DESIGN OF LEVEL III INTERACTIVE VIDEODISC TRAINING: EXPLOITING THE POWER OF THE TECHNOLOGY TO ENHANCE LEARNING*

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ABSTRACT

Interactive videodisc is now commonly being used in military training, but the new technology is so powerful that new design strategies are needed. Los Alamos National Laboratory's Training Research Team is developing experimental computer-based (IBM-PC based) training with interactive videodisc (Level III) on military applications. The goal is to exploit the technology to enhance learning, with the focus on learning requirements and not on the technology. As part of this process, the Team has compiled a set of nine design strategies. This set of strategies is readily portable to other training efforts using this technology. The strategies are unique in that: (1) the technology is so new and thus few guidelines exist, and (2) they incorporate learning theory and human factors principles. The strategies described are being used on Level III projects ranging from a tactical operations cognitive strategies tutor to a part-task helicopter trainer.

INTRODUCTION

During the past ten years a revolution has occurred in the way people view computers and the availability of personal computers for widespread use. Concurrently, the electronics industry has exploited many technologies used to produce a myriad of exciting products. In these innovative efforts, needs were recognized and potential hardware solutions were sought and subsequently marketed. However, the needs were specified in terms of tools, not as solutions to problems. Hence, the silicon adventurism of the past decade has given us many powerful tools that can be both used and misused. The videodisc is no exception.

This paper begins by defining the challenge of effective interactive videodisc training. Then, the "total" Level III interactive video training system, used by the Los Alamos National Laboratory Training Research Team (TRT), is described. The lessons that follow were learned in working with this equipment suite. Next, design strategies that evolved through working in Computer-Based Training (CBT) research within the level III domain are presented. In the summary the question posed in the challenge is answered. Implications of our findings, together with a new challenge for the training community, conclude the paper.

THE CHALLENGE

For problem solving-oriented training, the more realistic the problem situation presentation the greater the chances are for transfer of training. Interactive videodisc allows for even more realism and more rapid retrieval of realistic images than was possible in the past. Interactive videotape provided the realism, but response time was so slow that the technology was not very powerful. Interactive videodisc allows for extremely fast retrieval time and graphic overlay allowing for manipulation of realistic videoimages.

Interactive videodisc permits many different kinds of both running and still video: an instructor in the topic environment providing tutoring tailored to specific student difficulties, "living" pages from tech manuals, and views of terrain from tanks or helicopters. The United States Army recognized the great potential for the technology in training and initiated an effort to procure a specialized, standardized interactive video training workstation called EIDS--Electronic Instructional Delivery System.[1] But fully exploiting this powerful technology for the benefit of the student is extremely challenging and reaches far beyond the specification and acquisition of equipment.

CBT experts recognized the power of interactive videodisc technology; thus, the number of applications using interactive video is increasing almost exponentially. Because interactive videodisc training is an outgrowth of CBT, a 25-year-old field, many developers assume that the design strategies used in CBT can be transferred directly. The early developers of interactive videodisc lessons, however, soon discovered that this was not the case.[2] The interactive videodisc capability is so powerful that it requires a new level of creativity from the designer.[3] If the designer does not attain this new level of creativity, the technology is wasted. One can see examples of this waste at trade shows where videotaped classroom lectures have been converted onto videodisc, and occasionally the lecture is interrupted with a multiple-choice question or a request that the student stop and look at Chapter 5 of the textbook.

Aside from the videodisc technology, the field of CBT has taken great strides in the past five years. New approaches to interactivity and

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increased individualization in feedback have evolved, building on: (1) the gradual shift from the behaviorist to the cognitive school, (2) development of the field of human-computer interface design, (3) application of Artificial Intelligence to instruction, (4) development of microcomputer hardware, and (5) recognition that the programmed-instruction-branching models of past CBT could be much improved upon.[4] These new approaches, however, are not yet well-documented and thus are not commonly applied or incorporated into existing authoring systems.

A fundamental question that needs to be asked therefore is:

Is the power of the technology being exploited to maximize learning or is learning taking place *in spite of the technology*?

This question constituted the challenge to the TRT. At an early stage in the evolution of the Team, specific strategies were sought to ensure that exploitation of the technology maximized learning. The Team consists of experts in the areas of computer science, military systems, computer graphics, CBT, educational psychology, and human factors in computing. It was charged with several research and development projects, both internal and for the Army Research Institute, that were to use state-of-the-art technology to enhance human productivity and thinking skills. Recognizing the complexity of getting into this technology, Team members took minicourses at conferences on interactive video development (Metamedia, Inc.) and invited consultants [from On Line, Inc. and Videodisc Publications Inc. (VPI)] to provide an in-house Bourse. The contents of this paper therefore reflect the Team's combined expertise, based upon both actual experience and the experience of others in the field.

An early necessary step in the development process is to settle on, procure, and set up a hardware configuration. This new technology is far from standardized, and thus the exact configuration selected is dependent upon the development team's industriousness and upon the vendor(s) selected. In the section below, the hardware suite used by the TRT is described. This sets the stage for the later discussion on lessons learned and specific design strategies used with this suite.

THE SYSTEM CONFIGURATION USED

As yet, the hardware configuration for a microcomputer-driven interactive videodisc system (Level III) is far from simple. Although the core system may be a microcomputer system common to many, the peripheral devices and special boards required for graphics and specialized input do demand some effort in ordering and installing. Many vendors do facilitate the process by enabling you to order it all from them (even though they might not produce it all).

Figure 1 shows the hardware configuration required for a single, fully developed system. (Note that CDROMs and local area networks could be added, but these capabilities represent refinements not central to a Level III system.) Not all of the peripheral devices shown are necessary for a functional system. In fact, a simple CBT system can be enhanced by the addition of one or two of the peripherals shown. The objective is to maximize the use of the technology relative to the project's goals in terms of student learning, not to obtain all the peripheral devices possible within your budget. Also, for a specific application, you may need several of one item. A needs analysis will provide the guiding theme of creative, effective instruction.

LESSONS LEARNED

What are some basic lessons the TRT learned in its growth process, using the suite of hardware described above, and towards the development of design strategies? Twelve of the lessons learned are as follows:

- Taking low-quality CBT design and adding video will result in low-quality interactive videodisc CBT. The videodisc technology does not solve design issues.

- As mentioned earlier, design of exciting and educational Level III requires a new level of creativity. Designers must be in a working environment that fosters creativity, rather than encourages reproducing designs of the past.

- Several different instructional strategies are employed in CBT. In a 1984 handbook, Digital Equipment Corporation identified five different strategies: drill and practice, dialogues, testing, games, simulations, problem solving, and discovery learning.[5] A CBT system without audio or video is limited in its capability to simulate events that elicit performance

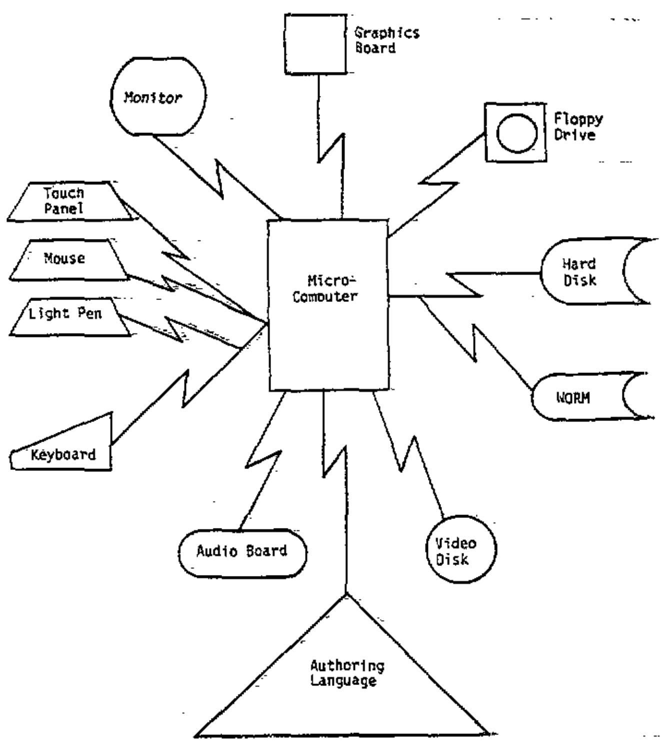

Fig. 1. Level III System Configuration

and provide feedback in a real world sense.[6] The Level III technology frees us, therefore, to fully utilize the more demanding instructional strategies (e.g. games, simulations, problem solving).

- The instructional design model developed for frame-based CBT must be amended for development of interactive videodisc training. The old model does not provide the structure necessary for the multitrack delivery that occurs in interactive video.[7,8]

- Essential to each project is the development of a prototype. A prototype is defined here as a small, manageable, and completely operational piece of the CBT that demonstrates the user interface and instructional strategy (i.e., game, simulation, tutorial). The prototype step is part of a trial-and-error (iterative) approach to full system development. The prototype must demonstrate that the CBT will work effectively in the target environment. The prototype for each project is tested internally and with users, then redisigned on the basis of feedback and direct observation of user behavior.

- A common misconception is that once the hardware and software configurations are figured out and procured, all else is a piece of cake. Alas, design is the largest cost consideration in terms of time and resource commitment--not hardware or software selection.

- The authoring language or system selected depends largely upon the talents of your particular staff. If you have one or more programmers on your staff, an authoring language that has the capability of calling additional in-house written subroutines is probably a preference. If there are no programmers on the staff, an authoring system is probably preferable. However, high-level authoring systems tend to restrict creativity while low-level languages require more work.

- Selecting a system is a complex process that could be never-ending because of the rapid development of the technology. Therefore it makes sense to rely on recommendations, after considering the source, rather than wait for the "best" system to emerge. Recognize that a system will be good for only a few years; look for flexibility and adaptability.

- Is the training subject matter suitable for video presentation? If you would not make a training film for teaching the subject in a noncomputer environment, you should carefully examine the appropriateness of interactive video. Do not use it just because it is there. Some examples of subject areas that are not cost effective for interactive videodisc training are:

  - writing, reading, and deleting an electronic mail message (which can be taught with an embedded tutor more efficiently with no transfer of training problems),
  - performing of arithmetic drills,
  - learning to use a text editor,
  - filling out forms, and
  - learning to use an information retrieval system.

- Video is a visual medium. Capitalize on this aspect in the presentation of complex situations that overcome the deficiencies of speech, text, and still graphics, but not as a substitute for them.

DESIGN STRATEGIES THAT ENHANCE LEARNING

At a more detailed level than the above "lessons learned" are the design strategies compiled by the Los Alamos TRT. These integrate the constraints and capabilities of the hardware and software suite used, along with learning theory and human factors principles.

1. Exploit Still Frames to Save Videodisc Space.

   One side of a videodisc can store up to 54,000 still frames OR 30 minutes of video. Running video is inherently more interesting for students to watch than still frames, but 30 minutes is not very long. It is distracting for the student to have to frequently turn a disc over. Therefore the ideal solution for storage is to use a mixture of still frames and running video and to maximize your space by careful planning. Running video must be carefully edited and whenever possible still frames are used. Additionally, video still frames can be used to save computer memory by reducing graphic file storage.

2. Increase the Degree of Humanism by Having Short Individualized Feedback Sequences on Videodisc.

   Often producers of videodisc-based training use video for scenarios or lecture, but do not use it to provide feedback. The use of short video sequences to provide individualized feedback to student input is very powerful. These sequences are not like a stand-up lecture, but rather informal and very specific to the answer the student just submitted. For example: A student is specifying his platoon's route on a map and he goes out-of-sector. The instructor could come on in a window on the screen and ask the student to reconsider the move in light of the overlay he was previously given. A definition of out-of-sector would be provided as well. The strong effect of having a human instructor talking to YOU about your last response is unmistakable. This approach also seems to enhance retention and accommodate slower readers.

3. Repurpose Videodiscs and/or Frames Using Graphic Overlay.

   Repurposing means that you use a frame or videodisc sequence that was originally produced for a function different from yours. Overlaying computer graphics, on top of a videodisc frame, is a powerful technique for reprocessing. Graphic overlays enable you to use the same video sequences for many different purposes.[9] In addition to saving the developer the cost of producing a disc, graphic overlays can provide students with the illusion of *actually manipulating the video image*. Also, through careful prior analysis and planning, one disc can support several lessons. An excellent example of creative videodisc design is the VPI, MYSTERY Disc in which 16 distinct scenarios are packaged in one two-sided disc. Each scenario, with interaction, runs about one hour.

4. Use a Combination of Video and Text to Give Instructions.

   This strategy may seem so obvious that it is trivial; yet it is not commonly employed. The instructional sequences of lessons are often the ones most dreaded by students. If the instructions can be shown with realistic images, the probability of getting the student to listen is higher. For example, a video sequence of a person manipulating the system can be shown, with text on top of the picture highlighting steps, important components, etc. Another example is showing students common pitfalls in the use of equipment and the consequences of *not following* directions. This can increase retention of correct procedures.

5. Show Students the Consequences of Their Actions.

   The old adage that you cannot really learn it until you experience it, but once you experience it you won't forget, is one that could not be readily used to increase retention in conventional CBT but can be used with interactive video. For example, a *student is watching* the plan for his platoon being executed on a map when suddenly he encounters a demolished bridge. He specifies he wants to ford the creek and a video sequence could show the tank getting stuck in the muddy creek bottom. He can then learn "from experience" the necessity to check that the creek bottom is rocky before proceeding across the creek. This is a technique used by videogame developers but is readily transferrable to training applications.

6. Use Video to Increase Individualization of Feedback.

   Although CBT is called individualized instruction, most existing CBT is not truly individualized in the sense of a one-on-one human tutor/student relationship. Thus far we have not been able to provide responses tailored to each student: *responses constructed on the basis of previous student performance*. The concept of intelligent tutoring systems[10] is gaining in popularity because prototype systems existing today do provide a higher degree of personalized feedback than is normally available in CBT. Interactive videodisc training, however, also enables the developer to provide more individualized feedback.[11] The increased individualization is possible because of rapid search rates on the disc and through careful mapping out of answers for four categories of *responses*:

   - correct answer,
   - suboptimal answers (where part of the answer is correct, but part is not correct),
   - incorrect answers (totally incorrect), and
   - unanticipated answers.

   The category of suboptimal questions is a frequent one, yet one which is rarely accounted for in answer-judging designs. For both the incorrect and suboptimal answers, a video sequence can be used to show the consequences of the student's actions or a video of a human instructor providing tutorial advice for that particular student response can be shown.

7. Alternate Means of Interactivity.

   The issue of quality and quantity of interactivity required for effective CBT is controversial. The CBT community is now well aware that quantity interactivity (e.g., student take action on each frame, but action may just be to press a NEXT or RETURN key) is insufficient and quality is important.[12] Quality is defined by the level of thinking required by the student in interacting with the computer. That is, it requires the use of problem-solving skills to answer a question regarding a situation presented but only psychomotor skills to press return. Ideally, there is a mix of the types of thinking skills required in the interactivity. The interactive video technology facilitates use of variety. Some examples of the means of interactivity are:

   - Show scenario on video sequence, ask questions about it, or have student stop video when he/she recognizes an error or potential problem in the system.
   - Have audio ask student question, reinforcing with text on the screen.
   - Use more than one input device; e.g., mouse for menu selection and keyboard for answering short-answer questions.
   - Display video of a system, ask question about which parts of the system you

would need to use if XXX problem arose, and then have student use touch panel or light pen to identify parts of a system on a screen.

- o Provide student with a command bar at the bottom of the screen which always displays the move options available from that screen (e.g., next, back, exit, help); from help option, allow student to review parts of video.

8. Exploit Videodisc Through Sound Overlays.

Because of the space constraint on one side of a videodisc (for running video), developers always need to be looking for ways to avoid adding more running video. One way is to use two sound tracks over one video sequence, with the voices/sound effects that are normally with the video sequence turned off and a new sound track superimposed. An excellent example of this is the MYSTERY Disc produced by VPI referred to earlier.

Another way to do this is to put a second sound track on digitized audio instead of on the videodisc itself. Hearing, as well as seeing and interacting, enhances retention. Digitized audio can be used to also ask questions or give feedback in computer-managed instruction.

Digitized audio is useful for providing further personalization in a CBT course. For example, have a student speak into a microphone at the beginning of a session, store it, and then echo it back to the student later in context.

9. Use Program Management Techniques to Increase Efficiency of Development Process.

The process of designing a videodisc training course is, as was mentioned earlier, more complex because of the need to coordinate and conserve resources such as different input devices, digitized audio, two audio tracks on video disc (one hour), still frames and running video, computer graphics, text displays, and computer storage space (working memory, hard disc, floppy discs). Resource consumption factors to consider are:

- o images required,
- o sound with still frame,
- o digital audio memory consumption rate,
- o main program file, and
- o graphic file sizes.

Careful resource planning and scheduling is known to be a key to success in complex, multidimensional projects. Software packages such as the Harvard Project Manager (November 1984) and MacProject (Apple Computers, 1984) were developed to facilitate such planning. These tools are not in common use for interactive videodisc development projects; yet they seem well-tailored for this application.

SUMMARY AND IMPLICATIONS

This paper provided some practical suggestions for developers of interactive videodisc training and some factors to be considered if the reader is contemplating using the new technology. It described the hardware configuration of a Level III interactive videodisc system and then went on to list several lessons learned by the Los Alamos TRT in their evolution as Level III developers. The core of the paper is a set of design strategies that were developed by the Team in their attempt not only to exploit the technology fully, but also to maximize the quality of learning of the users of our systems. The uniqueness of the strategies provided stems from the fact that they integrate human factors and learning theory principles with hardware and software issues.

A fundamental question posed early in the paper was, "Is the power of the technology being exploited to maximize learning or is learning taking place in spite of the technology?" Sound design is the key to successful systems and not state-of-the-art technology or interfaces.[13] If state-of-the-art technology is used, the need for careful design and interactive testing is that much more important as fewer published design guidelines exist.

Recently a reporter from a national news weekly was doing a story on interactive videodisc training and he said that he understood from people he had interviewed that interactive videodisc, at any level, would provide for a much greater degree of individualization for the student. He had been told that the student's ability to retrieve any frame on the disc would truly revolutionize training. This is a sad commentary on application of this technology, for increased speed in information retrieval has not been proven to enhance learning. It is up to us to meet the new challenge and demonstrate that we are being driven by student learning requirements rather than by technology; the contents of this paper are intended to facilitate achievement of this goal.

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