Computer-based Instruction

During the past decade, a quiet revolution has taken place in radiologic science classrooms across the country. Computers and videodiscs have gained new ground as legitimate instructional tools, establishing themselves as valuable supplements to traditional learning methods such as lectures and textbooks. Computer-based learning has brought an added dimension to the radiologic science classroom experience, benefiting students and educators alike.

Advantages of Computer-based Instruction

Carlton[1] notes that although students enrolled in subject areas such as liberal arts are not especially helped by computer-based instruction, students enrolled in health professions programs can benefit significantly from it. First, CBI provides students with material directly relevant to their discipline. Second, CBI is competency-based, a familiar format for most students in allied health disciplines. And third, health science students usually are familiar with computers because they already are involved with them in the clinical setting.

Carlton also notes that CBI probably will fail if students are not oriented to hardware and software and if there is no mechanism for providing assistance as problems arise.[1]

A number of recent studies have analyzed the effectiveness of CBI as an instructional tool:

- Bruce,[2] in clinical laboratory science, found computer-assisted instruction to be more effective than a correspondence course and as effective as a workshop in providing continuing education.
- Rowe,[3] in radiography, found that a CAI program on the x-ray circuit was an effective tool in increasing the knowledge of learners.
- Moran,[4] in physical therapy, found that hypertext CAI was superior in teaching wound physiology and care to physical therapists.
- Jones,[5] in respiratory therapy, found that taking traditional notes did not help learners using an interactive videodisc lesson. He

concluded that this technology might require emphasis on a different type of note-taking.

In a meta-analysis of studies of CBI in the health professions, Cohen and Dacanay[6] reviewed achievement effects and other factors such as long-term retention and attitudes toward content, instructional method and computers. They analyzed 47 studies, 10 of which were classified as allied health studies. A previous review of 65 studies showed an average effect size of 0.63, which favored CBI over traditional teaching methods.[7]

In 32 of the 47 studies, students using CBI had higher examination averages; their averages were significantly higher in 13 of the studies. In studies in which an effect size could be determined, students using CBI scored at the 66th percentile of the students in the conventional group.

Computer-assisted Instruction

General Aspects

The level of interaction between the learner and the computer is important. Increased levels of interaction should permit greater learning. For example, many educational programs are converting to a Windows interface because they assume that this interface is more "user-friendly" for the student.

But it is not the technology itself that makes a CBI program an effective tool; it is the ability of the learner to interact with the learning situation. This is the measure of the effectiveness of any learning tool. Thus, two factors are important to remember: First, learner training in the technology can be as important as the technology itself; and second, anything a computer can do, a human can do. Unless the computer is more efficient than the alternative learning method, it lacks value as a learning tool.

Tutorials

Tutorials are one of the most common types of computer-assisted instruction. In their simplest form, tutorials are "page-turners" similar to textbooks, interspersed with predetermined questions and responses.

Table 1
Basic Components of a Tutorial*

Component	Important Aspects
Learning objectives	1. Identify target audience. 2. Provide five to eight objectives per 30 to 45 minutes of instruction.
Opening screen	1. Prepares the student for what lies ahead. 2. Addresses the sequencing needed (e.g., can the student start with any lesson?). 3. Identifies any prerequisite study needed.
Main menu	Should have the following options: 1. Instructions. 2. Lesson content. 3. Self-test. 4. Bibliography and references. 5. Quit option.
Content outline	A good program features three to eight discrete lessons.
Lesson text/content	Should consist of three screens: 1. Text only. 2. Interactive questions and answers, ideally found about every third or fourth screen. 3. Graphics, including line drawings, maps and charts.
Self-test assessment items	Typically multiple choice, although true/false and matching also are used. Should directly assess material covered in the lesson.
Glossary	Covers unfamiliar terms; should be available to the learner at all times during the tutorial.
Bibliography and references	Identifies additional resources; should be timely, although classic works also should be included.

* Adapted from: Kruse M. *Interactive Tutorial Developmental Guidelines for Authors.* Edwardsville, Kan: Educational Software Concepts Inc. Used with permission.

More complicated tutorials offer analysis of the response to a question, branching and parallel sequencing of text, supplementary and remedial work and allow students to structure the work to meet their needs, rather than being specifically sequenced.

The one-to-one tutoring and feedback provided by a tutorial can make it an excellent tool for improving student knowledge (cognitive domain). Table 1 outlines the basic components of a tutorial program as a guide to writers and/or reviewers of programs. For writers, these components should be developed in chronological order.

Drill-and-Practice (Review)

As the simplest form of CAI, drill-and-practice programs also are the most common, although this is changing with increased technology and sophistication. Drill-and-practice programs work well in increasing student knowledge through repetition, usually through questioning. Students can take as much time as they need or repeat sections, helping to individualize instruction, but a drill-and-practice program really is not much better than traditional methods of instruction such as flashcards or certification examination review texts.

The advantage of drill-and-practice programs typically lies in the automatic feedback they provide to learners, relieving them from having to look up the answers in the back of the book.

Simulation

A computer simulation attempts to reproduce real-life situations and asks the student to provide data that may alter the outcome of the procedure. In the health professions, allowing a student to attempt patient care without "experimenting" on actual patients is ideal.

Simulations can bridge the gap from abstract knowledge presented in class to actual performance by letting the student learn the difference between good and bad decisions in patient care. Simulations also can bring about higher-order synthesis and analysis skills.

Most simulations feature a combination of text and graphics, using dialogue and inquiry to guide the student through a situation. In addition to text-based simulations, the potential is great for videodisc technology to provide more "realistic" simulations.

Games

A variety of computer games may be used as learning tools. Games typically are used to teach content, such as medical terminology. Occasionally, they also involve the learning processes such as decision-making and communication skills.

Utility/Problem Solving

Programs designed for general use by the public also can be used in the learning process. Spreadsheet programs, because of their ability to provide "what if" situations, sometimes are used to teach management processes; database management programs can be used to collect information; and word-processing programs can be used to help students become more effective writers. D'Souza[8] evaluated the use of e-mail to provide students with class information and assignments, finding clear differences in favor of the e-mail group.

Statistical programs can be effective in teaching students about the research process and the results of research. Walker, Stewart and Avdevich[9] taught health students information on HIV infection within the context of a unit on statistical computing, literature searches and modeling health systems. Fifteen Likert-type items were presented to provide information on each student's perception of HIV infection risk. Student responses were presented to the class using Quattro graphics, as well as compared to responses by experts in AIDS.

Computers and software are bringing about an environment in which mediation effects are as important as increases in productivity.[10] Word processing provides an environment conducive to working with words; graphics packages provide an environment conducive to making effective presentations. For students learning management concepts, for example, using a spreadsheet gives a sensory presence to data that, according to Brinkman,[10] "not only becomes easier but (is) more likely to lead to insight."

The various types of CAI are compared in Table 2. Each is useful in certain situations. Some programs combine the various types in one module; for example, an x-ray circuitry program by Corectec of Athens, Ga., combines tutorial, simulation and drill-and-practice.

Table 2
Comparison of the Types of Computer-assisted Instruction*

Type	Purpose	Goal	Control
TUTORIAL	Present new content; review known material in a different format.	To acquire basic facts and concepts (knowledge).	Primarily computer and author of program; additional learner control is desirable.
DRILL-AND-PRACTICE	Reinforce and practice content that already has been learned.	To help fix facts and concepts in the learner's mind (knowledge).	Primarily computer and author of program; additional learner control is desirable.
SIMULATION	Present and manipulate a model (typically text-based) in real life in which the student may make decisions.	To integrate skills and knowledge; to develop problem-solving skills (generic and specific); to provide insight.	Primarily learner.
GAMES	Provide a competitive situation with a defined outcome.	To develop insight into various strategies for reaching a defined goal; to provide "fun" in learning.	Primarily learner.
UTILITY/PROBLEM SOLVING	Task-oriented.	To acquire knowledge, insight about content and processes.	Primarily learner.

* Adapted from: DeTornyay R, Thompson MA. *Strategies for Teaching Nursing*. 3rd ed. New York, NY: John Wiley and Sons; 1987. Used with permission.

Computer-managed Instruction

Of course, computers also may be used to manage the individual classroom or an entire educational program. Carlton[1] provides a list of software designed to function as gradebook spreadsheets, databases, test item bank construction and grading and analysis as examples of CMI. Also often included in this category are software programs that permit interactive programming (authoring software) without a knowledge of programming.

A database of more than 80 software programs designed for interactive programming is available from the National Library of Medicine. To obtain a copy, send a PC-formatted disk, specifying the AuthorBase database, to Educational Technology Branch, Lister Hill National Center for Biomedical Communications, Mail Stop 43, National Library of Medicine, Bethesda, MD 20894.

Videodisc-based Instruction

Videodisc technology has the potential (as does CD-ROM) to be the most affordable and flexible instructional tool available to health educators and students. Videodisc offers many advantages:

- Any of the 54,000 images on a 12-inch disc can be selected instantly. This storage capacity is equivalent to 1700 books. Images stored on videodisc can be accessed in about 1 second.
- Action video segments with sound can be added without changing equipment; in addition, the use of two sound tracks means that the same program could be developed for two different audiences.
- Segments can be rerun at the touch of a button, and it is possible to switch back and forth between slides and motion segments. This ability is valuable in teaching a topic such as radiographic positioning — which requires both the performance of a psychomotor skill and an understanding of the resultant image — because it allows the student to view cause and effect.

The cost of the media can be reasonable. The "Slice of Life VI" videodisc, for example, costs about $300. This investment makes 30,000 images available at the touch of a button. That compares to

30,000 slides at $1 per slide (minimum) plus slide trays, not to mention trying to find Slide No. 28,536. Videodiscs are ideal for images such as radiographs, anatomical drawings and microscopic sections. Duplicating 30,000 images is much costlier in terms of both the media and time involved compared to a $300 to $700 videodisc.

A complete videodisc system without a monitor can be purchased for less than $1000. A television can be used as a monitor for the system, although higher resolution monitors are available. The videodisc player can be linked to a personal computer for interactive video instruction. The minimum requirement typically is a videodisc player, a monitor, a barcode reader (unless computer-assisted instruction is used) and a videodisc.

The videodisc itself is an 8- or 12-inch platter, similar in appearance to an LP record. It has two sides that are read by a laser beam. Because nothing comes in contact with the videodisc while it is playing, discs are considered virtually indestructible if handled with a reasonable amount of care.

Discs have been designed according to an industry standard that allows any system to play any videodisc, enhancing compatibility. According to Chew,[11] industrial players are preferred to those developed for general markets. Industrial players are equipped with built-in interfaces and do not have to be retrofitted; consumer players typically do.

Two types of videodiscs are available. With a constant linear velocity (CLV) disc, video frames are recorded in a single, continuous spiral track. This type of disc can hold up to 60 minutes of video per side but is not interactive. Also, still images cannot be seen without special added circuitry. The CLV disc is the type used for films and concert videos.

Constant angular velocity (CAV) is the type of disc used in interactive video because it can provide single frames. (See Table 3.) A constant angular velocity disc rotates at a constant speed of 800 rpm. Each frame occupies one of the concentric circular tracks on the disc. It is capable of interactive mode and freeze-frame. A 12-inch disc also can hold up to 30 minutes of video per side.

Table 3
Levels of Interactivity with Videodisc

Level 1

Controlled with an infrared or wired remote control or barcode reader. Frames or video sequences are selected by the user with these controls. All branching is under the direct control of the user.

Level 2

Makes use of a player that has a programmable memory. A computer program is encoded on audio channel 2 of the videodisc and loaded into the player's memory. Branching is controlled by the program in the memory of the videodisc player.

Level 3

Requires connecting the videodisc player to a personal computer, offering a high degree of interactivity. Branching is controlled by the computer and directed by the responses of the user.

Level 4

Also requires a computer. Computer instructions are linked with the videodisc, making possible high-speed access to large amounts of text and graphics.

Table 4
Comparison of Slides, VHS and Videodisc

	Slides	VHS	Videodisc
Still images	Yes	No	Yes
Video images	No	Yes	Yes
Audio	No	Yes	Yes
Random sequencing	Limited	No	Yes

Use of Videodiscs

Videodisc format may be used as a tool to enhance lecture presentations or as an interactive program used by students independently, without the assistance of an instructor. When used as a lecture tool, the videodisc player typically is treated much like a slide projector, with the images displayed on a monitor. If the lecturer places barcodes in the lecture along with his or her notes, they can be used to select still images and video sequences. Using a video projector allows the lecturer to project images on a large screen, just like slides. Table 4 compares videodiscs with slides and VHS technology as a presentation tool.

Many variations can be used to implement videodisc technology for individual instruction. At the simplest level, students work with a book that includes both text and barcodes. They review the material by reading the text and then scanning the barcodes to display images related to the text. This method is also very compatible for continuing education needs.

If a post-test of the material is required, the videodisc can be used as part of the exam simply by incorporating barcodes into the text. In this manner, questions can be posed about a particular image or a video sequence.

Programs can be produced from a videodisc using barcodes printed on a dot matrix or laser printer. Barcode software for personal computers is available at prices ranging from $100 to $1000.

In Cohen and Dacanay's[6] meta-analysis of studies of computer-based instruction in the health professions, the two studies showing the largest effect sizes were nursing studies that used interactive video to simulate clinical settings. One of these studies used a CVIS instructional program on therapeutic communication.[12] Cohen and Dacanay note that such studies show the qualities of CBI that make it an effective instructional tool — "active involvement, directive feedback and realistic stimuli."

According to Cronin and Cronin,[13] interactive video enhances learning because of its interaction with the learner, facilitating the instructional process. In physical therapy, Barker[14] found interactive videodisc to be as effective as lecture-demonstration in teaching psychomotor skills.

In radiology, Chew[11] notes the following uses of videodiscs for instruction, all of which may be implemented by barcode or CAI:

- Conversions of existing teaching files (collections of radiographs) to videodisc format.
- Reference encyclopedias.
- Textbooks.
- Single-subject focused tutorial.
- Interactive atlas of anatomy.
- Interactive self-evaluation quiz.

Chew also notes that the CD-ROM eventually will supplant the videodisc as the dominant means of digital education in radiology. A number of CD-ROM programs are under development now; they are attractive due to the smaller size of the media and the more common availability of CD-ROM players.

Although videodiscs can be developed "in-house," in a college or university setting, this is still rare due to cost, time constraints and the problems associated with copyright infringement. Improvements in technology and a loosening of copyright constraints could help alleviate these problems.

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