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ABSTRACT

The effects of instructional technology on learning are determined by the extent to which hardware and software amplify the basic capabilities of an instructor. Experience indicates that rational considerations such as cost-effectiveness are not usually the primary factors in making decisions about use of technology in training. Most large organizations are using one or more technologies in some aspect of their training activities. Interactive video, computers, and computer-based training are common; teleconferencing is just beginning to be used. Among the major obstacles to technology use are lack of instructor knowledge, lack of money to buy hardware or develop materials, lack of time to develop alternative training approaches, and poor reliability and usability of training systems. The following emerging developments are likely to affect training in the future: (1) widespread ownership of portable workstations; (2) electronic classrooms designed to support instructional technology; (3) products and systems with embedded training; (4) use of intelligent tutors and expert systems; (5) forms of interactive multimedia with more capacity; (6) hypertext systems; and (7) digital networks. A major area of research development is development of authoring systems and expert systems. Current and future applications of instructional technology relate to the following issues in the training field: retraining, basic skills, team training, participative management, and technology transfer. (Appendixes include a 41-item bibliography and information on military applications of instructional technology.) (YLB)

INSTRUCTIONAL TECHNOLOGY AND WORKER LEARNING NEEDS

Contract Report

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All opinions in this report are those of the authors and do not represent the views of the Office of Technology Assessment, U.S. Congress

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INSTRUCTIONAL TECHNOLOGY
AND WORKER LEARNING NEEDS

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Industry, Technology & Employment Program

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CONTENTS

SUMMARY OF FINDINGS, CONCLUSIONS, & RECOMMENDATIONS

Instructional technology of one form or another is becoming widely used in the training world. The cost of the hardware (e.g., personal computers, videodisc players) has become affordable to most large corporations. Studies have shown that instructional technology usually produces superior results to classroom instruction in terms of training duration, degree of learning achieved, and employee satisfaction. More significantly, the use of technology for training is often more convenient to deliver and administer than classroom instruction. In some organizations, instructional technology is providing a way to link training with job performance. Instructional technology is being embraced by many companies as a means of improving the overall quality of their operations.

Of the many instructional technologies currently in use, three media seem to be the most promising: videotape, interactive videodisc, and computer-based training. In addition, simulators play an increasingly important role in military training. Many large corporations are experimenting with televison and teleconferencing, but at the present time neither of these two technologies is used extensively. On the other hand, two low-technology media, print and overhead transparencies, are widely used in all training activities.

Instructional technology is most commonly used in large corporations and DOD agencies. Large organizations can afford the substantial start-up costs associated with technology and have the large student populations that result in favorable cost-benefit outcomes. Medium sized companies can afford to use video and computer based training because these two forms of instructional technology have low entry thresholds and a substantial amount of courseware is commercially available. Small companies do not currently use instructional technology to any significant extent partly due to the costs involved but mostly because they conduct little formal training.

Obstacles to the broader use of instructional technology in the near-term include: (i) lack of experience using technology on the part of instructors, (ii) lack of budgeted funds to initiate technology-based approaches, (iii) lack of time to prepare and develop courseware, and (iv) unreliability and poor usability of technology. Each of these major obstacles is being addressed by some component of the instructional technology world (universities, vendors) and by the development of better hardware and software.

There are many new developments underway that are likely to catalyze the broader use of instructional technology as well as provide new capabilities. Personal computers are becoming more portable, more powerful, and less expensive. As a larger and larger pecentage of the population owns such a machine, its use for training at work and at home becomes very natural. Organizations will no longer have to buy the computers needed to deliver instruction. Electronic classrooms will make the use of technology much easier. Embedded training will make instruction an integral component of most computer systems and equipment. Intelligent tutors and expert systems will make online training more responsive to individual needs. Furthermore, advances in optical storage will allow most forms of online instruction to be multimedia presentations. Hypertext/Hypermedia will make huge databases of information easier to learn and use. Finally, the presence of wideband digital networks will allow all of this online information to be transmitted to any location at an affordable cost.

Some long-term barriers to the use of instructional technology must be surmounted in order for all of these future developments to be realized: (i) the lack of sophistication of training professionals (both instructors and managers) about instructional technology, (ii) the low emphasis placed upon technology by senior management and HRD departments, and (iii) the inadequate amount of federal funding allocated to R&D for research in instructional technology. Unless training professionals know how to use, develop materials for, and manage instructional technology, it will not become a mainstream training approach. For instructional technology to become institutionalized, it must be a priority of both staff and training management. And, if we are going to discover the good and bad ways to use technology in training, there must be active and ongoing research programs. To date, DOD has supported almost all R&D in the instructional technology area. This needs to continue or another patron needs to take its place. It is a mistake to think that private industry will take on this role.

One other element that will strongly influence the success and rate of development of instructional technology is the continued evolution of authoring software. A tremendous amount of time and skill is required to create any form of interactive instruction. The availability of authoring software that can both speed up the process and minimize the experience required is a very important factor in making instructional technology affordable and cost-effective. Many current authoring systems are quite powerful and easy to use. They make the development of CBT or interactive video accessible to almost any instructional designer. Research is now focused on the development of automated instructional development systems that will help designers in more of the analysis and design tasks that are not presently automated. In addition, there is work being conducted to develop expert systems for instructional development that will compensate for limited experience designing instruction. Once these software tools become widely available, the time and skill required to develop materials for interactive instruction should decrease further.

It is important to examine how well current and future efforts in the instructional technology domain relate to major issues in the training field. Some of these issues include: (i) retraining, (ii)basic skills, (iii) distributed training, (iv) participative management, (v) team training, (vi) multiculturalism, (vii) technology transfer, and (viii) HRD training. This study concludes that instructional technology can have a favorable impact on all of the first six issues provided that adequate attention is given to the last two. In other words, as long as the results of research and demonstration projects involving instructional technology are widely disseminated and HRD professionals are properly trained about instructional technology, the major issues of workplace training in the coming decades will be addressed.

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I. INTRODUCTION

Scope & Organization of Report

This report discusses the current and future use of instructional technology in the workplace, concentrating on applications in the manufacturing and service industries. It also encompasses military applications of training technology since much of this work has immediate or long-term relevance to the civilian sector. The purpose of this analysis is to identify developments and trends that are likely to have a major impact on the way training is conducted and hence the overall effectiveness of the U.S. workforce.

The report is organized into five sections: (1) an Introduction which discusses the nature and history of instructional technology as well as cost-effectiveness, (2) The Present which provides an overview of current applications of instructional technology in the workplace, (3) The Future which summarizes R&D projects in instructional technology, (4) Development Tools which describes current efforts in the automation of training development, and (5) Critical Issues which discusses major training issues and how instructional technology relates to these issues. An Appendix discusses military applications of instructional technology.

The Nature and History of Instructional Technology

Instructional technology is easily misunderstood even within the training community. The biggest misconception is that technology equates to hardware. There are many serious consequences of this misconception: (1) when people plan for or implement technology-based projects they fail to account for all the non-hardware aspects, (2) by focusing on hardware only, they miss the components that determine success, and (3) expectations about the use or effectiveness of technology are unrealistic. Indeed, hardware is often a very minor component of technology applications -- simply the obvious tip of the iceberg that gets all the attention but has little to do with the total impact. While the hardware is a necessary component of instructional technology, it is not sufficient to ensure successful training.

A good way of understanding instructional technology is to grok the following equation:

Training Accomplished = Skills/Knowledge x Hardware x Software

This equation states that the amount or quality of training accomplished is a function of the instructor's or instructional designer's skill and knowledge multipled by hardware capabilities multiplied by the software that drives the hardware. In other words, the effects of instructional technology on learning are determined by the extent to which hardware and software amplify the basic capabilities of an instructor. If the instructor has very limited skills/knowledge, there is little to amplify; on the other hand, if the instructor is very talented, technology can result in a much bigger effect. The equation also says that if the contribution of the software component is small, so is the relative effect of either the instructor or hardware. All three components must be strong to get a good result (i.e., effective training).

This equation explains why the common misconception about instructional technology is so serious. If people fail to realize that hardware and software only amplify instructor abilities, they miss the central role of instructors and instructional designers in making technology work. If they miss the fact that software is a multiplier of hardware, they do not appreciate why so much time and money must be spent on the software if the hardware is to do anything worthwhile.

It is important to realize that the instructional skills/knowledge to be amplified can take many forms. The content of the training materials must be relevant, accurate, and complete. When the instruction is in self-study form, it is critical that it include many examples, evaluation activities, and be interesting. The design of effective self-study materials requires considerable instructional design skill. Furthermore, the training materials must take advantage of the unique characteristics of the media involved. When managing a training course involving self-study materials, the instructor must be able to tutor students when they have problems and motivate students to complete the course. In other words, there are a wide range of instructional skills and knowledge that must underly any use of instructional technology. We will elaborate on this expertise needed in Chapter IV.

The equation above does not address some of the other important aspects of making instructional technology work. For example, instructional technology is an innovation and hence involves the process of social and organizational change. Successful implementation of technology requires a great deal of deliberate political engineering to change existing policies, procedures, and roles. Another important aspect of making technology work is good administration and management. As in most other domains of human endeavor, instructional technology projects are successful because of careful and systematic planning and supervision.

The history of instructional technology provides ample data on these points (e.g., Cuban, 1986; House, 1974; Saettler, 1968). During this century, there has been a succession of new technologies that promised to "revolutionize" education and training: film, radio, television, teaching machines, programmed instruction, computer based instruction, interactive videodisc, teleconferencing, etc. While each technology has been used effectively, none has produced the kind of revolution that was heralded. This is because most practitioners (including instructors and training administrators) have a very superficial (technology = hardware) understanding of instructional technology. One finds that the projects where technology has been applied successfully consist of people who have a sophisticated view of technology -- a view that includes these tenets: (1) the central role of instructors in wanting to use and knowing how to use a technology, (2) the importance of doing a good job on the software, and (3) the necessity of getting everyone involved including the employees who will use the training, their managers, and the senior executives of the organization.

Cost-Effectiveness

Cost-effectiveness evaluations of technology-based training approaches often reflect the simplistic view of technology as hardware. The most common form of evaluation is the comparative study between a course taught via classroom instruction (the "conventional" method) and the same course taught via technology. The big problem here is that to really make an appropriate comparison, you may need to change the teaching strategy and the content as well as the media. If you do this, the two courses are not likely to teach the same thing and so the comparison is faulty. Hence many such comparisons have an inherent Catch-22.

Furthermore, such comparative studies are based on the idea that there is a simple dicotomy between classroom instruction and self-study instruction involving technology. In fact, there are many variations involving the use of technology in the classroom by the instructor as well as group activities associated with self-study courses. In a typical training course, there will be many types of instructional activities, some of which will be more suited to the use of technology and some which will be more appropriate to lectures or discussions. Comparative studies that examine a single module of a course using a stereotyped distinction between classroom lecture and technology-based instruction are not likely to reveal anything of significance.

These fundamental problems aside, there have thousands of such comparison studies conducted, especially for CBT and interactive videodisc. Orlansky & String at the Institute for Defense Analysis have summarized hundreds of studies of CBT, flight simulators, and maintenance simulators conducted in the military (see Orlansky, 1986) and shown that as far as military training is concerned, technology can save time and result in better achievement. Fletcher (1989) summarized the results of 31 studies of interactive videodisc training (15 military; 3 industrial; 13 higher education) and concluded that interactive videodisc was more effective than conventional instructional in almost all cases (the average effect size was 0.51). Fletcher observes that the more interactive features used, the more effective the videodisc training appeared to be. DeBloois (1988) also provides a cost-effectiveness analysis of interactive videodisc and reaches the same conclusions as Fletcher.

Table 1 summarizes some of the potential benefits that can result from the use of any type of instructional technology. The qualification "potential" is important because none of these benefits will automatically occur through the use of technology. In order to realize any of the benefits listed in Table 1, the correct combination of instructional

Table 1

POTENTIAL BENEFITS OF INSTRUCTIONAL TECHNOLOGY

1. Reduced learning time - typically 30-40% less time is required compared to classroom instruction.

2. On-demand training - instruction is available when and where the employee needs it. No need to wait for/travel to a scheduled class. Increases access to training for the disabled.

3. Increased motivation - students usually report that they find technology-based training more interesting and enjoyable than classroom lectures.

4. Increased achievement - when corrective feedback or a mastery learning strategy is provided, students often show better test results, retention, or job performance from technology-based training.

5. Better quality control - since training is delivered in the same way each time, it can be much more consistent and reliable than classroom instruction.

6. Increased safety - employees can learn about and practice dangerous procedures without a safety concern.

7. Greater flexibility - fluctuations in number of trainees or their backgrounds can be accommodated more easily than with classroom instruction.

8. Improved accountability - automatic collection of data on student performance can verify training accomplished and identify training problems.

9. Faster revision - to the extent that the instruction is delivered via a networked system, changes and updates to information can be made immediately.

10. Reduced delivery costs - once developed, technology-based training is likely to cost less relative to labor intensive classroom instruction. Also can be used instead of expensive equipment.

skills, hardware and software is necessary as explained in the previous section.

One of the most robust findings regarding the cost-effectiveness of technology-based instruction is that training duration is reduced 30-40% relative to the classroom. This result seems to occur because most people can learn faster by themselves than the slower pace set in a class. It also appears that the design of course materials for technology-based approaches is typically better and results in faster learning. A 30-40% reduction in training time can be translated into substantial cost savings in terms of reduced time away from the job or producing results sooner in a job. Alternatively, organizations take advantage of the time reduction by teaching more in the same training duration.

Note that the time savings outcome is not especially important in higher education where there is no incentive to get students through training as soon as possible. In academic settings, only improved achievement counts (if anything does). While the evidence suggests that technology-based approaches can result in improved achievement, it is a more variable effect than time savings. As already discussed, effective use of technology depends upon the skills of the instructor and the software involved. These are the two factors that most often account for the variablity that results in achievement outcomes.

The ultimate irony about cost-effectiveness studies of instructional technology is that they probably make very little difference in the adoption of technology in many training settings. Decisions to adopt technology are typically made on non-rational grounds. In my experience one of the most common reasons for using technology is to allow an individual or organization to give the appearance of being at the forefront or "leading edge" of things. Managers frequently do not care if the technology actually works (hence the lack of interest in evaluation) as long as it gets used and attracts positive attention to them or their organizations. We could call this the "peacock" basis for using technology.

An even more compelling reason to use technology is simple convenience. When it becomes administratively easier to provide instruction via technology relative to classroom instruction, it becomes the training method of choice (regardless of effectiveness). We see this happening in many large companies now for Computer Based Training. Since most employees have a terminal on their desk, it is easier and less expensive to provide training via the tube than require employees to go to classes. The quality of the training may or may not be as good as in the classroom but it is the most convenient alternative. Indeed, convenience is undoubtedly one of the key ingredients of a successful technology.

<u>Summary</u>

Instructional technology is often equated solely with hardware neglecting the importance of instructional skills and software. Historically this misunderstanding has limited the effective use of technology in training. Some technologies such as computer-based training, interactive videodisc, and simulators have been evaluated extensively with the results showing that they can be highly effective. The most common benefit of using technology is to reduce the training duration by 30-40% relative to classroom instruction. Experience indicates that rational considerations such as cost-effectiveness are not usually the primary factors in making decisons about the use of technology in training. Instead, technology is often used because it creates visibility or simply because it is convenient.

II. INSTRUCTIONAL TECHNOLOGY IN THE WORKPLACE: THE PRESENT

In this section of the report an attempt is made to chronicle the current use of instructional technology in the workplace. After some general remarks about the extent and nature of usage, a number of different technologies are discussed along with case studies that illustrate specific applications. Background reading about the technologies discussed in this section can be found in Gagne (1986), Gayeski & Williams (1985), Johnston (1987), Niemi & Gooler (1987), Schwier (1987), and Kearsley (1984a). Appendix A provides a more detailed analysis of current military applications.

Extent of Use

It is difficult to get solid data on the extent to which instructional technology is being used in industry for a number of reasons. In most large corporations, decisions to use technology for training are often made on a departmental basis and hence there is no organization-wide accountability. Many applications of technology are considered experimental and hence not included in descriptions of operational training activities. At the other end of the extreme, some technologies (e.g., overheads, video) are so common that nobody bothers to count their use. In general, most organizations do not have very extensive data about their training activities (e.g., how many students they teach, how many classes, etc.) unless this data is required by government regulations.

While instructional technology of one form or another may be common in large organizations, it is relatively non-existent in small businesses. Actually, formal training of any type is absent in most small businesses. Small businesses tend to rely on on-the-job apprenticeship for employee training. To the extent that any training materials are used, it is likely to be the printed documentation provided by vendors with equipment. There may be some use of CBT courses on personal computers to learn computer-related topics (e.g., a specific word processor) and video cassettes for sales, customer service or management skills since personal computers and VCRs are relatively common even in small companies.

The one exception to the lack of formal training in small businesses comes at companies that are franchises. In this situation, the parent organization can afford to develop materials that are distributed to each franchise. Fast food companies such as Dominos Pizza, FoodMaker, and Southland Corp (7-Eleven) make extensive use of video and are experimenting with interactive videodisc to train basic employee skills at the work site (see Domino's case study in Chapter V). To the extent that many small businesses are franchises, this may be one of the major ways that instructional technology affects small business.

Instructional technology is probably more prevalent in military training than the civilian sector. Certainly, the Department of

THE BUSINESS DISC (TBD): INSTRUCTIONAL TECHNOLOGY FOR SMALL BUSINESS

To date, instructional technology has had relatively little impact on small businesses since they tend to do little formal training and spend little on training materials. One way that instructional technology can impact small businesses is when it is used by the various government and professional organizations that small businesses interact with.

An example of such a program is The Business Disc (TBD), an interactive videodisc developed by the Maryland State Dept. of Education. The program provides an introduction to the factors involved in starting and operating a business such as type of ownership, location, salaries, capital investment, and cash flow. The program includes a simulation of the first year in business based upon decisions made in the planning stage by the user. Typical business issues are presented: rent increases, personnel policies, late deliveries, theft, and disgruntled customers. The workbook accompanying the disc provides a full range of advisory services (e.g., legal, insurance, real estate) and record-keeping forms for business planning.

The TBD program has been used at small business development centers and community colleges across the country. For example, New York state has decided to implement IVD workstations in 21 small business centers in order to make TBD program available. The program helps prospective business owners analysis their business idea and develop a business plan. At the community college level, the program is being used in business and marketing courses to allow students to try out business ideas they learn in classes.

People and students who have tried the program are very enthusiastic about it. The simulation allows the user to investigate their business ideas in a realistic setting. Even experienced business owners report that they learned things from the program.

Source: R. France. Experimenting in business with IVD: An evaluation. Instruction Delivery Systems, Sept/Oct 1989.

Defense conducts more research in instructional technology than private industry (e.g., see Ellis, 1986; Seidel & Weddle, 1987). The high interest in instructional technology from the military is due to a number of reasons: (i) it is a technology-based culture, (ii) there is an acute need for cost-effective training, and (iii) they can afford the high start-up costs associated with hardware and software/courseware development. There are many examples of large training programs using technology in the U.S. military ranging from interactive videodisc to simulators (see the EIDS JSEP and SIMNET case studies later in this report). Still, the overall bulk of military training today is still conducted by classroom instruction or on-the-job apprenticeship unaided by any form of instructional technology.

Why is No-Tech So Compelling?

Before surveying the various types of instructional technology in use, it is worth spending a little time examining why so much teaching uses no technology at all (beyond a blackboard/flipchart or the actual equipment). This question is fundamental to understanding the preconditions for the use of technology in training.

In order to use any form of technology in training, the instructor must be familar and comfortable with such technology. However, most instructors (like their students) have had very little exposure to technology in the classroom; they teach as they were taught. Even instructors who have had one or two courses about instructional technology do not usually have sufficient "hands-on" experience to confidently use it themselves in the classroom or design such programs. So, we have a self-perpetuating cycle of non-technology use that is hard to break out of.

The second reason why technology is not used is that it requires a significant amount of preparation time and development effort. Most instructors do not have the time (or are too lazy) to prepare the necessary courseware. For example, consider the amount of time required to develop a set of good quality overheads compared to writing out a set of notes. The former must be done at least a few days before in order to allow time for the transparencies to be made; the latter can be done an hour before the class. Futhermore, considerable thought must be put into the visual layout of the overheads which is not necessary for personal notes. When we move up to more sophisticated media such as video, computers, or teleconferencing, the amount of preparation and planning involved goes up appreciably.

Another aspect of developing technology-based training materials is that they often require a team approach. However, teaching has traditionally been a solitary affair. Indeed many instructors are attracted to this profession because they like to work alone and tend to be very independent. However, the development of a video or computer-based instruction program is likely to require the collaboration of two or more people with different kinds of technical skills. While it is true that some individuals can complete the entire production cycle of a video or computer program themselves, this takes a considerable breadth of skill and knowledge about instructional technology.

Finally, it must be pointed out that a large percentage of the people involved in training have no formal background or preparation in instruction. It is common for people to be placed in training roles because of their content expertise, because they excelled at their jobs, or because they do not fit anywhere else in the organization. Because they lack any formal preparation to teach, they have no conception of the various instructional methods or media that can be employed.

It is important to realize that even when well-designed self-study materials are available, instructors and training managers play a critical role in the successful use of these materials. If they do not understand the media involved, if they cannot modify the materials, and if they cannot participate in the development of new materials, they are not going to use instructional technology well or at all. One of the enduring myths of the instructional technology field is that once the training is "packaged" in some form of self-study course, there is no significant need for instructors. Nothing could be further from the truth.

To summarize, the no-tech approach to training persists because most instructors do not have enough experience using technology in the classroom to try it, because they do not or will not take the time necessary to prepare technology-based learning materials, and because many instructors are profoundly ignorant of even the most basic teaching techniques. Until ways are found to circumvent these considerations, instructional technology is likely to remain in the background at most organizations.

Why Lo-Tech Is So Successful

Despite the somewhat bleak picture of technology use painted in the preceding section, there are some technologies that are widely used in training, namely print and overhead transparencies. Almost every training course uses print materials in some form and most classrooms have an overhead projector. Let's look at these two technologies in detail to find out what makes them so successful.

As a technology, print has been around for a long time (at least 4 centuries). Printed materials are familar to everyone, almost everyone (in developed countries) can read, and there is a well developed infrastructure for the publishing business. Printed materials are highly reliable, they are relatively inexpensive to develop and reproduce, and they are very convenient (i.e., portable, compact). Almost any kind of subject matter can be presented via print and there are vast amounts of material already available in printed form.

Given these characteristics, it is no wonder that print is the main medium for instruction. In fact one puzzles over why we should need anything else. There are a few limitations: (i) when the amount of information to be learned becomes extensive, printed media become very bulky and difficult to search through, (ii) print is incapable of presenting information in dynamic or interactive form, (iii) it takes time to physically distribute printed media. Unless the instructional circumstances involve one of these limitations, there seems to be little reason to go beyond printed materials. Indeed, this has been the case.

Overhead transparencies are widely used in the training world (much less so in higher education). The prime rationale for their use seems to be to present more information in a shorter time. In essence, they are a labor-saving device for instructors since they save them the trouble of having to write the same things on the blackboard each time they teach. They allow color to be used, as well as the presentation of illustrations, photographs, or graphics. They also allow the flexibility to use prepared materials or create on the spot. Overhead projectors are fairly reliable (except for bulbs burning out), affordable, and standardized. They do not require any training to operate and the skills involved in developing good overheads are easy to learn (e.g., use large print).

It is helpful to summarize the attributes of print and overhead transparencies that make them successful as instructional technologies: (1) affordability, (2) reliability, (3) flexibility, (4) standardization, and (5) ease of use. Technologies that lack these characteristics are not likely to be widely adopted and

SIMNET - Networked Simulators
Filling a Gap in Military Training

In military training, one enduring problem is providing enough hands-on practice in the operation and repair of equipment -- including weapons, support vehicles, telecommunications gear, and logistics hardware. In many cases, it is simply too risky, too expensive or not physically possible to use the actual equipment for training. Consequently, the military has been a big advocate of using simulators as much as possible.

Even with simulators, there has always been a weak spot in hands-on training -- team skills and group coordination. To be effective on and off the battlefield, soldiers must be able to function as a unit. Conventional simulators only train hands-on skills at the individual or crew level. The advent of SIMNET changes this situation.

SIMNET is a research project initiated by ARPA to develop networked simulators, i.e., training devices that can talk to each other via local and remote networks. This allows trainees to respond to the behavior of other people in the network, not just their own actions. SIMNET provides a way for the military to train teamwork and group interaction skills in realistic battlefield circumstances.

The SIMNET effort presently consists of a network of 240 simulators at 11 sites (7 in the U.S.; 4 in Europe). Equipment currently simulated includes M1 tanks, M2/3 Bradleys, fighter aircraft, helicopters, command/fire control elements, and a battalion operation center. In principle, any of these sites can "fight" any other site via the network. Preliminary data from the use of SIMNET indicates that it significantly improves the performance of soldiers in actual field exercises.

SIMNET pushes the state-of-the-art in a number of technologies including computer animation and 3D graphics as well as packet-switched networks. It also presents new training opportunities such as "replaying" the recorded performance of a unit to analize mistakes or to repeat a combat exercise until training objectives are met. In addition, it opens up the possibility of "what-if" experimentation in combat situations -- something not really possible in actual field exercises.

SIMNET is likely to have major repercussions on the nature of future training in the military. Will it have any influence on civilian training? Clearly, there are some occupations such as emergency services that involve the same equipment-related teamwork situations. It is possible to imagine the use of interactive video sequences that depict all kinds of inter-personal scenarios rather than just equipment operation. This would make networked simulation applicable to "soft skills" training such as management, supervision, and customer service. On the other hand real-time interaction via videoconferencing may be a better alternative. While it is not clear what the ramifications of SIMNET might be to civilian training at this point, it is bound to have some impact. Team skills and group coordination are just as important in industrial training as military instruction.

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used. Many of the technologies to be considered in the following sections fail on one or more of these factors.

Broadcast Television

Considering the widespread acceptance of television as an entertainment medium, it would seem natural to expect it to be equally well used for instructional applications. This is not the case. Despite many attempts, broadcast television has never taken root in the training world. There appear to be many reasons for this lack of acceptance: (i) high production costs/time associated with television programming, (ii) costs of the receiving equipment including monitors in classrooms, (iii) the lack of involvement of local instructors, (iv) lack of flexibility in scheduling, (v) student boredom due to lack of interaction, and (vi) regulations concerning the use of television frequencies.

The use of satellites is changing the situation for television based training significantly. Satellites make it possible to deliver television programs directly to company sites without the need to involve cable companies or television stations. In addition, satellites can be used for teleconferences employing 2-way video which addresses the interactivity problem (although most teleconferencing uses 2-way audio as a more cost-effective approach).

Many large organizations have satellite uplink/downlink facilities at branches or plants and use television to broadcast training

NATIONAL TECHNOLOGICAL UNIVERSITY: A SUCCESSFUL INDUSTRY-ACADEMIC ENTERPRISE

The National Technology University (NTU) uses satellite to broadcast programs originating at universities to corporate sponsors. There are 24 member universities and 49 corporations involved (plus 5 federal agencies) with a total of about 200 receiving sites. In 1989, approximately 450 graduate courses were offered along with many additional short (continuing education) courses. NTU estimates that more than 4,000 people have enrolled in graduate courses since they were first offered in 1984 and that a total of 30,000 people are currently taking short courses. NTU averages over 250 hours of live broadcasting weekly -- more live programming than ABC,NBC, and CBS combined.

NTU graduate courses focus on engineering and computer science and they are taught by faculty members in the Engineering departments of the member universities. Even though a student takes courses that originate from different universities, the degree (MSc)is granted by NTU. NTU is accredited by the same body that certifies other universities. Corporate sponsors pay some form of site fees to receive the programs in addition to providing their own downlink and classroom capabilities.

NTU hosts many teleconferences (1 way video/2-way audio) as special programs for continuing education. The topics of these teleconferences tend to be leading edge areas in engineering and technology such as superconductors, super computers, distributed networks, automated manufacturing, etc. Such teleconferences allow engineers and their managers to stay abreast of the latest developments without having to leave their offices. The teleconferences add an interactive component to the broadcasts that allow participants to ask questions and share experiences, making the courses more interesting and personally relevant.

In general, students seem to be content with the quality of NTU courses. The currentness of the courses and the expertise of the instructors (who are often the leading experts in their field) are the most liked features of NTU courses. Although it is not freely admitted, most of the programs are dull and boring being strictly of the "talking head" variety. Some of the camera and transmitting equipment at the universities has been substandard resulting in poor picture quality. However, NTU has encouraged the universities involved to upgrade their equipment and many have done so.

Enrollment in NTU courses continues to increase yearly and by this measure it is a success. It meets the needs of continuing education for engineers in a cost-effective and convenient fashion for the organizations involved. Perhaps NTU will serve as a model for professional education in other areas such as medicine, law and finance.

courses. The National Technological University (NTU) broadcasts hundreds of engineering courses to corporations and federal agencies (see case study). However, few organizations have addressed any of the problems mentioned above that have prevented television from becoming a successful instructional technology. For this reason, it seems unlikely that broadcast television will become widely adopted or used in the training domain. It may fare better as a component of teleconferencing (discussed later).

Video/Videodisc

Video (and its precursor, 35mm film) has had a long gestation period as an instructional technology. Prior to the emergence of inexpensive 1/2 inch VCRs and the VHS standard, video was used only infrequently in corporate training, typically for special training situations such as behavior modeling or safety training. The need for expensive and often unreliable players deterred most instructors from using it in the classroom.

With the widespread commercial success of VHS VCRs. videotape has become a much more familar medium to most people including instructors. The players are inexpensive and highly reliable. Most training centers (including those at plants and branch offices) have a VCR and monitor. There is a large selection of commercially available programs covering most areas of training. For example, the American Management Association (AMA) and the American Media Center for Engineering Education (AMCEE) have large libraries of tapes for training. Professional societies such as the IEEE provide self-study courses based on videotapes for continuing education of their members. Most large companies and government agencies produce an extensive number of instructional tapes for use within their organization. Because so many people in the U.S. have VCRs at home, video is also a viable medium for self-study instruction as well as classroom use.

Data from the 1989 annual training survey conducted by Training magazine indicates that video is now used by almost 90 percent of all large corporations for some type of training. However, despite its wide usage, there are still some limitations to video as an instructional medium including: (i) substantial development time/cost required, (ii) unsuitability for presenting a lot of factual information, (iii) lack of customization by an instructor, and (iv) lack of interaction between the student and the material. Putting the video in videodisc format helps somewhat because a lot of text or graphic information (and possibly audio) can be added as still frames, the contents of the disc can now be randomly accessed, and branching can be added to make the program interactive (i.e., responsive to the responses made by the student). However, videodisc adds more development time/cost and requires a videodisc player plus a personal computer if it is interactive.

Many organizations seem to feel that the additional cost and equipment required for interactive videodisc is well worth the effort. For example, GM is using interactive videodisc extensively throughout the organization for technical and sales training. In conjunction with the UAW, it has established a Center for Health & Safety that offers dozens of self-study courses using interactive videodisc materials. According to industry figures, GM alone has bought over 10,000 videodisc players for use in training. Ford and Chrysler are also using interactive videodisc extensively for training. Various branches of the Department of Defense have made major committments to interactive videodisc for training. For example, the Army EIDS project expects to ultimately field 50,000 players for use in schools and unit training (see EIDS case study).

There are a number of application areas where interactive video appears to have unique instructional value. It has been used extensively in the design of simulations for maintenance training. For example, Federal Express developed a videodisc based course to teach their aircraft mechanics how to troubleshoot and repair electrical problems. The program allows mechanics to take readings, test components, replace equipment, and evaluate procedures. Interactive videodisc is also being used extensively to improve basic skills and literacy, taking advantage of the visual and motivating characteristics of the medium. For example, IBM developed and markets PALS (Principals of Alphabet Literacy System), an interactive video system employing a touch screen. PALS is used to improve reading skills in many schools and organizations. The Reynolds Tobacco Co. in collaboration with Forsyth Technical College in Winston-Salem, has been using the

An Army Wide Interactive Videodisc System: Electronic Information Delvery System (EIDS)

In the early 1980's, the Army was shopping for a multimedia delivery system to replace the slide-tape unit that had been in use for many years. In 1983, it asked a number of companies to develop interactive videodisc prototypes to evaluate as a potential alternative. After a number of years of field testing the idea, a specification for the Army Electronic Information Delivery System (EIDS) was established in 1986 and in December of that year, a contract was awarded to Matrox Electronics of Canada to supply the hardware and software. The initial contract called for a total purchase of 48,000 units over four years with a value of $223 million dollars.

The EIDS workstation consists of a IBM PC/AT type computer employing EGA/VGA graphics and a 12 inch optical laserdisc player. The workstation is capable of overlaying graphics on video displays, playing over 1 minute of sound per still frame, and storing/reading computer programs on the videodisc (so-called Level IV capability). In its most basic configuration, the unit has a commercial price of about $6000.

Actual delivery and courseware development for the system has lagged behind the planned development due to procurement difficulties. By 1989, approximately 10,000 units had been delivered to Army TRADOC schools and Army and Navy Reserve sites. In 1988, 14 solicitations to develop courses were authorized but many of these were not awarded due to lack of funds.

One of the strengths of EIDS effort is that a number of authoring systems are available for the system. The primary authoring system, ASSIST, was developed by Computer Sciences Corp. for the Army and is provided to contractors to use in courseware development. However, at least 10 other commercially available authoring systems can also be used to create EIDS courses. This is made possible by the choice of a standard MS-DOS computer and laser optical videodisc player. A number of companies have already developed "generic" courseware that can be run on EIDS and there are a large number of vendors capable of developing custom courseware for the military or civilian clients.

Indeed, it has been estimated that the development of EIDS courseware could be a billion dollar business opportunity for the interactive videodisc industry. How much courseware actually gets developed will depend upon the acceptance of EIDS within the Army training system and the amount of funding that is allocated for EIDS programs. Without specific technology transfer initiatives, it is unlikely that EIDS will be used for many civilian applications, unless one or more large companies decide to champion this system.

The choice of Matrox Electronics to manufacture and market the EIDS system has not helped since the company is practically unknown in the U.S. and has made little attempt to market the system outside of military circles. Furthermore, the anticipated cost reductions of the system due to large-scale production has never materialized. Indeed, the EIDS system is more expensive that comparable systems available from other vendors or assembled from off-the-shelf components.

PALS system to improve the reading skills of hundreds of employees since 1987.

Another interesting use of interactive video is its use on the factory floor to support Computer Integrated Manufacturing (CIM) activities. Henry (1989) describes two high tech plants (Apple Computer and Martin-Marietta) that provide workers with personal computer workstations capable of displaying brief video sequences about different manufacturing processes. These sequences can provide "just in time" training to correspond to the complex nature of a CIM operation that involves frequent shifting from one operation to another. What is interesting about this use of videodisc is that it involves simple linear video sequences rather than elaborate branching or simulation. The video is being used as a visual job aid to help workers remember the details of different assembly line tasks.

Evaluation studies conducted on interactive videodisc projects give the clear-cut impression that it is a highly effective teaching medium (see "A Powerful Multimedia Tool"). But will it be adopted on a widespread basis? According to data from the 1989 Training magazine survey, about 34 percent of large corporations are currently using some form of interactive video training (but only about 11 percent for all companies with 100 or more employees). Putting aside the substantial development costs involved, the cost of a single interactive videodisc student station (including player, monitor and personal computer)

INTERACTIVE VIDEODISC: A POWERFUL MULTIMEDIA TRAINING TOOL

Although its use has grown slowly, interactive videodisc is becoming an increasingly common training tool. Evaluations (when conducted) seem to be uniformly positive. Here are some examples:

* Goodyear Tire & Rubber - compared a videodisc-based training program for mechanics in the use of an oscilloscope and multimeter with the same training via videotape or instructor led. In actual job performance tests after training, the videodisc approach produced the best results. Futhermore, trainees indicated a preference for the videodisc training.

* McDonnell Aircraft Company in conjunction with Digital Equipment Corp. developed a videodisc training program for Computer Aided Design (CAD). Use of the program cut the training time required for this course from 12 hours to less than 8 hours for all employees, decreased the cost per student hour, reduced teaching loads, and resulted in better retention of the material.

* IBM conducted a research study at its Corporate Management Development Center comparing three different ways of using videodisc (instructor led, small groups, and individualized) relative to classroom instruction for an employee relations course. Learning gain scores and mastery levels in the videodisc approaches were better than classroom instruction that didn't use it.

* GTE of California used interactive videodisc to train network technicians to troubleshoot a statewide data network. The videodisc-based training was superior in terms of retention relative to a classroom version of the course and was well liked by the employees.

* The Wisconsin Foundation for Vocational Technical and Adult Education has developed an interactive videodisc course called Interactive ModuMath designed to improve the basic math skills of students in Wisconsin technical colleges. The course is used by a wide variety of students and is well liked by both students and instructors.

* The Florida Department of Corrections has implemented a state wide videodisc program to train corrections and probations officers on topics such as hostage negotiation, surveilence techniques, investigations and emergency preparedness. This program replaces the use of interactive videotapes.

* Unisys Corp. is using interactive videodisc to train its sales force on the companies' products and the UNIX operating system. Use of the videodisc materials is expected to save considerable training time and expenses and will be used by the entire Unisys sales force of approximately 5,000 employees.

is between $5,000-$10,000. Even at half this price, this is not something that is affordable in quantity by most training organizations. Furthermore, interactive videodisc is normally used for self-study instruction while the bulk of training is still conducted in classroom format. For these reasons, it seems that interactive videodisc is not likely to be widely adopted for training by most organizations unless they make it a special priority (as GM and the Army have done).

Computers

Computer Based Training (CBT) has been around for at least three decades, although it was not until the emergence of the personal computer in the early 1980's that it became a practical reality for most organizations. The availability of relatively inexpensive PCs made it possible for companies to try CBT at a minimum cost and also gave rise to a substantial courseware marketplace. Ironically, the main thrust of CBT today is mainframe-based systems at large insurance companies and banks (see "A Good Fit for CBT" case study). There is also a substantial use of PC-based CBT (often involving interactive video) for technical training (see "Using CBT To Teach Technical Skills" case study).

A study by Hirschbuhl (1988) presents some data about the extent of CBT use in industry. In 1986, 32% of all organizations with more than 100 employees and 54% of the FORTUNE 500 companies were using some form of CBT. By 1987, 75% of all corporations

A GOOD FIT FOR COMPUTER-BASED TRAINING: THE INSURANCE INDUSTRY

Even though Computer-Based Training (CBT) is used in all types of companies, it has been adopted most widely in the insurance industry. There are several reasons for its success in this domain: (1) insurance companies are heavily computerized with almost every employee having a terminal, (2) the nature of the material to be learned (policy information and procedures) is well-suited to tutorial strategies, and (3) insurance companies have a strong training tradition. Since the hardware is already in place, the usual barrier to large-scale use of CBT (i.e., the cost of buying lots of computers) is absent.

CBT is attractive to insurance companies for the usual reasons: (1) employees can take their training in their office when they need it, without having to wait for a scheduled class, (2) it works - questions and practice exercises built into the courses ensure that employees really learn the material, and (3) it saves training time relative to classroom instruction. Of the three benefits, the first is probably the most critical from an employee acceptance perspective; employees like CBT because it is makes learning convenient.

A large insurance company in the metropolitan Washington area serves as an example. The company first got started with CBT in 1981 with an introductuction to claims processing course. However, this first attempt didn't work out because the system used wasn't reliable enough. Another course was tried a few years later on a stable system...this course is still in use today. Today the system delivers about 20 courses with about 5 new courses being added per year. Thousands of employees take courses from the system.

While CBT provides effective training in this company, there is an ongoing problem developing and maintaining good quality courses. They find it hard to find authors/designers who know how to develop good CBT and can work with the particular system in use. One part of the company relies solely on CBT courses purchased from vendors (although they still customize these courses). Buying commercial courses reduces the costs of courseware development but only applies to generic course topics (such as data processing or customer service).

The insurance industry has tried to encourage courseware sharing through the Society for Insurance Training & Education (SITE). A catalog of courseware was published in 1987 and a new version is currently being prepared. However, this effort has not been very successful to date because of i) system incompatibilities, ii) confidentiality, iii) poor quality of courses, and iv) lack of customization capability. The industry hopes that vendors will start to market more generic courses of interest as well as providing customization services.

Using Computer-Based Training To Teach Technical Skills

One of the most effective areas where Computer Based Training (CBT) can be applied is technical skills instruction. The following examples illustrate the scope and variety of this particular use of CBT:

* Anheiser-Busch in St. Louis is using a MicroTICCIT system to teach assembly line workers how to properly run beer can packaging machines. The use of CBT is driven by a desire to improve quality control in manufacturing and an overall modernization effort in plants. The particular training task was picked because it is one of the most critical aspects of beer packaging.

* Burlington Northern is using a MicroTICCIT system to teach train crews the rules of operation for railroads. This particular course was selected because it is mandatory knowledge for all train crew personnel and classroom instruction is not very effective. CBT is being used to upgrade the quality of training and also distribut it to the field.

* The FAA has used the PLATO system to train flight inspection and maintenance specialists for almost a decade and has recently starte to use CBT for air traffic controller training as well. Courses are provided to about 50 sites around the country. Primary factor in the use of CBT is heavy demand for training that is difficult to meet with traditional classroom approaches.

* Bell Atlantic has developed a PC-based financial selling skills course for its telemarketing representives. The course includes CBT case studies that simulate the selling process and a Lotus 123 cash flow template used to calculate lease vs. purchase options The company reports that the course improves the competence and confidence of representatives in their sales activities.

* The Strategic Management Group (SMG) in conjunction with the Port Authority of NY/NJ has developed a PC-based course called "Export to Win" designed to teach business people all aspects of exporting products to international markets. This course is one of a series of business simulations developed and marketed by SMG.

* Applied Learning (formerly Deltek) offers hundreds of data processing courses that run under the Pheonix mainframe CBT system. These courses are used by thousands of organizations around the world to train their DP/MIS staff about mainframe operating systems, applications software, and telecommunications. In many companies, Applied Learning courses serve as the stimulus for developing their own CBT.

surveyed had over 100 CBT stations (compared to only 20% in 1985). Most courseware was supplied by vendors (70%) with only 6% developed in-house. Data processing training was the most popular form of CBT and category of commercially available courseware. All companies surveyed indicated that they planned to use CBT more heavily in the future. In the 1989 Training magazine survey, about two thirds of all companies with 100 employees or more indicated they were using computers in training, with the precentage increasing to 83% for large corporations with 10,000 employees or more. Both the Hirschbuhl study and the Training magazine survey confirm that the use of CBT in large organizations has become widespread and is more common, the larger the organization.

The U.S. military has been one of the major proponents of CBT having applied it to a variety of different types of training. Past efforts are summarized in Ellis (1986) and Seidel & Weddle (1987). In an August 1986 report about CBT projects in DOD published by the Training Technology Transfer Program, a total of 240 projects were identified with details available for 45 of these projects (16 Army, 15 USAF, 6 Navy, 3 USMC, and 5 Joint). Another report from the same group showed 368 research projects in the training domain involving 30 different DOD agencies, 29 universities, and 70 commercial contractors. As this data suggests, DOD is the major force in CBT R&D and is largely responsible for the direction that the field takes (see further discussion of this point in Chapter III and Appendix A).

When it is necessary to buy computer workstations specifically for CBT, it becomes a relatively expensive training approach. However, to the extent that computer terminals and PCs are already available for work functions, CBT becomes a value-added use of this equipment. Indeed, CBT becomes the most convenient way of delivering training since it does not require the effort of scheduling a classroom and instructor. Provided that CBT courses can be developed or purchased for a cost that is comparable to classroom instruction, CBT is likely to displace much classroom instruction in companies where every employee has a computer or terminal. This is why the development of authoring tools that reduce the cost and time to develop CBT materials is such a key factor in making this instructional technology successful on a wider scale (see Chapter IV).

A number of efforts have been made to apply CBT to basic skills training. The largest such effort is the JSEP program initiated by the U.S. Army and now being tried for vocational education (see JSEP case study). Another major effort is being undertaken by McGraw-Hill in conjunction with Apple Computer. Based upon the functional literacy work of Tom Sticht (supported by DOD for many years), a series of print and CBT programs in 6 areas (health, automotive, business, contruction trades, electronics, and office) are being developed at a cost in excess of $3 million. The Adult Literacy and Technology project being coordinated by

Applying CBT to Workplace Literacy: The Job Skills Education Program (JSEP)

One of the most extensive efforts to use computer-based training to improve basic skills is the JSEP program. JSEP was originally developed by the U.S. Army (contracters were Florida State Univ and Ford Aerospace) at a cost of about $11 million dollars. JSEP operates on both the PLATO and MicroTICCIT computer systems and provides more than 300 lessons (400 hours of instruction). The lessons were based upon an extensive analysis of the skills required for the 94 most common Military Occupational Specialties and common soldier's tasks. JSEP includes a student management system that keeps track of performance data such as the amount of time spent in each lesson, test scores, etc. The system also generates individual learning prescriptions for each student based upon pretest or other diagnostic information.

JSEP has been field tested in the Army with thousands of soldiers. Data indicate that if soldiers are given enough time in JSEP, their performance on standard Army tests improves. Students indicate a strong preference for JSEP over conventional instruction because it is more interesting and provides lots of feedback. Instructors like it too because they can use it to give students specific practice in deficient skills. The lessons were carefully designed based upon the principles of instructional design and adult learning theory. In addition, the JSEP curriculum includes learning strategy modules that help the student learn how to learn (e.g., time management skills, test taking skills, problem solving skills).

In 1987, Florida State was awarded a contract from the U.S. Dept. of Education to develop a civilian version of JSEP. Many of the basic skills required for Army specialties transfer over to civilian occupations such as health care aides, accounting clerk, electrician, police officer, machinist, auto repair, computer operator, etc. Under an interagency agreement between the Dept. of Labor, Dept. of Education, and Dept. of Defense, JSEP is being pilot tested at an adult education center in White Plains, NY with additional sites planned for Indiana, California and Delaware. The goal of the civilian version of JSEP is to provide basic academic skills for welfare recients, vocational education students and trainees eligible for JTPA programs.

Despite the funds spent on JSEP by the Army and its apparent effectiveness with soldiers, the widespread implementation of the program is not planned at the present time. Each JSEP station costs several thousand dollars and full-scale deployment would require a large purchase of either PLATO or MicroTICCIT terminals to be used exclusively for JSEP. Army decision makers are not clear if JSEP is the best solution to basic skills training in the military or if the cost of such training is worth the huge investment that JSEP would require. A similar dilemma is likely to be faced by civilian decision makers.

People's Computer Co, in California involves the use of commercially available educational software in vocational educational programs at community colleges and other training centers. The Technology for Literacy Center in St. Paul, Minnesota, has demonstrated the success of using computer based instruction with adults in terms of continued enrollment, student satisfaction and increased achievement.

Simulators

In many types of jobs, it is necessary for the employee to learn how to operate or maintain some piece of equipment such as an airplane, telephone switch, nuclear reactor, submarine, or robot workcell. Ideally, the training involves hands-on practice operating or repairing the equipment. However, in many cases, the actual equipment is too expensive, too dangerous, or too scarce to use for training. Instead, simulators (also called training devices) are used.

Historically, the military has been the prime user of simulators for aircrew and aircraft maintenance training. A series of analyses by Orlansky & String (summarized in Orlansky, 1986) showed that the use of such simulators for military training was highly effective. For years all of the major airlines have been using flight simulators for pilot upgrade training with significant cost savings. Despite the benefits and cost-effectiveness of such simulators, they are very expensive to develop and run. For example, a complex full motion flight simulator might well cost millions of dollars. The high cost of simulators has limited their use outside of the aircraft training area.

The advent of interactive videodisc and powerful PC-based workstations has changed this situation considerably. It is now possible to develop a "low fidelity" simulator for well under $100,000. This lower cost makes the use of simulators more feasible in a broader range of training applications including driving/repairing trucks, factory machinery, test equipment and electrical/electronic devices. Instead of spending a lot of development time/money on building a simulator that works exactly like the original equipment, video sequences can be shot and used with an inexpensive PC workstation. Furthermore, videodisc and CBT simulations can be used as part-task training devices that reduce the amount of time needed for full-function simulators.

One new twist in the use of simulators is the capability to network individual simulators together so that team behaviors can be practiced. The DOD is currently implementing a concept called SIMNET which allows simulators of armored vehicles as well as tactical aircraft and artillery to be connected together for realtime combat exercises (see SIMNET case study). It is not clear the extent to which networked simulators will be relevant to civilian applications, but the computer graphics and network aspects are likely to be important contibutions to the technology base.

time. The addition of a fax machine at participating sites allows for the two-way transmission of hard-copy documents for minimal cost. A new technology that could make two-way video more cost-effective and prevalent is the use of compressed video transmission lines (T1). T1 involves the use of a codec to digitize and compress the video signals. While the quality of compressed video is not always acceptable, it does provide a videoconferencing alternative when only two sites are involved.

With the increasing prevalence of personal computers, computer conferencing is also becoming more common. A number of organizations use computer conferencing as part of distance learning activities. For example, the International School of Information Management in Irvine, CA offers a Masters degree program using computer conferencing to conduct seminars and for student/instructor interaction. Boise State University has a Masters degree program in Instructional Technology that also uses computer conferencing for remote delivery of courses. This program is supported by, and designed to meet the needs of, the U.S. Army and National Guard. Since most large corporations already have electronic mail systems in place, the potential exists to use these systems for training activities.

Many large corporations have extensive satellite-delivered television networks that are used for training teleconferences. IBM, Motorola, and Aetna are examples of companies that regularly conduct training via teleconferences. As an illustration, Aetna delivers a business writing skills course to over 1000 employees

Teleconferencing

Teleconferencing can involve three different technologies: telephones, television, and computers. Audioconferencing involves two-way interaction among a number of participants via telephone bridges. Videoconferencing involves two-way interaction via televison (either full motion or slow-scan). Computer conferencing involves the use of electronic message systems (principally mail, conferencing and bulletin boards) to exchange information. Audiographics systems provide two way audio and graphics transmissions, the latter via computer or some form of facsimile/digitizing device.

All forms of teleconferencing have been explored for training purposes. While videoconferencing is probably the most preferred, it is too expensive for most organizations. Audioconferencing is relatively inexpensive but is limited by the lack of visual presentations. Similarly, computer conferencing is relatively inexpensive but requires access to a computer and modem. Audio graphics systems are fairly cost-effective (they employ two phone lines) but still require specialized equipment.

The best compromise in terms of cost and quality of information transmitted seems to be teleconferences involving one-way video (i.e., broadcast television) with two-way audio (telephone) links. This allows for the full presentation of visual information but allows participants to ask questions or make comments at any at more than 50 branches via teleconference. In a classroom, the course takes 2 days; via teleconference it reduces to two 1.5 hour teleconferences. The DOD and federal agencies are heavily committed to the use of teleconferences for training. In October of 1989, the FTS 2000 system went into operation which provides an all digital network connecting almost 1 million federal employees around the nation. FTS 2000 provides both two-way and one-way video teleconferencing capability that can be used by any agency simply by making a reservation (and providing the necessary facilities and equipment).

The U.S. Navy has conducted a number of projects involving the use of teleconferencing for training purposes. For example, in 1989 it initiated an "electronic schoolhouse" project at its fleet combat training center in Dan Neck, VA. The project consisted of linking classrooms at navy bases in Norfolk, VA, Charleston, SC, and Mayport, FL with the training center with two-way compressed video delivered via satellite. Each classroom contains two cameras, large monitors, microphones, an audio speaker and accomodates 30-50 students. Ten courses were taught using teleconferencing focusing on "soft skills" and basic concepts. Both instructors and students adapted to the use of teleconferencing with no problems and test scores were as good as traditional classroom instruction (Chandler & Lucas, 1989).

Until recently, teleconferencing has been used by a handful of organizations that could afford the equipment and could find instructors willina to trv it. With the advent of larae-scale diaital networks and satellite links. the use of teleconferencina for trainina is likelv to become more commonplace. However, anv form of teleconferenina involves sianificant preparation time and relativelv complex loaistics. This is likelv to deter manv trainina departments from usina teleconferences even if the deliverv svstem is available. Increasina pressure from emplovees and senior manaaement to reduce travel time and costs for trainina is likelv to be maior factor in forcina more trainina departments to use teleconferencina.

Obstacles Limitina Near-Term Use of Technoloav

It should be clear from this survev of present applications that many forms of technoloav are beina successfullv used in all tvpes of trainina situations. Indeed, aiven the favorable results that have been reported for most of the technoloaies discussed, one wonders whv technoloav is not used more widelv in trainina. The followina obstacles inhibit such broader use:

1. Lack of experience usina technoloav on the part of trainina professionals (includina instructors, developers, and manaaers) is probably the sinale biaaest problem. Most trainers are onlv familar with traditional classroom instruction and have no exposure or trainina in the use of technoloav bevond overhead projectors.

2. Lack of monev to buv the necessarv eauipment, develop the materials, and prepare the courses. This is primarilv a budaetina problem since the necessarv funds are often available as salaries

that need to be channeled into equipment, facilities, and contractor costs. Because of the reduced training time, less instructor time to deliver courses should be needed when instructional technology is used.

3. Lack of time to develop and prepare alternative modes of delivery. Due to lack of planning or adequate staffing, there is insufficient time to implement and test technology-based approaches.

4. Unreliability and poor usability of technology. In many cases, specific systems have been too complicated to use and too fragile for operational settings.

Each of these current obstacles is being addressed by the training community. As technology becomes more commonly used in schools and colleges, training personnel and students become more familiar with it. To the extent that training professionals take graduate degrees in the instructional technology field or attend conferences, they receive increasing exposure to technology use. There are now approximately 200 graduate level instructional technology programs in the U.S. and each year they produce thousands of specialists who have the necessary skills to design and implement technology in training. Almost all of these graduates go directly into industry or continue with their military careers; only a small proportion go into the school system. As organizations absorb these technology literate trainers, the use of instructional technology is likely to become more prevalent.

More and more training organizations are allocating a larger proportion of their budget to equipment and the development of materials. As technology-based training generates savings due to reduced training time or travel, these funds can be spent on more technology. However, in general, many technology based training projects result in better quality training and this simply costs more. Senior management must understand that more money needs to be spent on training in order to have better trained employees. Technology is often the vehicle for better training; hence it costs more than the status quo.

The time required to develop and implement technology-based approaches will decrease as a function of increased experience on the part of the training staff. A great deal of time is wasted by novices who don't know what they are doing. In addition, improvements in the reliability and usability of technology (see below) will decrease the amount of wasted time. The emergence and use of automated instructional development systems (discussed Chapter IV) will also help to reduce the amount of time required for technology based training.

Finally, the reliability and usability of technology has been improving significantly over the past decade. Solid state hardware and more adequately tested software are resulting in a generation of highly reliable electronic systems. The emphasis on user interface design has produced software that is much easier for people to learn and use. Incorporation of artificial intelligence and hypertext techniques in future software is likely to increase the usability further (see discussion in next chapter).

To summarize, most of the obstacles that limit the near-term use of technology for training applications are likely to dissipate over the next decade. By the year 2000, it is reasonable to expect most medium-large organizations to use some mix of technologies in their training activities. The use of interactive video, CBT, and teleconferencing should be as common as the use of overheads and VCRs are now. Many of the applications will probably be classroom based rather than individualized instruction, i.e., they will be used as teaching tools by instructors to enhance lectures. Since no one technology is right for all types of courses, it is reasonable to expect a combination of technologies to be used in any given training program.

Summary

While the extent of technology use in training is not clear, most large organizations are using one or more technologies in some aspect of their training activities. Interactive video and computers are frequently used for technical training and computer based training is common in the insurance and banking industry. Teleconferencing for training is just beginning to be used in large corporations, federal agencies and DOD. There appears to be little use of technology in small business; indeed very little formal training is conducted by small businesses.

The major obstacles to the near-term use of technology in training are (i) lack of instructor knowledge about how to use technology, (ii) lack of money to buy hardware or develop materials, (iii) lack of time to develop and plan alternative training approaches, and (iv) poor reliability and usability of training systems. All of these obstacles are likely to dissipate during this decade resulting in the increased use of instructional technology for training. The driving force behind the increased use of instructional technology by organizations is the need to become more productive and increase the quality of their services and products.

III. INSTRUCTIONAL TECHNOLOGY IN THE WORKPLACE: THE FUTURE

This section of the report discusses emerging trends in instructional technology and their likely impact on the training world. By its nature, such discussion is highly speculative since it involves guesses about future directions based upon present trajectories. For other views about the future directions of technology and training, see Cetron et al. (1985), Dede (1989) or IRS (1989).

One important point to realize about this section is that it discusses technologies that are in the research or prototype stage. While these technologies are already in existence, they are many years (probably decades) from operational use. This is the sense in which they constitute future technology.

Personal Workstations

The evolution of personal computers into small portable units is a clearcut trend. At the same time, personal computers are becoming more powerful with faster processors, larger memories, and higher resolution graphics displays. The storage capacity of future PCs is likely to be enormous based upon some form of optical disk (e.g., erasable CD-ROM). It is probable that cellular modems will be built into future PCs allowing people to access electronic message systems and online databases without the need for a phone jack. Furthermore, such workstations may also have television receivers built in so that they can view broadcast TV in addition to video still frames stored in optical memory.

By 2000 it is reasonable to expect that most people will own at least one personal computer which they carry around like a notebook and use for a myriad of purposes including communication, getting information, shopping, banking, and many work-related functions. Of course, all of these activities can already be done online -- the difference will be in the extent and variety of services available, and the number of people who use them. Since the display capabilities of these machines will match or exceed the resolution of the best quality print (e.g., at least 2000 dpi with infinite color range), they will be used to publish electronic newspapers, magazines, novels, and technical journals.

This evolution of personal computers has many possible implications for training. The most important outcome is that since almost everyone has their own workstation, it will be unnecessary to buy them specifically for training purposes. Buying hardware for technology-based training should become a non-issue (except for outfitting electronic classrooms discussed below). Since the personal workstation is capable of displaying multimedia, rivalries between different types of instructional technology (e.g., video, computers, teleconferencing) should be minimized. The personal workstation can take the place of what are currently separate technologies. Finally, since people use the personal workstation all the time, they are comfortable with it and using it for learning does not pose a novel experience. Indeed, since people use their workstation for informal learning all the time, it is a perfectly normal occurrence.

Even though personal workstations will eliminate many of the current problems associated with hardware, it will not get rid of them all. Since there are going to be lots of different models of workstations with different capabilities, there will still be compatibility issues (although they will seem minor relative to current problems). Some displays will look better than others, some machines will access/display things faster, some machines will sound better than others, etc. In essence, we will have the same functional similarities as we find with cars or airplanes but with different performance characteristics.

Electronic Classrooms

While the availability of personal workstations and the extensive use of networks (discussed below) will make self-study and distance learning very common, a lot of training will still be classroom based for reasons of social interaction. Many future classrooms will be equipped with a video projection capability or large monitors and a fully configured PC. Instructors will use this equipment to show multimedia materials, to access online databases, participate in teleconferences, and as an electronic blackboard. Some classrooms will outfitted with sound-activated cameras and rows of monitors to be used as electronic meeting rooms for teleconferences.

We already see such electronic classrooms and meeting rooms being built at some corporate training centers and universities. The IBM Management Development Center in Armonk, NY is probably the one of the best examples. An instructor's station (a PC) located at the front of the classroom allows the instructor to control all audio-visual devices in classroom including videotape, videodisc, slides, computer display, and lights. In addition, each student has a keypad that allows them to respond to questions posed by the instructor. The instructor and class can immediately see a display of the tabulated results of the class response to a question. The keypads allow the instructor to make the class interactive and assess student understanding. Control of all audiovisual equipment makes it easier and faster to use multimedia materials during class.

Such facilities are more expensive to build than conventional rooms and the additional cost must be justififed/supported by training management. Furthermore, because computer capabilities are evolving so quickly at the present time, the equipment installed in these classrooms becomes obsolete quickly and will need to be replaced periodically. The implication for training organizations is that a larger proportion of the budget will need to spent on classrooms, both initially and on a continuing basis.

It is interesting to note the relationship between widespread use and ownership of PCs by instructors and electronic classrooms. If an instructor gets used to creating presentation slides on their computer as well as working with computer tools, they will want to have a computer in their classroom to make use of these programs. Similarly, if instructors are expected to use computer software in their classroom, they will need PCs in their offices and at home in order to prepare their classes. In other words, widespread use of PCs in training reinforce the need for electronic classrooms and vice-versa.

Embedded Training

Embedded training is instruction that is an integral component of a product or system. To the extent that a piece of equipment is computer-based and has a display panel, it becomes feasible to build the training into the equipment. In a computer system, it is easy to provide online training as part of the system. Embedded training often takes the form of helps or tutorials that explain how to perform a specific operation or task on the system or equipment. Embedded training can also take the form of performance support systems that involve providing employees with computer tools that help them do their job more effectively.

Embedded training has many advantages over any other form of instruction for learning to use equipment or systems. The most important characteristic is availability -- training is always available when needed. Secondly, the training is specific and focused on the immediate needs of the user trying to learn how to operate (or repair) the equipment/system. Thirdly, the training should be up-to-date and tied to the particular equipment/system. Embedded training also simplifies the logistics of providing training to customers or employees since it is delivered along with the product or system.

DOD has mandated that all new weapons systems will include embedded training. This has focused the interest of military R&D contractors on embedded training. Most new computer products include help systems. Some automated manufacturing systems also include built-in training and documentation. However, the development of embedded training requires the involvement of training specialists as part of the system design process. Training materials have traditionally been developed after the system or product is completed. This inclusion of training specialists as part of the design team often requires organizational changes and different skills on the part of the training department.

Effective embedded training is difficult to design and many current efforts are not very successful. To be effective, the information available must address the specific questions or problems that people have when they are learning to use a product or system. To find out what kind of questions or problems will arise, it is necessary to do a lot of empirical work with prototypes and typical users. User testing early in the design cycle is a relatively new technique in system development and most engineers have not been trained in data collection methods (as training specialists have). In addition, it appears that it will be necessary to use artificial intelligence techniques to create embedded training programs that understand what the user wants to know.

Intelligent Tutors & Expert Systems

For many years, research has been conducted on the application of artificial intelligence techniques to the design of instruction (e.g., Polson & Richardson, 1988; Psotka, Massey & Mutter, 1988). Two different lines of research have developed: intelligent tutoring systems and expert systems. Both approaches involve the application of artificial intelligence methods to instruction but in different ways.

Intelligent tutors are computer based instruction programs that understand the subject matter they teach and can also understand the responses that students make to questions or problems posed by the program. Such programs include associative networks, the capability to make inferences based upon teaching rules, and the capability to build models of the student in order to diagnose misconceptions and assess learning. They are designed quite differently from traditional computer based instruction and have the potential to provide much more effective learning tools than current educational software (Kearsley, 1987a, 1989).

Expert systems are programs capable of asking questions and reaching conclusions based upon the answers provided for a specific domain. The rules used by experts in that domain are identified and built into a program. The expert system applies these rules to the information provided to produce conclusions. In realtime systems (e.g., in manufacturing or military settings) the data comes from sensors rather than answers to questions. When applied to training, expert systems can be used to help students understand the factors involved in making decisions or judgements (especially if they construct the expert systems themselves). Alternatively, expert systems can be used as intelligent job aids that reduce or eliminate the need for training on a specific task. See the "Flight Plan Critic" for an illustration of how an expert system can be used for pilot training. Applications of expert systems to training are discussed further in McFarland & Parker (1990) and Lippert (1989).

To date few intelligent tutoring systems have actually been implemented in operational training settings. Despite a lot of research in this area (mostly funded by DOD), there are many fundamental issues in learning and cognitive theory that have not been answered and will need to be before we know how to design intelligent tutors that really work. Indeed, much of the research in this area has shown how limited our understanding of learning is. Furthermore, the development of tutors takes an enormous amount of time and expertise in artificial intelligence. At the present time, such systems are not economically feasible -- the availability of better authoring tools and more instructional developers with experience in this area will likely change this situation.

EXPERT SYSTEMS APPLIED TO INSTRUCTION: THE FLIGHT PLAN CRITIC

Expert systems are the programs that use artificial intelligence techniques to provide advice or reach decisions in a specific domain. Since a great deal of training involves teaching people how to solve problems or make decisions, expert systems would seem to have a great deal of promise for instruction. By capturing the knowledge of experts in a program, their experience is made widely available.

The Flight Plan Critic is an instructional expert system developed to help aviation students learn how to plan a cross-country flight. The project is a collaboration between Wicat Systems (a CBT vendor), the University of North Dakota, and Northwest Airlines. The expert system was developed using the WISE authoring system linked to OPS5, an expert system development language, running on a WICAT workstation.

The student begins by developing a flight plan using a variety of information available such as aircraft data, passenger/baggage loads, and maps. All decisions made by the student are recorded. When the student completes the flight plan and files it, the plan is analyzed by the expert system which examines its correctness, diagnoses errors and provides feedback to the student including prescriptions that will help the student reach mastery.

Even though the program was developed by an experienced CBT team, it introduced many new considerations. Extracting enough information from the student's responses to diagnose problems was difficult and required the adoption of a "mixed initiative" approach in which the expert system would present its advice but let the student decide what to do with it. Determining when to give feedback and what kind of feedback also presented many design problems. The development of the Flight Plan Critic reveals many inadequacies in our current instructional theories and design techniques for computer based training regarding the analysis and representation of student comprehension during learning.

The Flight Plan Critic is now being tested with aviation students and being "fine-tuned" by its developers. The program represents one of the first instructional expert systems to be used in an operational setting using a commercially available CBT system. The project demonstrates that existing authoring tools can be extended to accommodate expert system and intelligent tutoring capabilities. It also illustrates that the development of new forms of interactive instruction will require substantial new research about learning and teaching.

By contrast, expert systems are much faster to develop and do not require artificial intelligence experience in order to use. The current generation of authoring tools for building expert systems are relatively easy to use and inexpensive. Many college students develop experts systems for term projects in education, management science, medicine, and computer science courses. It is conceivable that instructors could have trainees in management, marketing, and technical areas develop expert systems to help them learn a subject matter and create job aids for themselves and fellow employees. In order for expert systems to be used in training settings, instructors must be comfortable with them and students must have easy access to computers during training and back at the job.

Interactive Multimedia

In the previous chapter, the increasing use of interactive videodisc for training applications was discussed. While most training specialists are enthusiastic about the value of interactive video to learning, the current videodisc systems are too expensive and have a number of limitations that prevent widespread adoption. One limitation in particular that presents problems is the small amount of dynamic video (maximum 30 minutes) that can be stored on a videodisc. Another major limitation is that videodisc (as well as CD-ROM) is a read-only medium that does not permit local customization. Lack of local mastering/duplication capabilities for optical media is another factor that limits its use.

A considerable amount of research with new forms of optical media is taking place (e.g., Ambron & Hooper, 1988; Haynes, 1989; Souter, 1988). Large consumer electronic firms such as Sony, Philips, and Matsushita are working on new forms of compact disc (CD-ROM XA and CD-I) that provide greater storage capability. Intel has developed another technology called DVI (Digital Video Interactive) that involves compressed video and addresses the limited video capacity of videodiscs. Some companies market a read/write optical disk system (e.g., Panasonic) and at least one computer vendor (NEXT Inc.) has incorporated such a disk system in their personal computers. These developments are likely to lead to optical media that overcome the limitations of current videodisc technology for multimedia instruction. The further development of hypermedia systems (discussed in the next section) is also likely to facilitate the use of interactive multimedia.

At the present time there are only a few training organizations experimenting with these new forms of interactive multimedia. Applied Optical has developed a truck driver simulator for Du Pont that uses DVI technology. Federal Express is using CD-ROM to distribute training materials to all of its employees on a monthly basis. It is likely that many of the current interactive videodisc projects in training will eventually migrate to these new technologies to take advantage of the additional capabilities they offer.

Hypertext/Hypermedia

Hypertext describes a new method for organizing online databases that allows users to jump from one idea to another at their whim. This is accomplished by identifying links between text strings or graphic objects during the creation or use of the database. The linked information can also be multimedia in nature such as audio or video sequences in which case the database is called hypermedia. Hypertext/Hypermedia make it easy to browse around a large database and pursue connections between different items of information. Many scientists suggest that hypertext capabilites will have a significant impact on how people use computers in the future (e.g., Barrett, 1989; Jonassen, 1990; Shneiderman & Kearsley, 1989).

Hypertext appears to have significant value to the training domain. When used for college courses, students seem to learn more about the subject area when they use hypertext databases to study with. In the technical training domain, one of the most serious problems is the tremendous amount of detailed information that employees must learn about equipment or procedures. Hypertext can provide a way to present a lot of information that is easier to learn and use for reference. Hypertext/Hypermedia seems to match the needs of embedded training systems very well, especially if optical media is used for multimedia storage of information. At the present time, there is a great deal of exploratory work with hypertext/hypermedia at universities but not much in the training world.

Digital Networks

One of the most important areas of technological development we can expect to make significant progress during the next decade or two is digital networks. The growth of digital networks in the next two decades can be likened to the development of an interstate highway system in the first half of the this century. At the present time we have low speed/low bandwidth lines equivalent to dirt roads; in the future we will have high speed/ high bandwidth optical fiber on par with expressways. Such "digital expressways" are necessary to handle the high volumes of electronic messages and television signals associated with computer based training, teleconferences, and hypertext systems.

Parenthetically, it should be noted that the automobile analogy is probably appropriate for a number of reasons. As data networks evolve from the dirt road to the expressway stages, they are likely to bring about major changes in the nature of work and the way we live -- not all of which will be beneficial. For example, we may have the electronic equivalents of automotive pollution ("information pollution"), rush-hour congestion ("network saturation"), and urban blight (proliferation of network equipment). The hope is that such side-effects will be recognized earlier and managed better than with automobiles.

The increasing availability of digital networks is likely to profoundly impact the nature of training. Such networks will make the transmission of video and graphics information as inexpensive as voice. This will reduce the financial obstacle to teleconferencing and increase its use substantially. Once it is cheap and easy to transmit multimedia information (in conjunction with widespread ownership of suitable workstations, use of optical storage, and expert system/hypertext interfaces), we can expect to see more embedded training and distance learning approaches. This will likely mean that training becomes more informal and self-directed (see the IBM 2000 case study).

One nascent technology that could make a big difference to the evolution of digital networks is direct broadcast satellite (DBS) equipment. At the current time, transmission to satellites (uplink feeds) requires expensive and complicated equipment limiting its use to organizations. However, it is conceivable that transmitters could be miniaturized to the size of a small box or circuit card that would be a personal computer attachment. This would allow any individual to directly transmit information via satellites and hence open up the capacity of digital networks enormously. Of course, a very large number of satellites would be needed to support the transmisson capacity needed for DBS technology (space blight?).

Barriers to Long-Term Implementation

In this chapter, we have briefly surveyed some of the new developments in technology that are likely to affect training. The extent to which these developments impact the training

THE IBM EDUCATION 2000 SCENARIO

IBM has always been a leader in the training domain, especially in the use of instructional technology. An important part of the IBM corporate culture is the value of well-trained employees and hence a high priority is placed on training activities at all levels of the organization. IBM was one of the first companies to try out and implement computer-based instruction, interactive videodisc, and teleconferencing for internal and customer education.

In 1989, IBM commissioned a well-known HRD think tank to develop a scenario of how they might conduct training in the year 2000. They provided a detailed description of what they expected the company and the business climate to be at that time. By 2000, IBM expects to be a highly decentralized organization with most of its revenue coming from information systems services (not products). It expects the workforce to be older, multicultural, and well-educated. They anticipate that most employees will work in temporary project teams assembled for specific customer problems and will not have fixed job positions. The company will have a very flat and dynamic organizational structure.

Given this background picture of IBM, the following training scenario was developed:

* Most training will take place as self-directed learning in the context of job assignments rather than in scheduled classes. The self-directed learning will normally take place at the job site.
* There will be little distinction between the systems used for learning and those used for job tasks. The employee will learn and work using a multimedia workstation.
* Electronic networks will be fundamental to learning and job activities. Employees will interact with each other via online messaging and conferencing systems and acquire information needed through searching multimedia online databases.
* The major role of the training staff will be to act as resource managers helping employees find information and develop skills needed for their current project assignments
* The major role of managers will be to act as advisors/mentors to the employees assigned to them and facilitate communication
* A sophisticated Human Resource Information System will be used to track employee skills and match them up with project needs and available training resources

This scenario paints a much different picture of training than is currently the norm. It suggests that the employee workstation will be the focal point for most learning. However, much learning will occur through group interaction in the form of teleconferencing rather than the traditional type of computer based instruction. Furthermore, learning will be tied to the needs of specific project assignments rather than job positions. Training specialists and managers will need to focus much more on the micro learning needs of specific individuals rather than the macro needs of large groups. In general, this scenario predicts that training activities will become much more complex to deliver and administer than at present.

world and how rapidly is dependent upon a number of factors including: (i) how much emphasis is placed upon technology in HRD departments and training programs, (ii) the technical sophistication of people attracted to the training profession and, (iii) the amount of federal funding allocated to R&D for research in instructional technology.

In order to institutionalize the use of instructional technology in any organization, it is necessary to have a high degree of support and committment toward training from the senior management of that organization. Because projects involving technology require significant capitalization and usually take a long time to bear fruit, they must have strong and consistent support from the top. For this to happen, the company must really believe in the importance of effective training and the potential of technology to help achieve this goal. Thus, the culture of an organization must encourage instructional technology if it is to have a long-term effect.

Creating and sustaining such a culture comes from the ranks of the training department as well as senior management (there must be both "push" and "pull"). In order to sell the rest of an organization on using technology, the training staff must have the necessary background and experience. This means that they must hire new training staff with instructional technology degrees (or retrain existing staff). The company must also provide R&D funds to explore technology approaches. Projects involving technology are almost always innovative in nature and hence require time/money for testing and tuning alternatives. Unless a training department is allowed to conduct such R&D activities, they are not likely to become very sophisticated about the use of technology for operational settings, even if the training staff have the appropriate formal background.

When an organization does support training R&D projects, these efforts are usually proprietary and very narrow in focus. Only the largest companies (such as IBM, AT&T, Motorola, GM) can afford to conduct their own research projects and they are usually not publicized widely nor evaluated rigourously. Federal support of R&D in instructional technology is essential for the field to mature. Large scale funding of new ideas, demonstration projects, and basic research catalyzes the pace of development in organizations and stimulates university activities. We can see this very clearly in the case of DOD support of instructional technology -- almost all of the advances in this area over the past two or three decades have occurred in military training projects. If civilian agencies (e.g., the Department of Labor or Department of Commerce) took over the leadership role in funding instructional technology research, it is likely that technology would be much more prevalent.

The three barriers to long-term implementation just discussed are closely inter-related. Serious commitment by organizations to the use of instructional technology creates a demand for training professionals with expertise in the area. Federal funding of R&D in instructional technology supports university activities in the field which in turn provide the specialized courses needed to train instructional technologists. The results of research projects encourage organizations to try things and avoid dead ends. In other words, the long-term viability of instructional technology is seen as a problem of establishing and maintaining an infrastructure rather than debugging the technology itself (which is a near-term issue). Historically, this infrastructure has been provided by DOD to serve military rather than civilian training needs.

Summary

This chapter has reviewed a number of emerging developments in technology that are likely to affect training in the future. These developments include: widespread ownership of portable workstations, electronic classrooms designed to support instructional technology, products and systems with embedded training, use of intelligent tutors and expert systems, forms of interactive multimedia with more capacity, hypertext systems that improve access and usability of online databases, and digital networks that reduce the costs of information sharing. The net effect of all of these developments will be to make instructional technology more powerful, less expensive and more widely used. The major barriers to development are: lack of support for the use of technology in organizations, lack of training professionals with the necessary expertise to use technology, and lack of sufficient R&D funding at the federal level to keep the ball rolling.

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IV. INSTRUCTIONAL TECHNOLOGY: DEVELOPMENT TOOLS

One element of instructional technology that has not been discussed in detail so far in this report is the nature and importance of the software tools available to develop training materials. Like most other areas of human endeavor, better tools can improve the productivity of training developers. Until very recently, the development of training programs has been strictly hand-crafted and highly labor-intensive. One of the reasons why training programs (especially those involving technology) cost so much and take so long to develop is that every step in the process must be done manually. Variations in the skill and experience of training developers result in variations in the quality of training programs and materials. Despite some attention to quality control methodology (i.e., formative evaluation), the outcomes of training courses are often unreliable and not as intended.

In the past few years, it has become clear that we can develop software tools that will help us design, develop and implement better quality training. It should be emphasized that this area is still in an early R&D stage (with the exception of authoring systems) and hence is not ready yet for widespread implementation. This chapter provides an introduction to and overview of current work on instructional development tools beginning with a discussion of authoring systems. More background on authoring tools is provided by Kearsley (1987b).

Authoring Systems

Authoring systems are programs that write other programs. They allow an instructional developer or subject matter expert with no programming background to create a computer-based instruction course. When the content is provided and the nature of the interaction is specified from menu choices, a program is automatically generated by the authoring system. Not only does an authoring system eliminate the need for programming but it also creates a bug-free program. Eliminating the need for programming and debugging can reduce development time by a substantial amount. So, authoring systems have two principal benefits: they make it possible for almost anyone to develop their own computer based instruction courses and they cut the time required to do it.

Today there are dozens of authoring systems available for all types of personal computers and mainframe systems. Most of them support interactive video and provide student management capabilities. For some of the more popular systems, there are also user groups and consultants available for training or contract development work. All of this makes it relatively easy for individuals and organizations to get involved in computer based instruction without a major investment. Prior to the availability of authoring systems, the development of instructional software required the use of general purpose programming languages or authoring languages (programming languages specifically designed for creating instructional programs) and necessitated the involvement of programmers.

Most commercial organizations that develop courseware create their own authoring systems or use authoring languages to avoid licensing constraints, maximize program performance, or ensure maintainability/portability. In large-scale courseware development, the availability of libraries of screen formats, graphics, and response processing sequences becomes the single most important productivity factor since reusing things already developed is the best way to save time. Some authoring systems come with such libraries developed by the vendor and/or users.

Authoring systems have evolved to the point that the programming aspect of designing computer-based materials is no longer a major consideration in the development process (other than to choose which system to use). Instead, the focus is on the design of the courseware. An authoring system makes it possible to implement any screen or sequence if you know what you want to do and the best way to do it. Unless they have had specific training in the design of interactive instruction, most instructors or training developers do not have a clue how to create effective computer-based learning materials. Experience carried over from the design of print materials or the preparation of classroom lectures does not help much. So the major limiting factor in the use of authoring systems is not the features of the particular authoring system used but the design skills of the developer. This is one of the reasons why current attention in the authoring system area is devoted to the creation of automated instructional development systems and instructional development expert systems.

Automated Instructional Development Systems

Large organizations and the DOD frequently develop courses that involve hundreds of lessons and take years to complete. For projects of this magnitude, there are big payoffs to any automation of the instructional design process. Over the past 5 years, a number of companies have developed prototype systems, some of which have gone into operational use or become commercial products (see Table 2). Most of these systems focus on the front end analysis aspects of developing instruction: task analysis, behavioral objectives, and syllabus creation. Many of the systems also provide project management capabilities specifically oriented to the needs of training efforts. Since many of these systems have been developed for military projects, they are often linked into military specifications and integrated logistics support requirements.

Automated instructional development systems could improve the productivity of training developers in many ways. By doing the mechanical aspects of tasks (e.g., sorting information, drawing charts, tabulating numbers), considerable time can be saved. By providing templates for common tasks (similar to the libraries used in authoring systems), even more time can be saved. Once data is entered into the system, it can be reused in every subsequent task that involves that information.

TABLE 2

AUTOMATED INSTRUCTIONAL DEVELOPMENT SYSTEMS

System	Developer	Scope	Status
ISD Tools	ISD Inc. San Diego,CA	All aspects of ISD	proprietary in-house use IBM PCs
Expert Media System	IntelliSys Inc. Syracuse, NY	media selection (see Olson, 1988)	commercially available IBM PCs
Pahavior Obj. Problem Anal Cost/Benefits	Park Row Inc. San Diego, CA	front end analysis (see Kearsley, 1988)	commercially available IBM PCs
LOC Tool ISD/LSAR	DRC Wilmington, MA	objectives, ISD logistics	research IBM PCs
VISTA	Naval Trng Ctr Orlando, FL	front end analysis (see Maxey & Ahlers, 1989)	research IBM PCs
IDA/CWCM IRV1NG	MacDonnell- Douglas Corp St. Louis, MO	front end analysis (see Cross et al., 1989)	research Macintosh/ HyperCard
IDE	Xerox PARC Palo Alto, CA	front end analysis (see Jordan et al., 1989)	research Xerox 9000/ NoteCards
ISC	IS Assoc. Alexandria VA	integrated logistics support	commercially available IBM PCs

Combined with project management software and electronic mail capabilities, automated instructional development systems can improve project tracking and facilitate the flow of information between team members and clients.

Even though most of these systems have been designed as research vehicles to investigate how automated tools could improve the quality or efficiency of training development, very little research about the instructional development process has yet to be conducted. To date, the systems are of the "proof-of-concept" variety, i.e., demonstrations that working systems can be built. No studies of how the results of automated systems compare to manual procedures or what kinds of time savings might be realized have been carried out. It is clear that the development of automated systems will require a great deal more detailed examination of the instructional design process since even the most explicit and procedural models of instructional development do not provide the level of detail needed to create programs. What this line of research has shown us so far is that we have a very fuzzy understanding of how people create instruction (Kearsley, 1984b).

Incidently, it is interesting to note that the impetus for the development of automated instructional systems has not come from the companies that develop and market authoring systems. To date these two categories have largely followed separate paths. The companies involved with authoring systems tend to focus on the CBT/IVD marketplace whereas those involved with automated ID systems are concerned with training systems generally. To the extent that CBT and interactive video are becoming major forms of instructional delivery, it seems that it would be a good idea for these two tracks to merge. In particular, it would be nice if the outputs of front end analysis programs could be automatically fed into the storyboarding process for CBT/IVD programs. The final link in a fully automated system would be a program that could convert completed storyboards into working programs.

Expert Systems

In the previous chapter the use of expert systems as part of the teaching/learning process was mentioned. One of the most important applications of expert systems may be to provide intelligent job aids or "advisors" for instructional developers. A number of prototypes of such systems have been developed. In fact, at least two of the commercially available systems listed in Table 2 (the Expert Media System and the Park Row Behavioral Objectives program) incorporate expert system techniques.

The ID Expert is a Macintosh/HyperCard based expert system being developed by M.D. Merrill at Utah State University with DOD funding (See Merrill & Li, 1989). The system is intended to guide novices through the instructional design process as well as speed up the productivity of experts. ID Expert consists of hundreds of rules about instructional design that can be invoked at any stage of the design process to give advice or complete a task. Based upon the content information provided, the system can suggest organizational or teaching strategies as well as make recommendations about the best design approach. Another system called Expert Computer Managed Learning is being developed by CBT Systems of Calgary sponsored by the Alberta Research Council. This system not only helps designers create a course but also provides advice on evaluation and course administration.

Developing an expert system for instructional development runs into the same general problem facing automated instuctional development systems -- the lack of detailed knowledge about how to design instruction. However, expert systems are a little easier to construct because all you need to find is an expert who can consistently perform a task with good results. Then the problem of building the system is a matter of knowledge engineering, i.e., representing the expert's knowledge in terms of procedural rules. While this is not an easy thing to do, it has become a routine activity for expert system developers. It seems likely that expert systems for instructional development will proliferate in the coming years. The dilemma will be for consumers to decide whose expert system they want to use. This is likely to be an area ripe for a lot of marketing hype as well a few honest evaluation studies.

Summary

The development of tools to facilitate the development and implementation of training materials and programs promises to be a major area of research and commercial activity in the next decade. Authoring systems for the creation of computer based instruction have already established themselves as a major category of software tools for training departments. Work on automated instructional development systems that cover all aspects of analysis, design, and evaluation is just beginning. The application of expert systems technology to instructional development is at an early stage but is likely to catch on quickly. We can expect the development and marketing of automated instructional systems and expert systems for training to be a major undertaking in the coming decade. As more and more training personnel use computers, interest in such tools will increase.

The overall impact of these tools is to make it easier and faster to develop training programs. Less expertise will be needed to create high-quality training materials because the tools will contain instructional design/development expertise. Note that this impact should be felt in all aspects of training, not just those involving instructional technology.

V. TECHNOLOGY & TRAINING: ISSUES

This chapter discusses how the current and future applications of instuctional technology relate to important issues in the training field. The issues include: retraining, basic skills, team training, participative management, distributed training, multiculturalism, technology transfer, and HRD training. Many of these issues are documented in recent studies conducted for the Department of Labor (e.g., Quality of Work Life; ASTD).

Retraining

A major issue in the technical training area is employee retraining. The impact of introducing new technology into manufacturing is to make the skills and knowledge of many workers obsolete. In many cases, the nature of the job changes dramatically requiring quite different skills and knowledge. For example, when a robotic system replaces manual labor in an assembly line, the new jobs involve the supervision, programming, and repair of robots. When electronic circuits replace electromechanical ones, the repair skills and troubleshooting knowledge needed is different. On the other hand, the outcome of new technology in the workplace is sometimes in the opposite direction - it makes the new job almost menial requiring no specialized skills at all. For example, someone who used to actually perform a task is asked to supervise an automated assembly line and monitor the "idiot" lights.

Retraining employees can take a number of different forms depending upon what kind of career choice they opt for. If they decide to upgrade their skills to match the needs of the new technology, they could require a lengthy training program that requires months or years. If they decide to switch jobs and try a new career, this could also involve a long training period. If they decide to stay with the old job in a deskilling situation, the training is likely to be on the job and relatively minimal.

Instructional technology would seem to have a lot to offer in any of these alternatives. To the extent that minimizing the length of the training time is highly desirable, the use of CBT would seem to be appropriate since it consistently reduces the training time required. In most cases, workers undergoing retraining are older and less motivated to learn new skills and jobs than younger workers just entering the workforce. The use of interactive multimedia is more likely to capture and sustain their attention than traditional classroom instruction. Since a lot of learning is likely to occur on the job (especially in the upskilling situation), embedded training that is built into the new equipment or systems is highly desirable. In addition, expert systems that can compensate for missing skills and knowledge would seem to be a good idea for workers who are not completely retrained.

The bottom line is that workers in a retraining situation cannot afford the consequences of poor instruction. There is a lot higher probability that training that uses technology will provide better quality instruction than conventional methods. This should be a compelling reason why instructional technology be used in most retraining situations.

Basic Skills

The extent of illiteracy and lack of basic skills among a large proportion of the adult population is well documented. Not only does this limit people from carrying out their current jobs properly but it presents a significant obstacle to any form of retraining since more advanced skills as well as the learning process itself are going to be dependent upon basics. Indeed, it is very common for remedial instruction in basic skills to be the first phase of a retraining program.

Instructional technology can contribute to improvement in basic skills in a number of ways. Computer based instruction and interactive video have been shown to be quite effective in improving basic skills with adults (See "Functional Literacy and Interactive Video" case study). By providing individualized instruction in the specific areas where a person is weak, it is possible to rapidly improve their level of reading, writing, or mathematical ability. The use of interactive video is especially helpful because it minimizes the amount of reading needed. The use of electronic mail has been shown to improve the written communication skills of students. The interactivity and feedback provided by technology are important in motivating students who are typically poor learners to keep going.

FUNCTIONAL LITERACY & INTERACTIVE VIDEO

Dominos Pizza faces a problem common to many organizations: employees who have very limited basic skills. Limited reading skills are especially problematic because it prevents employees from learning how to do their job using printed training materials. To deal with this problem, Dominos adopted an innovative approach to training employees how to make pizza using an interactive videodisc system.

The purpose of the dough certification program is to ensure that the pizza dough made in each of 30 plants is consistent in quality. The original program involved thick training manuals and videos as well as written test. Employees found the manuals and test itimidating and did not do well in the training. In 1987, with support from the U.S. Department of Labor, Dominos set out to develop an interactive video program that would accomplish the same training and at the same time remediate any basic skills deficiencies that occurred during the training.

Employees interact with the system using a touch-sensitive screen, respond to questions, select correct procedures, and stop the program action when something incorrect is shown. The program uses animated characters for the narrator and a villian ("the Noid") and involves game strategies. To deal with literacy problems, the program provides for four levels of comprehension: literal, inferential, critical, and creative. Questions can be generated at all four levels and adapt to the level of responses made by the employee as they go through the course. Thus, deficiencies in basic skills are addressed as an integral part of the instruction rather than as separate remedial lessons.

While teaching employees how to prepare pizza dough properly is the primary purpose of the program, it also achieves a secondary goal -- improving the literacy skills of all employees who take the course. The use of interactive video makes the course interesting to employees and differentiates if from "school learning" which many employees dislike. The system solves two problems simultaneously: getting employees to complete training, and dealing with basic skills problems.

Intelligent tutors may be most applicable to basic skills instruction. One of the most powerful features of such tutors is their diagnostic capability. Students who are weak in basic skills often have difficulty learning and require a lot of extra help. Tutoring programs would be able to determine exactly what problems a student is having and provide remediation. Considering how expensive and time consuming it is to develop tutors, it makes sense to focus on basic skill areas where there will be a large population to justify the effort.

Distributed Training

Travel required to attend training classes has always been a major expense category associated with training (not to mention lost job productivity and home life disruption). Most companies and employees would be delighted if effective training could be provided at the job site, eliminating the need for travel. Furthermore, the economic benefits to organizations can be immense. For example, Bowsher (1988) reports that IBM saves about $200 million per year by using self-study training approaches. However, it has been hard to break the tradition of training centers and classroom instruction.

There are many reasons why distributed training is hard to implement successfully (see Kearsley, 1985, for a complete discussion). When organizations try distributed training, they make many mistakes. For example, they expect employees to learn at their job site or at home. Neither of these places provides a suitable learning environment for most employees. Instead, it is often necessary to provide a room or center designed specifically for learning that is free from workplace or home disruptions. Another common mistake is to simply package lecture notes in print and video form. To be effective, distributed learning materials must be highly interesting and preferably interactive. The examples and motivation normally provided as part of the classroom experience must somehow be included in the materials.

Instructional technology can play a pivotal role in making distributed training work. Computer based instruction and teleconferencing provide interactivity which maintains the motivation of the learner. Furthermore, these technologies allow students to interact with the instructor and each other substituting for classroom interaction. The use of networks allows students to share information and access online databases extending their reach far more than the confines of a classroom. As efforts like NTU and other distance learning projects demonstrate, it is possible to provide a much greater selection of learning alternatives through the use of technology than with conventional instruction. To the extent that the training is available via the same workstation used on the job and blends seamlessly with work activities, distributed training is likely to be successful

Participative Management

Studies and scenarios of the future suggest that the structure of most organizations will be much flatter and less hierarchical than in the past. The nature of management will change from a directive, supervisory role to one of information provider, coach and coodinator. Effective management style will be highly participative, allowing employees to be relatively autonomous and independent.

In order to facilitate this style of management, the nature of management training needs to be changed. Although a lot of lip service is given to the concept of participative management, relatively little training along these lines is provided. We need more attention to communication and interpersonal skills. Managers also need to taught how to help employees find information rather than to be a source. In other words, managers need to be taught information handling skills.

Instructional technology can play a role in more effective management training. Interactive videodisc can be a highly effective way to teach communication and interpersonal skills since behaviors can be visually modelled and the effects of good/bad interventions shown realistically. Expert systems can be used to help managers become more adept at analyzing problems as well as providing decision tools. Teleconferencing can be useful in teaching managers how to provide access to resources that are not immediately available. In management training, the emphasis needs to be placed on using technology as a tool rather than to deliver instructional content.

There is also a hidden agenda is using instructional technology as much as possible for management training. The more exposure managers have to successful uses of technology in training, the more supportive they are likely to be for the use of technology for other kinds of training. As discussed in Chapter III, a major obstacle to the institutionalization of instructional technology in organizations, is the lack of support from management. Having experienced positive examples in their own training, managers can become advocates instead of obstacles.

Team Training

Many jobs (if not most) involve coordination with other employees to perform satisfactorily. However, few people ever have any formal training in how to do their job as part of a team. Most training focuses on individual skills and knowledge. Learning how to work as part of a team is usually something acquired on the job. Many people perform poorly in their jobs because they cannot function well as part of a team. This applies to many different types of work such as emergency services, manufacturing, sales, and construction. Indeed it appears that the importance of team-work at all levels of employment will increase as more and more workers interact via some form of computer or telecommunications network.

There are a number of different ways that instructional technology can affect team training. In Chapter II, we discussed the use of networked simulators in military crew training and the possibility of expanding this approach for civilian jobs using interactive videodisc. The use of teleconferences can facilitate group interaction and problem-solving. Computer-based simulations can help people to see the impact of their actions on other people and the organization. Hypertext systems may also be helpful in letting people see the connectively between aspects of their job and others. Finally, intelligent advisors and expert systems may help people work together and become an active component of a team.

It should be emphasized that team training is a relatively neglected part of the training spectrum and there is little research or practice to build on. On the other hand, there is also no strong tradition of classroom instruction in this area to overcome. It would seem like a good area for exploration with instructional technology.

Multiculturalism

One of the very important demographic trends that is likely to have a profound impact on the nature of training programs is the increasing multicultural makeup of the U.S. workforce. While the U.S. workforce has always been a "melting pot" of different cultures, the scope of diversity is now much greater spanning large percentages of African, Middle East, East Asian, Indian, Caribbean, and Central/South American immigrants. Furthermore, there is a much stronger tendency to retain language and customs that in past generations. This means that training programs need to be designed to support different languages and cultural learning styles.

Instructional technology can address the multicultural issue. For example, CBT and interactive videodisc can easily provide a choice of language and present information in slightly different ways for different learners. Video and television can be dubbed with other languages. Online databases and help systems can be available in multiple languages. Teleconferences can use interpreters to translate questions from participants. Because of the economies of scale involved in most applications of instructional technology (e.g., large student populations) and the longer development cycle, it becomes feasible to prepare multilingual versions or capability for training programs.

Multilingual presentations are only one aspect of designing multicultural training programs however. Workers of different cultural backgrounds must learn how to work together with an understanding of each other's customs and Weltenschung. Such understanding is most likely to occur through opportunities to learn more about other cultures and look at problems from a broader perspective. To the extent that technology can provide such opportunities through television, video and teleconferencing, it can contribute to multicultural training.

Technology Transfer

Since a great deal of the research in the instructional technology domain is conducted for DOD, there is always an issue of transfer of this technology to the civilian sector. In addition, there is a technology transfer issue between industry and institutions of higher education (and possibly vice-versa).

The surest route for technology transfer is the development of commercial products and services. Once instructional technology enters the marketplace, it becomes available and accessible to all organizations and individuals -- provided they can pay the price. Competitive pressures usually force product enhancements, reductions in price, and widening of marketing and distribution channels. Entrepreneurs play an important role because they are willing to take risks introducing new innovations and spend time evangelizing about their product/service.

As has been discussed earlier in this report, one of the most important ways that instructional technology is transferred from military research to civilian applications is through the movement of personnel from the military and military contractors to commercial organizations. For example, many of the individuals involved in military CBT and interactive videodisc projects during the 1970s and 80s went on to develop CBT and interactive videodisc for commercial applications later in those decades. The same is likely to be true for current research with intelligent tutors, expert systems, automated instructional development and networks. One aspect of military research that facilitates this transfer is that most work accomplished is in the public domain (provided that it is not classified) and hence has no contraints on commercial development.

The problem with this form of technology transfer is that it is not systematic and does not necessarily address the most critical training needs of individuals, organizations or the nation. For example, if a market is difficult to reach (e.g., small business), perceived as irrelevant (e.g., elderly) or unfamiliar (e.g., minorities), it may not get much attention. Another problem is that much of this type of technology transfer is carried out by small companies with very limited resources who are unable to fund the level of development needed. Consequently, an enormous amount of instructional technology developed in the context of military, academic and industrial research does not get transferred to organizations, institutions and individuals where it might improve learning.

HRD Training

It has been emphasized a number of times in this report that the knowledge and skills of instructors with respect to the development and use of technology are paramount to its success. Yet, a large proportion of training professionals have little experience with or understanding of instructional technology. The increasing prevalence of instructional technology programs at universities and the increased attention to the topic of instructional technology by professional organizations in the HRD domain helps to improve this situation but not in a broad fashion.

In order for instructional technology to have wider usage and greater impact, it is necessary that almost every instructor understand how to develop and use technology in sophisticated ways. This can happen in only one way: all instructors must receive extensive exposure to the use of instructional technology during their own training. Training professionals need to see technology used during graduate HRD programs at universities as well as continuing education received at seminars and conferences. Thus, universities and professional organizations have a major role to play in producing a generation of training professionals who will use instructional technology significantly in their own organizations and businesses -- but not by merely encouraging courses or talks about instuctional technology.

For a long time, there has been a split in the HRD profession between those interested primarily in "soft skills" (interpersonal training) and those concerned mainly with "hard skills" (technical training). The use of instructional technology has always been seen as the province of technical training and not very relevant to interpersonal training. In fact, technology can be applied equally well to either kind of training. There is a need to apply more awareness of human relations to the use of technology and vice-versa. The HRD profession needs to look at technology much more broadly than it has in the past. It should not be viewed so narrowly but as a way of improving human potential and organizational growth.

Summary

In this chapter, some of the major issues in the training field were reviewed and the relationship to instructional technology discussed. It was argued that technology could have a major impact on issues such as retraining, basic skills, distributed training, participative management, team training, and multiculturalism. Two factors that determine the extent of the impact are technology transfer and HRD training. Unless the results of technology-based projects are available to the organizations and individuals who need it, the potential benefits will not be realized very widely. At the present time, technology transfer occurs in a largely random fashion. Furthermore, a relatively small proportion of training specialists have a high level of expertise using instructional technology which also limits the extent of its impact. These two areas, technology transfer and the training of instructors about technology, need much more attention.

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Appendix A

Military Applications of Instructional Technology

This Appendix summarizes some of the current initiatives of the Department of Defence (DOD) in the area of instructional technology with particular focus on basic skills and maintenance training. It should be appreciated that military training is an enormous enterprise with no centralized coordination. This makes it very difficult to provide any kind of comprehensive or complete description. Even within a given service, there is no single entity responsible for managing instructional technology efforts. Thus, this report can only hope to provide snapshots of the kind of activities being conducted. Futhermore, since a large percentage of the instructional technology projects undertaken by DOD are of a research nature; many of these projects do not move into an operational status.

Overview

In an attempt to provide an overview of instructional technology efforts in the military, we can examine data collected by the Training and Performance Data Center (TPDC) under the Training Technology Transfer Program (TTTP) and reported in August 1986 (latest public report). At that time, there were 368 training technology projects underway in the USAF (33), Army (143), Navy(189), and Marines (1). Of these projects, 197 were being conducted by outside contractors, 137 were being conducted in-house, and 34 were intra-service or undetermined. A total of 30 different military organizations were responsible for these projects with the bulk being conducted by the Air Force Human Resources Lab (31), Army Research Institute (136), Naval Training Systems Center (79), Navy Personnel Research & Development Center (48), and the Office of Naval Research (34). As far as contractors concerned, the projects were spread across 29 universities and 70 corporations.

The projects being conducted fell into the following six areas:

1. Artificial Intelligence - expert systems, intelligent CAI, intelligent coaches (43)
2. Automated Job Performance Aids - decision support systems, authoring tools, automated ISD (18)
3. Computer Based Instruction - tutorials, simulations, games (86)
4. Embedded Training - operational systems with training built in (6)
5. Interactive Videodisc (IVD) - computer controlled video (11)
6. Simulators - trainers for operational equipment (82)

While the TTTP report is now a little dated, it does convey a fairly accurate picture of instructional technology efforts at the present time. However, in the past five years, more attention has been focused on embedded training and interactive videodisc with less emphasis in the areas of computer based instruction and artificial intelligence (although these are still important areas).

Basic Skills

One area of considerable importance to almost all branches of DOD is basic skills instruction. Many recruits enter the miliary service with major deficiencies in reading, writing or mathematics skills that handicaps all further learning/training activities. The nature of these deficiencies and attempts to correct them are well described by Thomas Sticht (1989). Sticht's functional literacy (FLIT) approach has been the basis for basic skills programs in the

Air Force (JORP), the Army (JSEP), and Navy (JOBS). The basic thrust of the FLIT approach is to encorporate basic skills instruction in any entry level training program, thus putting literacy in a functional context.

There have been two major basic skills projects in the military based upon the FLIT approach that involve instructional technology: JSEP and SDMS. The JSEP project is described in detail in the main body of this report. The Spatial Data Management System (SDMS) project was an attempt to use interactive videodisc to teach basic skills in the context of map reading and navigation skills. This project was conducted by the Human Resources Research Organization for the Army Research Institute in the early 1980s. It did not continue into an operational phase, although it served to demonstrate the potential of IVD for basic skills training.

Maintenance Training

Military readiness depends heavily on the effective maintenance of equipment. Consequently, maintenance training is a major focus of DOD training efforts. Over the years, there have been many attempts to use instructional technology, mostly in the form of simulators, to improve maintenance training. Orlansky & String (1981) provided the definitive study of the cost-effectiveness of maintenance training simulators showing that the simulators resulted in improved job performance, reduced training time, and lower costs relative to the use of actual equipment for training. Subsequent studies have simply reinforced the conclusions of Orlansky & String.

The use of instructional technology for maintenance training has focused on simulations involving computer based instruction and more recently, interactive videodisc. For example, in 1987, the Air Force Communications Command (AFCC) fielded 92 interactive video systems for electronics maintenance training on the AN/GRN radar and test equipment. The IVD system delivered on the job training for skills that had previously been learned only through apprenticeship. The project involved a detailed follow-up on 160 trainees; however no comparative evaluation of the IVD system versus apprenticeship only was conducted. The follow-up study indicated that the system was effective when used but difficult to integrate into the workplace (see Slater, 1988).

A research project conducted by the Navy investigated the use of interactive videodisc as a tool to evaluate job performance in electronics troubleshooting (Kidder & Laabs, 1988). The preliminary results indicated that interactive video simulations provided as good a testing method as hands-on tests. In another IVD project for maintenance training (Nicholis, 1990), the system was used as a job aid to help trainees isolate faults. The study concluded that the use of the system reduced skill requirements, repair times, and reliance on technical manuals.

Other Applications

Current applications of instructional technology in military training are very diverse and involve all of the technologies discussed in the main body of this report. Here is a sampling of current projects:

• Computer Assisted Medical Interactive Video System (CAMIS) - Medical Heath Sciences Education & Training Command, Naval Medical Command. Over 25 interactive videodisc courses in basic medical skills and medical knowledge areas have been fielded and many more are in development.

• GUARD FIST II - Army National Guard. A simulator employing IVD and computer-generated imagery will be used to provide tactical training in simulated battlefield scenarios. The simulator includes all equipment normally used by the Forward Observer MOS

• Piloting and Navigation Team Trainers - U.S. Navy. A set of simulators that are used to train navy officers on ship navigation and piloting skills. .These simulators provide realistic presentations of shipboard equipment and use a variety of hydrographic databases.

• 89- OBT ASW Trainer - U.S. Navy. The OBT-89 is a simulator that provides embedded training for the AN/SQQ-89 sonar systems installed on surface ships for Anti-Submarine Warfare (ASW). The OBT-89 allows an instructor to program the AN-SQQ-89 for training exercises.

• Student Evaluation System (SES) - Air Command & Staff College, USAF. A computer managed instruction system involving computerized testing and student administration is used to deliver distance education to over 500 students in 70 locations worldwide.

• Army Logistics Management College (ALMC) uses satellite teleconferencing (one-way video, two-way audio) to teach logistics at over 30 sites. The televised courses have been taken by over 13,000 students.

Effectiveness

There have been many effectiveness studies of instructional technology in military training settings. A general outcome of these studies is that relative to other training approaches (usually classroom lecture or apprenticeship), instructional technology results in the same or better student performance regardless of what measures are used (e.g., achievement, job performance, retention, time on task). Futhermore, technology-based training almost always reduces student completion time relative to classroom instruction by 30-50%. These outcomes are well-documented for CBT and simulators by Orlansky & String (see Orlansky, 1986, for a summary). More recently, Fletcher (1989) has summarized the results of evaluation studies for IVD.

While there are many methodological problems with these studies, it is clear that instructional technology is effective in most settings. However, instructional technology is often not successful because of implementation problems. For example, one factor that strongly determines the success of technology-based training is the degree of involvement of the instructional staff with the technology. It has been repeatedly shown that if the existing instructors are not significantly involved in the design and use of the technology, it is not likely to be effective. In other words, implementation considerations, rather than inherent characteristics of the technology itself, are usually the limiting factor in its successful use.

Transfer to Civilian Training

The fundamental question of this study is the extent to which instructional technology can contribute to increased U.S. competitiveness. What impact does military use of instructional technology have on this question?

First, it should be noted that a sales of U.S. developed and manufactured weapon systems generate enormous revenue for U.S. companies. These sales usually include training support and to the extent that technology-based training programs are available, they are included. If such technology-based training systems are seen as providing more effective training, they could enhance the marketability of a system and hence make U.S. companies more competitive in this arena.

Secondly, it should be observed that a large proportion of enlistees leave the service after their initial tour and enter the civilian world. Thus, DOD provides technical training which is then utilized directly by the commercial sector. To the extent that this training is made more effective through the use of instructional technology, it makes new employees more skilled and hence increases the competitiveness of the companies hiring these individuals.

Another effect to be taken into account is that the military support for instructional technology creates a large pool of companies and individuals with expertise in this area. These companies take the systems and expertise developed in the context of military training and apply it to the civilian sector. This can take place directly through services and products, or indirectly through personnel transfers.

Finally, there is the possibility that systems and curriculum developed for military training can be directly used in civilian training. To the extent that this training provides more effective instruction, it would improve the quality of worker skills and hence result in more competitive companies. The Training Technology Transfer Act is an example of legislation that could faciliate this process. Indeed, this Act is already being employed to transfer the JSEP program into civilian use.

Summary & Conclusion

Instructional technology is widely used by the U.S. military for all types of training. Basic skills and maintenance training are two areas that have received some attention, although many more projects are underway in the latter than the former. Evaluation studies of instructional technology in military training consistently show that is as effective or more so than existing classroom or apprenticeship methods. To the extent that instructional technology increases the effectiveness of military instruction, it contributes to increased competitiveness in the civilian sector.

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