DOCUMENT RESUME

ED 329 248 IR 014 913

AUTHOR Lowenstein, Ronnie; Barbee, David E.
TITLE The New Technology: Agent of Transformation.
INSTITUTION Department of Labor, Washington, DC. Office of Strategic Planning and Policy Development.
PUB DATE 14 Nov 90
NOTE 11p.; Based on "A Report on the Nationwide 'State of the Art' of Instructional Technology," by David E. Barbee and Gabriel D. Ofiesh, March 1990. Prepared for The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor.
PUB TYPE Information Analyses (070) -- Viewpoints (Opinion/Position Papers, Essays, etc.) (120)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Business; Distance Education; *Educational Technology; Elementary Secondary Education; Expert Systems; Hypermedia; Interactive Video; Microcomputers; Military Training; Postsecondary Education; Systems Approach; *Technological Advancement

ABSTRACT

New technologies available today can be used to improve accountability, establish and manage learning environments, and extend contextual learning. To harness these technologies, however, beliefs and practices must be redefined in education, training, and human development. If technology is developed according to a systems approach, new technological tools and resources can be applied creatively to the solution of educational challenges. Some of the new tools currently being used in educational, business, and military educational and training settings include microcomputers, interactive video, authoring systems, hypermedia, expert systems, and distance education. Technology tools of the future include optical magnetic storage, laser cards, voice recognition, and virtual reality. (5 references) (DB)

THE NEW TECHNOLOGY:

AGENT OF TRANSFORMATION

Based upon: *A Report on the Nationwide 'State of the Art' of Instructional Technology*, by David E. Barbee and Gabriel D. Ofiesh, March 1990.

Prepared for: The Secretary's Commission on Achieving Necessary Skills (SCANS)
U.S. Department of Labor

Prepared by: Ronnie Lowenstein, Ph.D. & David E. Barbee, Ph.D.
Center for Advanced Learning Systems
ETA/OSPPD, Room N-6511
U.S. Department of Labor
Washington, DC 20210

November 14, 1990

INTRODUCTION

Today's technologies are the agents that can be used to transform the nature of both school and work. Our premise is that:

The new technologies are vital to:
____improve accountability
____establish and manage learning environments (as opposed to teaching environments)
____expand the dimensions in which we think and learn
____extend contextual learning that builds on understandings of real-world situations through the use of interactive scenarios.

Need for Transformation

Numerous reports indicate that our present and future workforce lacks the skills required to work and live productively in a rapidly changing, increasingly technological society. If we are to confront the specific education and training needs of our workforce, choosing a prosperous future of high skills over low wages, we must transform our failing systems. Schools and businesses both have a stake in developing the workforce of the future.

Education and training must become responsive to changing societal needs and reflect the emerging research findings on how people learn most effectively. Such findings challenge the traditional formal approach to instruction in our schools and businesses that has caused artificial distinctions between knowing and doing, education and training, academic and vocational education, and school-based and work-based learning. In short, schools and businesses need to change what, how, when, and who they teach.

Rethinking and Restructuring Training & Education

Developers of human resources currently possess the tools and techniques capable of transforming education and training. But to harness the technologies, we need to rethink some of our beliefs and practices. This requires a redefinition of education, training, and human development. It also requires a shift from a focus on teaching to a focus on learning, with learning under control of the learner. Moreover, it necessitates the creation of learning environments that:

recognize that intelligence and expertise are built out of interaction with the environment and not in isolation from it;
take into consideration the individual characteristics of the learners who will be using them;
provide alternative learning strategies;
establish learning as the constant and time as the variable;
reflect cognitive research findings, including:
1) that individuals actively construct knowledge and meaning; they learn best when they are taught in meaningful contexts of situations, activities, and problems; and
2) people are more likely to transfer knowledge and skills appropriately when they acquire them in such settings;
focus on performance outcomes and take into consideration the learners' prior knowledge.

It is our belief that new technology has a vital role to play in this transformation in how we educate and train our most valuable asset, our people. In this paper we define technology and describe its process and impact; briefly explore the new tools useful in human resource development; and answer the question of who is using the new technologies and with what results in business, in government, in the military and in education.

A DEFINITION OF TECHNOLOGY

Often people describe the new tools, such as microcomputers, videodisc players, hypermedia, expert systems and other developments, as *technologies*. In this paper, the term is used to describe both, the tools, and the processes that facilitate the establishment of learning systems. An operational definition used by the authors describes technology as tools, process, material resources and creative human intelligence applied to the solution of practical problems.

The process of technology is the *systems approach*. Not simply a sequential series of steps, it is a dynamic, iterative process. Initial objectives are modified as a result of later analysis; constraints may be modified as a result of seeing their impact on the cost of the system; the proposed solutions will be modified as a result of trade-off studies; the entire system may be redesigned as a result of the operational evaluation. Hence, at every step of the way, the results are analyzed to verify or modify earlier decisions. It is in this rigorous process that tools are forged into technologies for addressing the challenges facing education and training.

THE IMPACT OF TECHNOLOGY

New technology is already having a significant impact on our education and training systems. Computers and the interactive systems they control (videodiscs, CD-ROM and others) are finding their way into classrooms, offices, and plants across the country. But the surface of its potential has hardly been scratched. New technology is often used to automate the past before new, more creative uses are found; this seems to be a recurrent pattern of human behavior. It is in this stage that we find ourselves, but with evidence that things are changing.

Technology is:

becoming increasingly transparent; individuals will interact with systems without being aware that learning is occurring and that their behavior is being modified.

changing the way we think. According to *Ofiesh: With the speed, power and storage capacities of the new microcomputers and the sophistication of the information programs, we are on the threshold of having knowledge presented to us in a way that emulates our thinking, rather than forcing us to think the way information is presented.*

expanding human capacity, enhancing human reasoning ability, and facilitating information processing that promotes new insight and depth of thinking.

becoming more commonplace throughout our society, with the result that the learning processes are also becoming more embedded in society -- in the workplace, home, shops, library, and even in our cars.

Tools and process, then, must be combined with resources and applied creatively to the solution of practical problems. The Appendix contains *The Characteristics of a Good Instructional System*, that has been used by the authors as a guide for reviewing the utility of new tools and techniques in forging appropriate technologies for facilitating learning.

THE AGENTS OF TRANSFORMATION

Following are descriptions of tools that can be used for human resource development:

The Microcomputer
The Videodisc
Authoring Systems
Compact Disc-Read Only Memory (CD-ROM)
Compact-Disc Interactive (CD-I)
Digital Video Interactive (DVI)
Hypertext/Hypermedia
Expert Systems
Distance Learning
Learning Stations
Other Promising Tools

You will notice that some of these tools are machines, others are software, while still others are complete "systems." These categories are somewhat arbitrary but the tools that they represent, in the opinions of the authors, hold substantial promise in human resources development.

The Microcomputer. At the heart of the new technologies lies the microcomputer. It has made possible the creation, delivery, and management of learning environments that provide textual, audio, video, and graphical stimuli to the learner, and over which s/he has control. Simulation, tutorials, practice, sophisticated branching, manipulation of data and information are available in a highly *interactive* mode.

The computer is not just another tool, as it is sometimes described. A computer can program and manage a CD-ROM, videodisc player, expert system or other tool, functioning as part of a *learning technology*. When used in this way, computer-based systems can not only deliver training, but also act as *tools of learning* that can help humans gather, manipulate relevant information, and even "create" intelligence. Computer-based systems hold the promise of creating more "ideal" instructional systems.

The Videodisc. Videodisc players employ a laser to access video images stored on the 54,000 frames available on each side of a videodisc. Two independent sound tracks may be recorded, with additional audio storage available by using some of the video frame space.

Most videodiscs used in the more sophisticated instructional applications are controlled by a computer. These *Level III* applications use the computer to access frames, motion sequences and audio, while overlaying computer-generated text and graphics for maximum instructional utility. The user interface can be touch screen, light pen, mouse, keyboard, voice recognition, or all of the above, or some other device that represents, for example, a control panel, welding station, or simply the top of a table or desk.

Unlike the digital data stored on a hard disk or a CD-ROM disc, the videodisc stores its data in analog form. This means that the image or sound itself can not be altered, since it is not in a form the computer can recognize.

Authoring Systems. In the past, the cost of programming the computer for instructional use was very high. In addition to an instructional designer, a computer programmer was required. A few years ago, authoring systems were developed that enable instructional developers, without knowledge of a computer language, to generate text and graphic lessons on the computer. They can call upon the still frame, motion and audio sequences of a random access videotape or videodisc player, or they can call on other peripherals that are driven by the microcomputer for sound, visuals, text, graphics or other electronically-stored material.

Compact Disc-Read Only Memory (CD-ROM). The CD-ROM is but one of a family of "compact discs." The 12 cm. disc can store up to 550 megabytes of digital data (about 250,000 typed pages or 1,500 floppy disks). Since the data on the disk is in digital form, it can be read and manipulated by a

microcomputer. For education and training purposes, this means we can store pictures, text, graphics, sound, and even color video sequences.

Compact-Disc Interactive (CD-I). This system incorporates a microcomputer and a CD-ROM drive in a stand-alone unit, providing random access to compressed graphics, sound, and both still and a small amount of motion video. The data format is proprietary, so that CD-I discs can only be used on CD-I players. Originally targeted for the home market, the developers, Philips and Sony, are now marketing to businesses. At present few applications exist but there are a number under development.

Digital Video Interactive (DVI). DVI is a set of algorithms for the compression and decompression of digital signals, expressed in a chip set on a PC board. It allows real-time presentation of up to 72 minutes of full-motion, full-screen digital video, audio and graphics from a CD-ROM or comparably large storage device. Because all signals are digital, every screen pixel, and every second of sound may be adjusted by the user, giving a highly interactive tool.

Hypertext/Hypermedia. Hypertext is a way of organizing, storing and retrieving textual information through nodes and links. Hypermedia extends the hypertext concept to include pictures, graphics, sound, and/or motion video in addition to text.

In **Hypertext**, each "node" (a word, words, or concept) can be linked easily to other information, and information can be accessed easily via these nodes and links. The user can therefore follow almost any conceptual path either he or the developer chooses.

In **Hypermedia**, links can be made not only among documents, but also among pictures, sounds, video sequences, or whatever media are available in the machine environment being used. Videodisc and CD-ROM are commonly used media devices in Hypermedia.

Expert Systems. "Intelligent" computer software systems in which the specialist "knowhow" of experts is stored in the form of factual knowledge and experience. They make use not only of facts and rules, but also of heuristics and vague knowledge. Expert systems are capable of independently drawing conclusions from the knowledge they have via a set of rules, i.e. they are able to solve problems.

An expert system consists of a knowledge base, an inference engine and an interface with the user. The knowledge base is a set of thousands of rules and decisions that make up the expert's knowledge. The inference engine is a sophisticated computer program which contains the general problem-solving knowledge and processes the domain knowledge. The inference method is the technique used by the inference engine to access and apply this domain knowledge. The user interface is generally a keyboard and program that makes it very easy for the individual to interact with the "expert" as "naturally" as possible.

Distance Learning. More than simply physical or electronic delivery of a local training or educational program to another location, distance learning is an interactive phenomenon, where human resources (learners, experts, teachers, others) come together with material resources (text, audio, and visual databases; predesigned packaged learning environments; etc.) to "learn."

There has been substantial growth in the use of distance education for business and education. Through television, computer and video conferencing, and other distance techniques and media, more synergistic and cost effective human development experiences are provided.

Learning Stations. Increasingly companies, schools, and government agencies are developing learning stations at the worksite to deliver interactive assistance and training. Combining the features of a number of tools, this interactive learning station, can provide *embedded training* that acts as an extremely effective environment for increasing worker and student productivity.

Learning stations that combine CD-ROM, videodisc, hypermedia, expert systems, and other elements with the computer are particularly suited to delivering:

simulations
tutorials
help
surrogate travel and exploration
learner controlled lessons

Other Promising Tools. There are a number of tools that hold promise for human development, but as yet have not been broadly applied. Listed below are some that can be imaginatively designed and developed to create more effective learning environments:

Write Once Read Many (WORM). While CD-ROM discs are pressed at the factory, information on WORM discs is placed there by the user. The special drives needed to read the WORM discs are expensive; yet, they are particularly suitable for uses requiring archiving and audit or revision trails.

Optical Magnetic Storage. The magneto-optical discs differ from CD-ROM and WORM in several important ways: they can be erased and rewritten, and they can hold up to one gigabyte (1 billion bytes) as compared to the mere 550 megabyte capacity of CD-ROM.

Laser Cards. Looking very much like a credit card, a laser card or smart card, holds up to 4 megabytes of information in read-only and/or erasable form. It is being used in several test locations, such as in the state of Michigan where each person carries his personnel "credentials" on the "Opportunity Card" or with policy-holders of Blue Cross-Blue Shield who carry medical information with them on their smart card.

Voice Recognition. Systems now exist that, when "trained" by the user, can function with a 1,000 or more word vocabulary. An interactive videodisc (IVD) training simulation developed by the Technology Innovations in Medical Education (TIME) Project at the National Library of Medicine, uses voice recognition to give medical students control over the care of various video-patients during their stay in a hospital. The design of the discs enables the medical students to simulate patient-doctor interactions, gather information, develop differential diagnoses, make medical decisions, prescribe treatments, and witness the consequences of their actions.

Computer Graphics. Tremendous advances have been made in this field in recent years. Sophisticated graphics can be produced on the desktop, at an increasingly affordable price for training developers. A high level of realism, including three dimensional graphics, can be achieved. This has lead to the development of multimediated computing, with desktop publication of multimediated training systems imminent.

Neural Networks. A developing branch of Artificial Intelligence (AI) in which circuits are designed to replicate the way neurons act and interact in the brain.

Suplee describes this new form of computer architecture: *It differs from traditional system design as a conference call differs from a walkie-talkie, and from traditional system behavior as an infant from an adding machine. It makes mistakes, finds solutions that are "pretty good" rather than perfect, keeps running even when "badly hurt," and organizes itself according to its own idiosyncratic rules.*

Virtual Reality. Technology-enhanced environments for learning that are responsive to the users. As described by *Churbuck*:

> *Why settle for the real thing if you can live in a dream world that is safer, cheaper, and easier to manipulate? Computers will soon make such a world possible.*

Just point a finger and fly through cyberspace. In one demonstration program, reality consists of a 3-D image of an office, complete with desk and desk chair, drawn using AutoCAD. When the user slips on the Eyephones and Dataglove, he walks, in effect, into that drawing. His hand becomes visible on the eye screens as a disembodied computerized hand, floating a few feet in front of his face.

There are three basic commands: Point a finger and you fly in that direction; make a fist and you can pick up whatever object the fist touches; open the fist and the object will fall or fly away in any direction.

WHO IS USING THE NEW TOOLS

Military. The Armed Services have historically been the first to take advantage of developments in educational technology, including television, language labs, simulators, early computer assisted instruction, and currently, AI and interactive systems. The trend continues today with financial allocations for IVD training stations, called EIDS (Electronic Instructional Delivery System), CD-ROM, and other technologies amounting to several billions of dollars.

Contrary to what has happened in education, once committed to an innovative methodology, the military forges an orderly transition to the new training technology from the research and development efforts to its operational application. In the "research to implementation model," the military

first familiarizes all instructors and training supervisors with the concepts, terms, principles, techniques, and procedures associated with the new tools;
then, it develops an in-house capability at each training facility to produce courseware;
next, it develops experimental instructional materials;
conducts formative and summative evaluations of the effectiveness of these experimental programs; and
finally determines the feasibility of further expansion, exploitation, and sophistication of interactive media.

Business and Industry. The trend in industry toward the cost-effective use of the interactive learning environments is becoming well-established. In these circles, traditional classroom procedures, never having much merit, are on the way out. Interactive learning stations or other interactive learning environments prove to be less costly than on-the-job training and more cost-effective than traditional classroom training.

Examples include:

IBM, Xerox, and other major corporations increasingly shifting delivery of their training to the microcomputer. IBM is projecting that by the late 1990's, their classroom training will be reduced to less than 25% of total training, with new technology making up the difference. Training of aircraft designers, pilots, telephone installers, bank tellers, security guards, medical students, and even sales personnel.

Government. The U.S. Departments of Labor, Agriculture, Commerce, Energy and Treasury have been experimenting with new technology in training and education for some years. Noteworthy are the use of interactive learning environments by:

Agriculture, both in their Extension Service and the Forest Service
IRS, with their Automated Training System (ATS) Learning Centers at 169 sites and their movement toward "work-based training;"
Labor's Employment and Training Administration's use of computer-based learning at several Job Corps sites, in Job Training Partnership Act Programs, and with their new "work-based learning" focus of the Office of Work Based Learning.

Government, like education, is slower to adopt new practices, but as requirements escalate, with attendant demand for change, new technologies are being applied. With microcomputers permeating

government offices, there will soon be a discovery that it isn't only a tool of productivity, but perhaps the most efficient and effective learning environment, for many purposes, yet devised.

Education. Although behind other sectors in implementing new technology, education is doing some significant things. An education focus having major national impact is the STAR Schools project supporting various innovative "distance learning" applications of technology at sites throughout the country.

The classroom and administrative uses of the microcomputer have increased dramatically in the past decade. Through creative applications of technology, students may:

observe an underwater archeologist at work in the Mediterranean Sea,
explore the ruins at Palenque in Mexico,
interact with the characters on Sesame Street and participate in the Voyage of the Mimi.

No longer does the student watch passively; he is now a full participant, *actively involved and controlling the action.*

THE RESULTS

One of the first questions people ask about new technology is, "Does it work?" Research and experience in business and in the military has shown that use of well-designed technological solutions results in improved learning outcomes in shorter time-- workers acquire competencies that carry over into improved job performance and productivity.

Since we know that learners do indeed learn in different ways, at different rates and with different strategies, it appears appropriate to design learning systems that provide different strategies, individual pacing, and differential prescriptions based on the learner's unique learning characteristics.

The Military. The Institute for Defense Analyses conducted a meta-analytic review including 31 studies of interactive videodisc instruction (IVI) in the military, industries, and higher education. It investigated factors such as effectiveness, cost-effectiveness, time on task, retention, and overall applicability to current and future Defense training and education requirements. This review, the *Potential of Interactive Videodisc Technology for Defense Training and Education*, was presented to Congress in February 1989. It concluded that:

IVI was more effective than conventional approaches.
The more interactive features that are used, the more effective the resulting instruction.
More positive results were obtained for IVI applications in higher education settings than in military and industrial training.
Directed, tutorial approaches are more effective than free-play simulations in IVI.
IVI is equally effective for imparting knowledge and improving task performance skills.
IVI is a viable, cost-effective alternative in training and should routinely be considered as an option in the design of military training programs.
IVI can significantly increase the efficiency with which training time is used by increasing opportunities for practice and requiring students to participate more actively in instruction.
Retention under IVI is at least equal to or greater than that found under other instructional approachers.

Business. Federal Express, after extensive comparison of IVD to classroom instruction, has wholeheartedly endorsed the use of IVD. They found that with CD-ROM/IVD technology:

Employee errors were reduced by an average of 30% and incorrect student responses were reduced by 40%
A 60% reduction in employee training time was also achieved;
Direct cost savings of $100 million in terms of travel, employee time and training control is projected over five years, despite the system and development costs of $40 million. *Indirect* cost savings may be greater.
A 10% improvement in worker productivity and performance is estimated, saving the company approximately $150 million.

McDonnell-Douglas, in using IVD workstations in training their designers and draftpersons on the Computer Aided Design and Drafting system (CADD) in their St. Louis Plant, found:

that course content, previously requiring 12 hours of instructor-led, hands-on training, is now completed in less than 8 hours by all students.

videodisc trained students were more advanced than those previously trained by traditional techniques, and had greater retention.

the cost per student hour dropped from $15 in 1984 to $12.07 in 1987; these costs include both instructors' salary and students' compensation for training, which is given during normal working hours.

the CADD courseware showed an excellent return on investment; not only was the cost of six IVIS workstations and the courseware paid back in 16 months, but the corporation anticipates saving over one million dollars in training costs over five years.

the system reduced the teaching load on instructors and relieved a critical problem of not having sufficient computer graphics terminals available for training use.

Evidence of satisfaction in applying new technology may be found in other companies like IBM. After 20 years of study and implementation, they now deliver 50% of their education and training using interactive learning (rather than teaching) environments that use new tools and techniques, *and* they project that by the mid-1990s, this figure will rise to 75-80%.

Education. *DeBloois*, after examining a number of studies of the effectiveness and efficiency of learning systems developed using IVD, concluded:

The technology is versatile-- its application appears suitable, both for skill training and concept learning.

The ability to scale down, compress and control time and distance through simulation may well be one of the most attractive features of IVD training.

Target learners enthusiastically accept IVD, enjoying the benefits of learning in an individualized mode, working at their own pace, and exercising personal control.

Computer-based instruction is successful in supporting both group and one-on-one instruction.

A growing number of studies report greater learning achievement, better retention, and often more effective problem-solving ability, with no increase in time required.

Lowenstein, in an analytic review and Delphi study of IVD in public schools, concluded that:

IVD can best be understood within its context of use. The introduction of IVD into public schools is difficult; it represents major changes and innovations related both to individuals and to organizational structures.

Successful implementation of IVD in public schools demands a dual concern -- concern for the relationship of the technology to individuals and concern for the culture of the institution it will serve.

The ability of public schools to assimilate interactive technology is a far greater problem than that of technological development; the current structures and traditional attitudes within public schools appear incompatible with widescale use of IVD.

The Delphi findings concerning barriers to school use of IVD indicated a more complex reality than is usually delineated: While economic considerations are important, the attitudes and infrastructure of schooling on adoption and implementation act as equally important barriers.

If the potential of IVD is to be actualized, comprehensive and coherent strategies are needed at all levels of organization.

Bibliography

Barbee, David E. and Gabriel D. Ofiesh. *A Report on the Nationwide "State of the Art" of Instructional Technology*, Washington DC, 1990.

Churbuck, David. *The Ultimate Computer Game*, Forbes, February 5, 1990.

DeBloois, Michael. *The Use and Effectiveness of Interactive Videodisc Training, A Status Report* (ISBN 0-938907-10-7), Future Systems, Inc., P.O. Box 26, Falls Church, VA 22046.

Lowenstein, R. *Interactive Videodisc Technology in Public School Settings: An Analytic Review and Delphi Study*, Ann Arbor MI: UMI Dissertation Information Service, 1988.

Suplee, Curt. *Outlook*, Washington Post, Oct. 5, 1986.

U.S. GOVERNMENT PRINTING OFFICE 1991 0—863-795