of business, industry, and education, the U.S. economy also shifted from an industrial society to an information society. Between 1950 and 1983, the number of people involved in the information industry rose from 17% to more than 65%. The information industry accounted for only 3.3% of the Gross National Product (GNP) in 1985; it now is more than 6% of the GNP. This growth is expected to continue; and before the year 2000, the information industry will be the world's largest business.

As the computer brought dramatic changes to information processing, hypermedia technology is expected to bring significant changes to education. Hypermedia technology can revolutionize a student's view of learning. The educational environment will advance beyond lectures, taking notes, computer-assisted instruction, and other common forms of teaching. Students will be able to access unlimited amounts of information from a universal library and enter computer-based worlds that imitate reality. This section presents the future direction of hypermedia and how it will affect the way people learn.

Edutainment

By integrating text, audio, graphics, and video, hypermedia presentations both entertain and educate. The word "edutainment" often is used to describe this mix of function.

Hypermedia systems will become common in homes. Future home and school hypermedia systems will access information from databases located throughout the world. Students will have the world's data at their fingertips by having ready access to magazines, audio and video, journals, and other reports in electronic form. Browsing through this universal electronic library will be similar to searching the stacks of a school library. Students will be able to find information that interests them almost as easily as they now play video games.

Virtual Reality

One of the most talked about extensions of hypermedia is virtual reality. A student enters a high school, observes the principal's office, walks the halls, plays basketball in the gym, and checks all the classrooms. All seems in order except the school does not exist in the physical world. It exists in virtual reality, a world that lives only in a computer's memory.

Virtual reality places students in a computer-generated universe while they are physically present somewhere else. Students will enter virtual reality by employing a head-mounted display (HMD). The HMD is a mask-like device that replaces the physical environment with the computer-generated virtual universe. By using two tiny video displays, one for each eye, the HMD projects an image that seems to surround the student. Since each eye has a different view, the projection appears three-dimensional.

By attaching sensors to the head, hands, and legs, the computer is able to sense body movement and alter the image based on that movement. The student in the virtual world can turn around, look up or down, and see what is there. Sensors on the feet and hands enable the student to navigate the virtual world and manipulate virtual objects. Headphones or speakers provide computer-generated sounds.

Students who enter this virtual world could find themselves "touring" any city in the world. They could view the Washington Monument, the buildings of the Smithsonian Institution, and the Capitol in Washington, D.C. Each student would decide which buildings to visit and what to explore; while one student visits the Capitol, another may be taking the elevator to the top of the Washington Monument. Each student decides a destination based on his interests and needs.

Classes will be able to travel to virtual reality destinations as a group. The teacher's and each student's head-mounted display will be connected to the same computer. If the computer modeled Paris, a French teacher would be able to direct students through the streets of Paris. The group could travel by boat down the Seine and eat lunch at a French cafe, where students would order their lunch in French. After the teacher finishes the tour, students are free to explore Paris on their own or exit virtual reality and return to the physical world.

Eventually, there will be "virtual reality rooms" for students. Although that may sound like something out of science fiction, a current example of a virtual reality room is a flight simulator. Pilots in a flight simulator enter a computer-controlled environment that simulates an aircraft. Using computer-generated graphics, video, sounds, and movement, pilots are positioned in a virtual reality that creates the sense of flight.

Students entering these rooms will choose from numerous virtual realities to match their educational needs. From the inside of an atom to the edge of the universe, students will be able to experience whatever environment they require.

Conclusion

When microcomputers were first introduced in the schools, many teachers were concerned that they would be replaced by a machine. Instead of superseding the classroom teacher, computers illustrated the need for competent teachers who could design meaningful learning environments. Research demonstrated that incorporating technology into the classroom could both increase and decrease the amount of learning. Only when the classroom teacher evaluated the technology and rationally incorporated well-designed computer applications into the curriculum did learning increase.

Although computers have proliferated into all areas of our schools, studies indicate that less than 10% of the teachers are using them in meaningful ways. However, the public may demand better use of computers. For example, a high school advanced placement teacher developed a hypermedia system for his classroom using computer equipment that was not being used by other teachers. He used the technology to reinforce his lectures and provide enrichment opportunities for his students. Parents of students not in his class complained that their children also should benefit from the hypermedia system and that it was not ethical for only the advanced placement class to have access to the technology. The advanced placement teacher was willing to train other teachers to use hypermedia, but only a few teachers attended the training sessions.

Without teacher involvement, the best-designed technology and applications will do little to increase learning. Instructors who overcome their anxiety about technology will discover that these electronic tools enrich student learning. Commitment by teachers should be supported by institutional commitment. Administrators must provide resources for equipment, technical assistance, faculty development, and release time for course and curriculum development.

Educators claim that one of their goals is to provide students with the best-possible learning environment. By continually assessing technology and its implications for learning, teachers will be able to design curricula today that will best prepare their students for the future. By incorporating hypermedia into the curriculum, teachers allow students to control access to information. This gives them a sense of ownership in the ideas and concepts that are represented, thus advancing the learning process.

Resources

Organizations

The International Interactive Communications Society
2298 Valerie Court
Campbell, CA 95008-3723

Minnesota Education Computer Consortium
6160 Summit Drive North
Minneapolis, MN 55430

The Society for Applied Learning Technology
50 Culpepper Street
Warrenton, VA 22186

The Videodisc Design/Production Group
KUON-TV
University of Nebraska-Lincoln
P.O. Box 83111
Lincoln, NE 68501-3111

The Videodisc Compendium
Emerging Technology Consultants
P.O. Box 12444
St. Paul, MN 55112

Journals

Electronic Education
1311 Executive Center Drive
Suite 220
Tallahassee, FL 32301

Electronic Learning
730 Broadway
New York, NY 10003-9538

Hypermedia
500 Chesham House
150 Regent Street
London, England W1R 5FA

Incider
80 Elm Street
Peterborough, NH 03458

Journal of Educational Multimedia and Hypermedia
Box 2966
Charlottesville, VA 22902

Journal of Research on Computing in Education
2700 Bay Area Boulevard
Box 509
Houston, TX 77058

Technology and Learning
2451 East River Road
Dayton, OH 45439

T.H.E. Journal
150 El Camino Real
Suite 112
Tustin, CA 92680-3670

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235. Legal Basics for Teachers
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