WHERE DOES CBT FIT IN, NOW THAT WE KNOW SO MUCH?: A FRONT END ANALYSIS STUDY

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ABSTRACT

Computer-based training (CBT) has now been in existence for over two decades. It has been implemented in both the private sector and government organizations at an exponential rate. Nevertheless, many institutions, particularly educational institutions, have not yet introduced CBT. Our knowledge of what works and what does not, as well as hardware and software advances, has greatly increased in the past few years. This paper addresses many management considerations with respect to CBT. First, we consider the generic environment in which CBT might be used and then issues that affect costs and benefits, including lessons learned by the Cognitive Engineering Design and Research Team (CEDAR) of the Los Alamos National Laboratory in its assessments. The final section gives some "how-to" guidelines on increasing the probability of successfully introducing CBT into the training environment. The underlying theme of the paper is that management should be guided by what we now know about costs and benefits in its decisions regarding CBT and fight the lure of "high tech" glitter.

INTRODUCTION

Since computer-based training (CBT) has been in existence, we have seen the field progress from using the computer as a control for electronic page turning to the current state-of-the-art systems that permit a wide variety of instructional strategies. Additionally, we have the expectations that computers can now think like instructors and thereby dialog with the student.

If one peruses any recent issue of the popular computer magazines dealing with microcomputers, one can find several advertisements offering rather complete systems for less than one thousand dollars. If one looks at colleges or universities, such as Stanford or Drexel, the use of computers to support the curricula is readily apparent. At Drexel, all students must have access to a personal computer and use them in all courses throughout their four years of college.[1] If one looks at the CBT literature, one sees many studies touting CBT as the answer to such instructional problems as self-pacing, reaching the advanced student, laboratory or simulation shortage, and preserving instructor time. So why shouldn't any institution wanting to use modern technology, reduce costs, and implement a CBT program?

The answer is that this simple, casual promise of CBT is not simple and cheap, or necessarily the best course of action for the institution. In fact, a recent Army Research Institute report asserts that clear-cut benefits of CBT have not been demonstrated.[2]

This paper deals with why one should choose to adopt a CBT program and, assuming a positive choice, some guidelines on how to go about it. The bold assumption is that to see a definite advantage or benefit of CBT commensurate with its cost, great care must be exercised in the selection of applications and in justifying CBT based upon its merits alone. Many of the questions that should be asked during the front end analysis process are identified.

ENVIRONMENTAL IMPACT

The impact of CBT is dependent upon the environment in which it is used. As a simplistic illustration, one would not place a CBT unit at a swimming pool to teach Olympic hopefuls better butterfly stroke technique. The presence of water is an essential element that cannot be simulated by the computer. In contrast, welding has been effectively taught using CBT, with emphasis on simulating the welding process.[3] On a general level, CBT can be used in three different environments:

CLASSROOM: A formal training environment in which performance can be measured in terms of terminal performance objectives. CBT in this environment can be used either as a substitute for classroom or laboratory instruction or as a supplement to conventional instruction. Often, because of differing physical needs for CBT, a separate learning center used by several different classes is built and monitored by advanced students or by support personnel. The specific strategy of the CBT depends upon how the lessons are implemented relative to the classroom.

ON-THE-JOB: A less formal environment in which improvement is more difficult to measure. Generally, the "instructor" is the front-line supervisor whose principal job is other than training. CBT offers the opportunity for standardization of instruction as well as improved quality, but its effectiveness is difficult to measure. This category subsumes many subcategories including apprenticeship, sustainment, and retraining for new equipment.

EXTENSION COURSE: Usually not required of the employee, but made available on a basis similar to "continuing education." Benefits to the "company" are extremely difficult to measure and such programs are supported on the premise that better educated employees are better employees.

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> Within the Department of Defense, however, extension courses are essential to accomplishing the training mission and may be required.

The importance of distinguishing among these environments is that CBT, which may have great benefit in one environment, may be of little value in another. For example, standardization may be of great importance for the National Guard with respect to instruction that must be exported to the field (extension courses). Consistency in quality of instruction may be essential if the largest number of trainees is to achieve a minimum acceptable level of proficiency. In contrast, for the active forces consistency is important, but quality controls on instructor presentation are inherent in the classroom environment. Hence, an advantage of CBT in one environment (the National Guard) may not be a worthwhile benefit in another (the Active Components).

COST AND BENEFITS

There are several reasons for introducing CBT into the training environment, including the following:

- Improving the cost/benefit ratio with respect to the training of personnel. Cost is the total expense (both fixed and variable) associated with training an individual. Benefit reflects the difference between the value of the trainee to the organization before and after training. The goal is the lowest cost/benefit ratio possible (note that costs and benefits are always positive values that can approach but not equal zero).

- Providing training that is otherwise not feasible (for example, extension courses).

- Doing research into CBT. Academic departments, industry, and organizations, such as CEDAR, engage in this type of activity. The benefit is knowledge gained on how to do CBT better (or perhaps what to avoid).

- Improving the image of the organization. Image is an elusive quality and its importance should not be overlooked. It is similar to "goodwill" that is paid for when a company is purchased. As such, it is a benefit assessed only in subjective terms.

- Making a capricious decision by management to do it. Management may decree that CBT will be used without providing the rationale to the organization. Of course, it may not be capricious. Rather, management may know what it wants to do but, as is the case with many experts, cannot or does not believe there is a need to explain the rationale.

While the last three reasons can have great merit in certain circumstances, they do not withstand hard-nosed management examination in the context of profit and loss. Instead, a decision in favor of CBT should be based on an improved cost/benefit ratio. That is, can costs be reduced, benefits (as seen in better trained people) be improved, or both?

Benefits of training should be measured in terms of the organization. From a business perspective, one trains people to increase productivity. And, if people with the requisite skills can be hired directly without additional cost, this choice is the preferred one. This approach has severe limitations, however, because a person's heuristic knowledge base is developed on-the-job. In many businesses, particularly national defense, the requisite skills are not taught elsewhere.

A good way to assess the benefit of CBT is to introduce it on a small scale and measure its effectiveness in a controlled manner. However, success is directly related to the quality of the implementation and does not necessarily indicate future success of a broader scale implementation. In the business sense, one would like to forecast the gains of CBT, that is, make an estimate of the near-term benefits based on some sort of regression analysis from past results. Generally, the benefits of CBT can be predicted based on experience in the field and the application of heuristics derived from it. Quantified predictions of benefits should be viewed with great skepticism.

Doing a cost/benefit analysis is a difficult task at best. And when management is considering a new field or application, the complexity of the field can obfuscate otherwise obvious factors from consideration. In this section, a few critical factors that should affect a decision for or against implementing a CBT effort will be discussed. The discussion will lead to identifying these CBT applications with the greatest potential return on investment.

As already observed, the benefits to be derived from a new CBT application must be predicted, not forecasted. As such, benefits (before the fact) represent sophisticated hand waving and (after the fact) frequently correlate to the quality of the implementation. The quality of courseware design largely determines the success of CBT. Many comparative studies have been performed comparing CBT to conventional instructional methods.[5] These studies show that CBT can be more effective than conventional instruction, but the degree of effectiveness (and hence benefit) depends upon design issues as well as the local situation.[6]

Up front, CBT usually represents a more costly approach because of the high initial investment.[7] The low priced computer systems lend themselves to the old electronic page turning techniques but do not necessarily support modern instructional technology. The instructional strategies of simulation and gaming, among others, require more sophisticated technologies. Reaping the benefits of CBT for your application might require a spectrum of capabilities that can include interactive video disc, digital audio, graphics, color, data and program storage, compact disc read-only-memory, computational speed, multiple displays, and simulation. The list can go on and is limited only by one's imagination. Yet, central to the list are both the cost of acqusition and the cost of courseware to be run on the system.

In general, the cost of courseware development will greatly exceed the cost of equipment.[7] Equipment acquired today probably will be obsolete five years from now. It is therefore necessary to be requirements-, not technology-, driven.

In estimating the cost of CBT, the price of equipment and facilities usually can be established in a fairly sound fashion. The cost of development of courseware, maintenance, administration of the program, and the time employees devote to learning can be only imprecisely estimated at best. These factors are interdependent and nearly impossible to predict for creative endeavors.

Nevertheless, it is clear that CBT cannot replace instructors, only free them up to spend their time aiding individuals and in lesson design, production, and maintenance. The roles of instructors will change, but the manpower commitment will remain and may grow. Of course, classroom instructors may not have the skills for CBT development.

Table I, for example, lists the talents required to develop and produce good quality CBT using interactive video. The breadth of skills required leads to an argument against the assertion that CBT cannot replace instructors. If courseware is to be contracted, perhaps the size of the training department can be reduced. Further, the courseware company can take the lessons already taught; put them on a computer; and, hence, eliminate the need for lesson design, development, and maintenance. The fallacy of this argument has two aspects. First, contracting for courseware production does not eliminate the in-house manpower costs for courseware development but shifts them (perhaps increases them) to a different line item. The second aspect is that CBT, which consists of straight conversion of a classroom course, is generally not successful. Revision of the instructional design is required. The implication is that CBT is going to cost more than classroom instruction.

TABLE I

REQUIRED TEAM SKILLS

- Subject Matter Expertise
- Computer Science
- Cognitive Science
- Human Factors
- Instructional Design
- Graphic Arts
- Script Writing
- Video Expertise
- Management

AND A GOOD WORKING ENVIRONMENT

Now wait a minute! If the benefits of CBT are hard to predict (often being sophisticated hand waving) and costs are likely to go up, why do it? The answer lies in the potential of CBT benefits, that is, what CBT can do that conventional training cannot and what CBT can do better than conventional training. The point is that CBT represents a risk with significant rewards for the innovative, aggressive training program.

WHERE SHOULD CBT BE USED?

The key to success is in selecting appropriate applications for CBT--those that cannot be achieved by other means or those in which a moderate CBT investment can provide other savings. For example, a CBT simulator could serve as a part-task trainer to teach "switchology," thus taking the training burden from more costly simulators.[9] Selection of CBT implementations should be based on what CBT can do well as evidenced by improved performance or permitting achievement of a teaching strategy not easily achieved through other means.

Looking at Bloom's Taxonomy (Table II), most training today is at the lower cognitive levels. Yet, there is a growing awareness of the necessity to provide good training at higher cognitive levels. Students need to go beyond the facts and procedures of the classroom and experience real world dilemmas. In essence, it is desirable to give the student artificial experience before he tries it in actuality, thus improving his chances of good performance. CBT can be used for high cognitive level objectives (for example, synthesis or analysis), but the design time required is greater than for lower level objectives (for example, comprehension and knowledge) because the instructional strategies are more complex (for example, simulation and gaming).

TABLE II

BLOOM'S TAXONOMY

(high cognitive level)
- Evaluation
- Synthesis
- Analysis
- Application
- Comprehension

(low cognitive level)
- Knowledge (recall)

(Adapted from: TAXONOMY OF EDUCATIONAL OBJECTIVES: The Classification of Educational Goals: HANDBOOK 1: Cognitive Domain, by Benjamin Bloom, et al, (Longman, Inc., 1956).

Simulation means different things in different contexts. With respect to the training environment the term can include physical, procedural, situational, and process simulations.[10] The differences between games and simulations are twofold. First, games require competition, either with the computer or with another player. Second, games focus on broad, less quantifiable concepts (soft concepts), while simulations are concerned with highly accurate, technical detail (hard concepts). Simulations are required to correctly predict a great many details, while games are not. A comparative matrix is shown in Table III.

TABLE III

A GAMING VERSUS SIMULATION MATRIX

	Gaming	Simulation
Purpose	concepts	analysis
Prerequisites	fewer	more
Need to understand "the system"	yes, but can learn while playing	yes
Fidelity	not as critical	must be high

The distinction between games and simulations is critical with regard to the development effort. If you require a simulation when a game would suffice, you will spend more money than is necessary. Also, if you do not have an instructional strategy in mind, both games and simulations may be the wrong choice. The use of computers for educational purposes without a strong, underlying instructional strategy that matches human need will produce suboptimal results.

As a bottom line of cost/benefit, CBT has certain applications that make it an attractive alternative and worthy of careful consideration. These applications are as follows:

- Simulation of equipment to support procedural training.
- Gaming and simulation to support the acquisition of artificial experience.
- The export of training (at all cognitive levels) to make it more widely available and consistently good.

GETTING INTO CBT

At some point, you get a visceral gut feeling that CBT is required. You see some potential applications, and the other alternatives are not as attractive. You have made a rough-cut estimate and believe that the potential rewards justify the risk. How do you go about it such that a high probability success path is followed? Table IV contains some guidelines that are discussed below.

TABLE IV

GUIDELINES FOR THE INTRODUCTION OF COMPUTER-BASED TRAINING

- Allow time for a front end analysis to determine if you have a training problem or a performance problem.
- Obtain support from high-level management early in the process and then make an effort to continuously foster it.
- Determine who is in charge--establish a focal point for CBT.
- Assemble a diverse development team.
- Establish the training requirements, enumerate potential applications, prioritize, and select the one with the greatest possible payoff commensurate with acceptable risk.
- Involve instructors in the design process and ensure that they are adequately trained regarding the CBT medium.
- Gradually introduce the new training approach. Let the instructors and students become accustomed to it and then become the prime advocates.
- CONTINUALLY REVIEW THE COSTS AND POTENTIAL BENEFITS OF YOUR CBT PROGRAM AND DEMAND THAT CBT BE COST EFFECTIVE OVER OTHER MEANS.

First and foremost, allow time for a front end analysis to determine if you have a training problem or a performance problem. If the worker has the knowledge, skills, and abilities required for the task, you probably do not have a training problem. Often, the true problem may be obscured by the organizational environment. For example, operational policies and procedures may be inhibiting creativity and initiative on the part of the worker, thus ensuring continual inefficiency.

The second step is to obtain support from high-level management early in the process and then make an effort to continuously foster it. This support is essential to success. The initial investment for CBT equipment is too large to obscure within the budget. However, on a continuing basis, CBT will have to fight with other budget items until it is established, a process that could take several years.

Next, determine who is in charge--establish a focal point for CBT. In organizations we have visited and observed, those that did not follow this guideline tended to have a variety of equipment and multiple standards for CBT quality, and lacked flexibility with regard to the exchange of materials. Without a single point of contact, a CBT program can quickly look like the start of a computer thrift shop. At the same time, the people on the implementation team must recognize that centralization benefits them and that they can get the resources they need as long as they are responsibly flexible regarding certain details. The focal point of the CBT activity must be sensitive to corporate needs, operational constraints, the operative technologies, and both the implementers and users of the training system. Conflicts among these variables will occur; the focal point for CBT is the focus of conflict resolution and the link to continuing management support.

CBT is a team effort that requires the skills shown in Table I, or a variant of it. The next step is to assemble a diverse development team or select a contractor with one. Assembling the team yourself requires a commitment to team building. For example, script writers and computer programmers view the world differently and have different requirements to accomplish their jobs. Yet, to be successful, a CBT team must communicate within itself, and the members must adapt to one another. A separation of functions leads to lower quality, less creative CBT. By implication, CBT lends itself to project management techniques and a matrix management approach. However, if you cannot assemble a team with all the requisite skills, look for help elsewhere.

With the team assembled, revisit the training requirements, enumerate potential applications, prioritize, and select the application with the greatest possible payoff commensurate with acceptable risk. Note that to this point no mention of hardware acquisition has been made because you should be needs-driven, not technology-driven. Choose equipment that will support your priority courseware requirements but has the potential for expansion to support all the courseware requirements. For example, if you need to teach switchology, you almost certainly will need a good graphics capability but may not require interactive video disc, thus reducing capital outlays while you are on the steep part of the learning curve. Also, opt for applications that CBT can do well. If you have a choice between teaching workers the steps in a process by rote memory or how to set up equipment through a procedural simulation, opt for the latter because it matches what CBT can do well while having a good potential return on investment.

Keeping costs down also helps with winning and maintaining upper management support. First, by purchasing only the hardware capabilities required, costs are minimized. Second, by focusing on the courseware with the highest priority and best payoff, you optimize the potential benefit and produce recognizable results in minimal time. The cost/benefit ratio will be clear, near-term evidence of upper management's wisdom in supporting CBT.

Next consider what you may be doing with regard to the existing training organization. At the very least, the introduction of CBT represents change. At the other end of the spectrum, CBT threatens the jobs of the instructors. The existing training team will resist the introduction of CBT unless they are participants in it. However, simply being asked or directed to participate does not mean the problem is solved. The trainers also must understand what CBT is about and how to do it. Be prepared to train the trainers. This point can be stated as the following: Involve instructors in the design process and ensure that they are adequately trained regarding the CBT medium.

Just as CBT causes change in the instructor's environment, it causes change in the student's world. To be successful, the inertia of the traditional learning experience must be overcome. While at some time in the future the population will regard computers in the classroom as commonplace, the vast majority of today's work force experienced a more traditional approach to learning during their formal schooling.

Gradually introduce the new training approach. Let the instructors and students become accustomed to it and then become the prime advocates. In essence, let both student and instructor, by themselves, evaluate the evidence of student performance both with and without CBT. A corollary implication is that the courseware for application selected for the introduction process should support the self-evaluation process. For example, a CBT-type part-task trainer can help students perform with greater skill and confidence when they advance to full system simulators.

WELL, THERE YOU HAVE IT!

A look at the costs and benefits of CBT, what CBT can do best, and some guidelines on how to do it. For convenience, the guidelines are gathered together in Table IV. With these guidelines and the lessons listed earlier, is there a central theme or single, pervasive guideline that should be followed? Yes there is!

> CONTINUALLY REVIEW THE COSTS AND POTENTIAL BENEFITS OF YOUR CBT PROGRAM AND DEMAND THAT CBT BE COST EFFECTIVE OVER OTHER MEANS.

The cost/benefit ratio for the CBT solution must be better than the other potential solutions. While the decision criterion is simply stated, getting to the decision point is a very complex issue. There are many underlying considerations that include who, what, when, where, why, and how. CBT represents a risk or gamble. And while CBT may be akin to the glitter and glamour of gambling in Las Vegas or Atlantic City, winning likewise demands concentration on the fundamentals--here, teaching and learning. If you avoid the lure of high technology and demand a solid, comparative, decision base, use of CBT when supported by the evidence will result in better training.

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