The Future of Computers In Industrial Training

Can the Potential Become Reality?

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Abstract. Recent surveys indicate a considerable increase in the number of industries and businesses employing computers to support their training. Examination of a number of factors, especially the advance in computer technology, the national acceptance of technology, appearance of the "Office of the Future" and others, indicate a strong potential for business use of Computer Based Training (CBT) to grow. However, the training managers must demonstrate that they have learned from CBT's past failures. They must employ skillfully the total art of instructional technology, plan project implementation systematically, create an effective management organization, and begin with a detailed cost affordable justification.

For several decades technologists predicted commanding roles for the computer in the management and operation of business and industry. They asserted not only that the basic operation of many businesses would change drastically as a result of the impact of computer technology, but that the technology would generate new industries. Trainers and educators have followed these developments closely to see if the rewards of technology were meant for them. While the record is still unclear, and results uneven, an assessment of the situation indicates that industry and business are positioned to expand greatly their use of these technologies for training.

It is probably useful to pause and summarize the uses and benefits of the computer to support training. The computer can deliver training, test performance, manage the delivery of training and manage the resources and administrative details of the training system. A variety of terms have emerged as shorthand titles for each of these functions but they have served more to divide the community than to unite it. This article will use the general term computer based training (**CBT**) to refer to the use of computers in support of training, computer assisted instruction (**CAI**) to refer to the use of computers to deliver the training, and computer managed instruction (**CMI**) to refer to the computer in its management role. The reference in note one provides detailed descriptions of the benefits of CBT. This work, as well as others, assert that CBT in one or more of its forms can: reduce the length of training, make training more interactive, make training more interesting, take training closer to the job site, standardize the delivery of training, replace expensive end items, deliver training twenty fours a day and on demand, and provide real time information on individual and group performance. Since evidence exists to support each of these assertions, the primary issues concern the *amount* of gain, the ability of an organization to *achieve* the gain and the *cost paid*.

The Use of Computers in Industrial Training

A 1981 survey by the Alexandria, Virginia, based Human Resources Research Organization (HumRRO) provides an excellent snapshot of industrial and business use of computers in training. HumRRO contacted 160 "Fortune 500" companies, of whom 56 responded (Kearsley et al., 1981). Half the respondents indicated that they used computers for their training responsibilities. Of the half using computers, twenty reported that they used microcomputers. Microcomputer use for training was often in addition to the use of mainframe computers for similar purposes.

Figure 1 displays the survey results. Two conclusions are especially interesting. First, most CBT use supported technical training. This observation is substantiated by the figures indicating that a large number of companies use simulations (an approach that many training organizations find useful to make technical training effective and efficient). Second, the sample companies use CBT across the total range of training requirements, employ a broad range of approaches, and use many different hardware systems. This diversity indicates both a willingness to experiment and the presence of imperatives for the companies to try CBT.

Significant questions for this article are whether the 1981 survey represents an increase in the use of CBT and, if so, what factors drive the change. Data concerning business and industry use of CBT is fragmentary at best, forcing us into inferences.

A 1980 study surveyed 113 companies and found 21% of them using computers for training. A study of 400 companies in 1978 found about 10% of them using computers for training (Kearsley et al., 1981). While the available evidence seems to indicate that the use of computers for training in business and industry is on the increase, we can only put it in perspective by looking backward and examining expectations concerning computer based training over the past decade or so, along with the reasons why reality differed from those expectations.

Although technologists and futurists of the sixties and seventies predicted widespread use of computers to support training and education requirements, those predictions missed the mark. Dramatic changes failed to occur. A variety of causes explain this failure. Hardware was extremely costly;

courseware was not only costly but took a long time to develop. The systems seemed extremely complex and when the programs were finally delivered, they were often boring. In fact, the products of the seventies seemed to support the critics' charge that CAI was primarily automated programmed instruction. The most damning result was that despite all the expense and time, the delivered CAI programs turned out to be primarily supplementary rather than substitutional. Hence, CAI was an "add-on" cost. Examples of the type of results that could deter business were the two major military CBT efforts which took from 4-7 years to become operational, reduced CAI to less than 10% of the delivered program, and provided supplementary rather than substitutional CAI (Seidel and Wagner, 1981).

Despite the presence of two large CAI systems, one developed and supported by IBM and the other by Control Data Corporation, business and industry funding for computer based education represented only about 10% of the funds spent within the U.S. on CBT and CAI during the seventies. Support of education in the colleges and schools of the United States was the major driver (Office of Technology Assessment, 1979). Even Control Data's program focused more on education than training. The business managers of the seventies apparently did not see CBT as an attractive option.

Despite the problems of the last decade, the evidence available today indicates a considerable increase in the use of computers to support business and industry training over the past 2-3 years. This result should not be surprising when one examines the recent advances within technology and other changes in the business environment. A host of factors, once seen as constraints on the use of such technology for training, now appear to propel some companies boldly into computer based training.

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Advances in Training Technology

Clearly, the first change is the advance in computer technology. We face a situation in which computers the size of a typewriter provide the power that required a computer the size of a room a decade earlier. A series of curves depicting drastic reductions in cost and size and equally dramatic increases in capacity could illustrate dramatically the increase in computer technology. The singular benchmark of this shift is the microcomputer, a self-contained instrument rivaling the power provided by the mainframes of a decade or so ago.

The National Science Foundation estimates that the power that cost $20 million fifteen years ago will be available for a few hundred dollars by the mid-eighties. The small computer now being advertised nationwide for under a hundred dollars is only the forerunner of this shift. Within a period of thirty years, capacity has increased 10,000 fold while price has dropped 100,000 fold.

Another important factor in technological advance is the increasing graphics capability available on all computers, and the ease of access to it. Sophisticated graphics are not only available in such systems as PLATO or TICCIT but are found in typical microcomputers such as the Apple II. Graphics capabilities enable the computer to support simulations and displays critical to effective training in such areas as equipment operation and maintenance. Anyone who has seen "Three Mile Island," a nuclear plant simulation, or the "Aviation Flight Simulation," two microcomputer simulations, cannot help but be impressed by the power of the microcomputer graphics and simulations and their potential to support effective training.

Keyboards still frighten many people or are cited by managers as a reason they are deterred by computers. The advent of more user-friendly interfaces is another important step toward making CBT more attractive. Touch panels and light pens have been particularly successful interfaces for operator and maintenance programs. They are attractive not only because they circumvent the keyboard but because the student action in touching a portion of the display may have greater psychological fidelity to the real world task than does making a keyboard entry. Voice input is becoming more practical and is already appearing in some hardware configurations. It represents an even more attractive option for many types of human-computer interaction.

Until recently the training manager had several stark alternatives when choosing a CAI delivery system. A multi-site, multi-terminal mainframe system such as the IBM IIS or ITS or Control Data's PLATO could represent a considerable investment. It was cost effective only for certain circumstances involving a specific number and geographic distribution of students. A single site, multi-terminal system such as Hazeltine's TICCIT could be cost effective for other circumstances but required a critical mass of students. Stand alone microcomputers also had their uses. None of these options was a perfect solution. Each had its own advantages and disadvantages. Advanced technology has created a variety of network operations. The ability to have micros operate

Areas	
Technical Skills	71%
Sales/Mgmt	29%
Admin/Clerical	20%
Prog/Computers	39%
Trng. Mgmt	21%
Users	
Simulations	79%
Problems/Tests	50%
Tutorials	36%
Systems	
Apples	21%
PLATO	21%
IIS/SCHOLAR	21%
Others	32%
Custom	18%

Figure 1. Results of HumRRO's 1981 Industry Survey. Sampled 160 major corporations (56 responded). 50% (26/56) active in CBT, 36% using micros.

as stand alone delivery systems but to network for management and information purposes offers an attractive option for a number of industrial and business training situations. The importance of this advance is apparent in the speed with which Hazeltine and Control Data have adopted this option for their systems.

Another new training technique that is particularly interesting is embedded training. Embedded training consists of using the computer within a piece of equipment to deliver the training program and testing program for its operators and/or maintainers. Xerox is employing this approach for customer operator training on the Xerox 8010 professional workstation, the STAR. The Army has also employed this approach in several of its command and control systems.

Although authoring effective instructional courseware is still a major undertaking, it is difficult to deny the emergence of authoring languages and systems that tend to make the development of computer assisted instruction easier for non-programmers. Admittedly, each authoring language or system internalizes an instructional approach, which has been described by some as a straight jacket. But for many uses they represent an effective compromise between program flexibility and development cost. Authoring languages such as Pilot, the TICCIT Authoring Language, and PASS are examples of the headway made in developing user friendly languages for the use of instructional developers. Moreover, authoring difficulties are being addressed by automated authoring approaches and by authoring job aids, many of which show promise.

The nation is in the midst of a major environmental shift which may have as much an impact as any factor on the probable success of computer based training. That shift is the invasion and acceptance of technology in everyday life. The exploding popularity of personal computers, the extraordinary success of video games, and the proliferation of video arcades are all manifestations of this phenomenon. One has only to count the number of articles in popular magazines such as *Time* and *Newsweek* during 1982 to grasp the pervasiveness of technology. Industry sources estimate that over 750,000 people in business are being supported by microcomputers and that these smaller computers are selling at the rate of 30,000 a month. The 30,000 figure is probably conservative by a factor of two.

The presence of the "Office of the Future" and the maturing of the Office Information Systems (OIS) concept create an environment, provide tools, and generate a demand for computer based training. OIS is an electronics revolution which provides a highly automated office environment. This automation performs clerical tasks electronically and brings new electronic tools to bear on professional and managerial jobs. These tools will redefine and reconfigure some professional positions. The nature of the electronic environment should produce an acceptance of CBT seldom found in present industrial or business settings. More importantly, the managerial and professional workstations can themselves become the new training delivery system. Finally, the presence of such sophisticated electronic equipment will generate a demand for CBT programs to train their users. Traditional training would be anachronistic in such a setting.

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As transient as the present economic situation may seem, its importance cannot be neglected. Informal conversations with representatives of a number of companies indicate the movement of more training to decentralized locations because of the cost of transporting and housing students. This does not spell doom for centralized facilities. It may mean instead, the development of a set of objective criteria to determine whether training for a given requirement should be provided in a centralized or decentralized setting. Neither setting is the answer for all requirements. (Editor's note: see Sarenpa this issue.) However the cost of transportation, and the related issues of skill decay and poor likelihood of early use of some of the skills provided, places a great deal of training in a local setting. The major shortcoming of decentralized or distributed training systems is the lack of standardization of training delivery and the uneven quality of field or job site trainers. Computer based training can address this effectively. Hence, the increase in decentralized training ought to increase the demand for CBT among those organizations concerned with effectiveness. A companion impact is the current economic situation's impact on the willingness of a company to invest in expensive training technologies. Some companies are making this investment during the hard times of 1982.

Instructional Design and CBT

Another factor which supports industry acceptance of CBT is the increasing systemization of industrial and business training, and the simultaneous, but unrelated, greater involvement of instructional technology professionals in the development of computer based training. Both phenomena are difficult to quantify, much less prove. The greater acceptance of instructional systems development and criterion-referenced instructional approaches in business and industry training leads one to assert the increasing systemization of training. This result places any training requirement in a better position to be supported by computer technology. In those cases where the manager is able to specify a job in terms of a list of tasks and specify those tasks as objectives, he/she has provided the pre-conditions for an effective training program, regardless of the delivery medium. Similarly, the increased involvement of instructional technologists in CBT program development bodes well for the development of effective programs. The HumRRO survey described earlier noted that a number of companies which had not implemented CBT programs had taken the preparatory step of converting their programs to criterion-referenced form with appropriate behavioral objectives.

It can be also argued that more companies will conclude that the use of computer based training, to support either their own training requirements or to train their customers to use and maintain their products, represents a competitive

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edge that must be accessed. As an example, market analysts are beginning to assert the need for effective training programs to support the expanding microcomputer market. The analysts usually cite the few CAI tutorials available as examples of the training required. The first microcomputer manufacturer that can support its hardware and application programs with effective CAI tutorials, as well as better documentation, may gain a significant competitive edge. This need can be projected to any other sophisticated electronic item requiring training to operate it.

Other Technologies in Training

In addition to the technologies already described, other approaches, supportive of the larger area of training, are becoming both available and affordable. An increasing number of companies are developing programs delivered by microcomputer driven videodisc players. The videodisc offers exceptional possibilities in its immense storage capacity, random access, excellent video quality and capability to being controlled by a computer. A videodisc can store 54,000 separate pictures or frames of information. At the August 24-26, 1982 Society for Applied Learning Technology workshop on microcomputer driven videodiscs, over eighteen videodisc programs were demonstrated or described. They supported fields as diverse as leadership training, equipment maintenance, and data base management. At present, videodiscs are not a panacea; they are more expensive than the video tape to produce, cost effective only if produced in quantity, and impossible to revise once mastered and duplicated. More near term use may be made of computer-driven, interactive video tape. Although lacking videodisc's random access speed, video tape is more cost effective where the number of copies is small. It enables trainers to access the same video results that videodisc provides. Computer driven, interactive-type video tape production at this stage should be viewed as complementary rather than competitive with videodisc development since most of the advances it will make will have a direct impact on the development of better videodisc programs.

The use of artificial intelligence (AI) processors to support training appears to be moving from the experimental to the operational. The work on SOPHIE by John Seely Brown and Richard Burton of Xerox's Palo Alto Research Center illustrates the sophisticated interactive instructional medium that the (AI) processor can support. The migration of the Navy Personnel and Research Development Center's (NPRDC) STEAMER project to an artificial intelligence processor is another example of the potential of the AI machines. The strength of an artificial intelligence supported approach is its ability to help students learn strategies, rather than to teach lessons. Students try out their own strategies under the eye of the expert tutor (the AI processor's program) rather than being forced through someone else's programmed approach.

The Case of Xerox

One corporate example of the impact of these factors on training program can be seen by examining computer based training at Xerox. Until 1981, the primary operational CBT program within Xerox was a multi-site, multi-terminal, time-sharing system used to provide training to office, administrative, and data processing personnel. Although the program remained cost effective for several years in the areas it addresses, the technology never gained a foothold in the company's premiere training interests—sales, equipment servicing, and management. Training managers in those areas perceived the program as automated program instruction and felt that the absence of graphics and simulations made it inappropriate for their areas. This reaction to shared, multi-site CBT systems surfaced in many other larger companies.

However, during the last eighteen months, Xerox developed or initiated development of computer based training programs across a wide spectrum of topics. Each of these programs took advantage of a new technological capability. When Xerox announced the Xerox 8010 professional workstation, and STAR in 1981, one of the competitive capabilities demonstrated was an embedded training system. STAR*T, the embedded training program, required operators to hit any key to enter a program which guided them through STAR's principal features and taught the system's capabilities, including operation of the "mouse," the device to move the cursor. The program is interactive and provides precise feedback derived from the operator actions. The STAR also contains two other embedded programs: fourteen training modules to provide greater skill in STAR's capabilities, and a HELP function which is really an electronic embedded job aid.

Other Xerox programs were developed in 1981 and 1982 to take advantage of the presence of microcomputers throughout the company. These programs included knowledge and troubleshooting programs for factory technicians, and a pre-school knowledge program for new sales representatives. An experimental microcomputer data base game on sales representative knowledge requirements was developed to take advantage of NPRDC's work in this area.

The largest microcomputer based training program was developed to support Xerox's 9700 electronic printing system. The Xerox 9700 Electronic Printing System was selected as the focus of a CBT demonstration project. It is a sophisticated system which reflects the latest technology in printing. The material to be printed is provided to the 9700 either by keypunching into the terminal atop it or via computer tape. Most purchasers use the printer to print forms as one of its outputs. Reducing a form to a series of coded commands is an art taught in a short course to customer operators. When the operator keys the coded commands for a form into the terminal, all that is seen on the display are the commands keyed, not the resulting form. The operator must print one copy to see if the desired result is obtained.

The operator course is a two day program taught to Xerox personnel at one location and to customer operators at six locations around the country. The company's goals in developing a computer

In this CBT application, the Xerox 820-II simulates the operation of a Xerox 9700 printer in the creation of forms. The student hardware consists of a Xerox 820-II with a second monitor.

based training course were: to reduce the training time required; to shift the training to all Xerox branch sites or to customer locations; and to increase operator effectiveness over the present course.

The solution to this training requirement was the creation of a computer assisted instruction training program on the Xerox 820-II microcomputer. The Xerox 820-II is an upgrade of the Xerox 820. It offers business graphics, runs faster and has more disk storage than the 820. This training program is built around a simulation in which the Xerox 820-II simulates the operation of a Xerox 9700 printer in the creation of forms. The student hardware consists of a Xerox 820-II with the monitor of a second Xerox 820-II driven by it. When students key the commands into the computer, they will see on the first monitor the commands keyed, which is all that would be seen on the terminal atop the printer. The second monitor displays the resulting form.

The key to the program is the use of the Xerox 820-II as a simulator. It simulates the running of the 9700 in the creation of forms. When the student creates forms, the 820-II microcomputer reacts like a 9700 printer. It will display the result the student would actually achieve on the printer.

The training program is in three parts. In the first part, the student is introduced to the eleven most frequently used commands for creating a form, and to the actual form created from those commands. Students change the nature of a form by changing each of the parameters in the command set. As a result they are able to relate a command change to a form change. In the second part of the course students are provided a form and told to create the necessary commands on the microcomputer. The system provides feedback on the actions and displays the resulting form. After successfully coding several forms, students are allowed to move to the printer, where they are given a form and required to verify their proficiency by coding it and printing the desired outcome within three trials.

Instructional developers will appreciate the strengths of this program. It is an interactive program demanding the total involvement of the student. The student is continually coding and changing forms and receiving feedback after each action. The course is built around considerable practice at performing the terminal job task — creating forms.

Several important benefits are expected. Developmental testing to date indicates that the course should be reduced from its current two days to one day or less (probably 6-8 hours). This reduction will enable one full day of work to be captured by each Xerox worker and each customer operator who takes the course. It also appears that the CAI course will reduce the average number of tries a student requires to code a form successfully. The course will be shifted to Xerox branches and be available whenever a prospective student requires the training.

Thus the range of CBT Courses across Xerox is considerable. While a mainframe based system probably will continue to be cost effective to support distributed administrative and data processing training requirements, the other programs are more apt to be supported by microcomputers. Embedded programs have just arrived and will increase in number. The whole equipment servicing training area will receive considerable attention as simulations of increasing fidelity become available.

The factors which I have mentioned thus far represent a considerable change in the situation and hence bode well for the growth of computer based training. The eighties could well see the flowering of this technology.

However, I have purposefully used the conditional term because of the obstacles and pitfalls that confront training managers and developers. CBT is still an expensive technology. Lead times will remain long, managers will become impatient, and the temptation to take shortcuts may be overwhelming. There are several key issues which training managers and instructional developers must address more effectively in the future if they expect the new training technologies to succeed.

Key Issues for the Future

First, project planning must begin with a complete cost benefit assessment to quantify the alternatives and to ensure that the project will be beneficial. An effective cost benefit assessment will examine a number of alternatives, especially the location of the training, hardware configurations, and the means of acquiring the courseware. This is a difficult step for an organization that may not have completed a computer based training program previously. But it is more important for such an organization, because it raises critical variables and consciously forces assumptions in areas in which the organization may be ignorant. Further, it surfaces a number of hidden costs, especially those associated with the maintenance of the hardware and ongoing software maintenance which otherwise would be surprises. Computer based training is not inexpensive and is not the answer to every training requirement. It must be addressed like every other business issue in an objective and professional manner, so that managers understand their costs, risks, and returns.

A second major issue is establishing appropriate forms of project management with due attention paid to several critical management concerns. An organization is faced with choices among functional management, project management, and matrix management. Cases can be made for each in certain situations according to the application of different decision criteria. However, our concern, for the most part, is not with the upgrade of existing CBT systems or development of single experimental prototype. These are both simple projects that probably can be handled by functional management. The larger problem is those companies which make a conscious decision to establish a computer based training *system* and begin the development of courseware. The expenses involved, the complicated nature of the technology, the time length of the project, and the probable size are all factors that many combine to defeat a functional organization. "Business as usual" will destroy an emerging CBT program. The project manager must take steps to develop a carefully balanced staff that includes all of the disciplines required. Planning, development, implementation, and evaluation of a CBT program is a truly interdisciplinary effort. Another aspect of management is the requirement to ensure that the expectations of the different parties agree. Most military CBT efforts of the 1970s failed because the research and development expectations of the developers differed substantially from the operational expectations of the users upon whom the products were going to be imposed. Early phases of any large CBT effort will by their nature include more developmental and evaluation aspects than may be included later in the project. The potential users must not only understand this; they must share in the development and evaluation. Finally, the project management must ensure a serial development of critical components. Hardware and software environments must be stabilized before courseware is developed. Unfortunately, parallel development is often used because of time restraints. It leads to situations in which hardware and software shortcomings create courseware errors and ultimately slow and make more expensive the courseware development. This occurred in the Army's Computerized Training Project and in the Computer Education Research Laboratory's test of PLATO for the Air Force. Skeptical project managers or their management seem to feel that a CBT"law of gravity" does not pertain to them (Seidel, 1981).

Third, the necessity of performing effective needs assessment, front end analysis, and instructional development is as critical as in any other training development effort. The best skills of the art of instructional technology must be skillfully brought to bear. Put simply, bad instruction supported by computers becomes"computer-based-bad-instruction." The need for a systematic approach to instruction is required at the start of the project when the performance technician seeks to determine the performance problem and then, if a training solution is required, selects tasks for training. CBT is an expensive distraction if the performance problem requires a solution other than training. Further, if poor analysis causes inappropriate tasks to be selected for training, this will increase the program cost considerably. Although the costs of CBT may be difficult to cite in the abstract, it is reasonable to assert that each lesson delivered via the computer probably costs 5-10 times more to develop than a conventional form of instruction. The CBT lesson can only amortize its development costs in the savings made during the delivery of the training. Effective front end analysis is critical to ensure that CBT lessons do not suffer the fate of much traditional material that is developed following a hasty front end analysis and then sits on the shelf as the trainers and managers find that training in certain tasks is not critical to job performance. CBT demands an even more rigorous application of a systematic approach to instruction since the shortcomings become apparent more quickly than in the development of materials for a conventional course.

Organization for curriculum development is a highly significant but separate issue that relates to project management and systematic use of instructional technology. If a company or business intends to employ computer based training in other than the most experimental way, it must take a serious approach to the creation of a computer based training development capability. One of the problems of the CBT efforts of the past is that each business or military CBT effort was a prototype venture in which the participants committed all of the obvious errors. As long as each CBT effort is an ad hoc affair, this track record will continue. However, if a company recognizes the long term investment required, acquires the diverse skills necessary, supports them with the necessary equipment, and then develops the programs sequentially in order to draw systematically the appropriate lessons from each project, an effective development group can be created. Such a group is akin to a successful team in any professional sport. It requires individual skills at each position, as well as a skilled and experienced management and group cohesion, to obtain the synergism that is possible. Creation of such groups is one of the best ways to reduce the present high ratio of hours of development time to hours of course time found in most CBT efforts.

Finally, considerable thought and planning must be applied to the plan for implementing the CBT program. This is a technology transfer issue. Our principal concern must be with the transfer of CBT technology from a group of developers, steeped in the technology and accepting of its characteristics, to a group of users who wonder what strange apparition is about to be imposed upon them and upset the order and stability of their world. Instructors and trainers must be won over. They must be continuously involved so that they feel they"own" the program. The implementation list is endless and does not bear detailing. It is important to remember that some of the of CBT programs developed in the past eventually reposed permanently on shelves (or on the computer equivalent thereof) due to poor implementation plans. The issue is a complicated one to address because it involves all levels of the users. It is insufficient to obtain only the agreement or support of the user management. Individual trainers and instructors can sabotage the effort if they are not involved. Coordination meetings are not enough. Examples abound of CBT efforts wherein numerous meetings were held but did not address the substantive project issues in a shared way. Finally, the entire user apparatus must be subjected to a training program to produce computer literacy and provide other necessary skills in order to obtain planned results. Personnel turbulence compounds these imperatives. It demands a concerted of effort to overcome. Great technology can fail if the plan for transferring the project to the user is not thoughtfully designed and systematically implemented.

Our principal concern must be with the transfer of CBT technology from a group of developers who accept the technology, to a group of users fearful that it is about to upset the stability of their world.

A conclusion about the future of computer based training in industry and business is easy to surmise. The shoals of inadequate systems development, incomplete implementation planning, and failure to conduct a cost benefit assessment will remain present. However, extraordinary advances in technology, combined with changes in the business environment, will drive a number of companies toward trying computer based training. Some will fail, but as more succeed, and if lessons are exchanged through professional societies, American business and industry ought to make a generational leap in the delivery and management of its training. The high technology age of the eighties demands nothing less.

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