DOCUMENT RESUME

ED 309 736 IR 013 842

TITLE	Feasibility of an Integrated Expert Video Authoring Workstation for Low-Cost Teacher Produced CBI. SBIR Phase I: Final Report.
INSTITUTION	IntelliSys, Inc., Syracuse, NY.
SPONS AGENCY	Department of Education, Washington, DC.
PUB DATE	28 Feb 89
CONTRACT	RR88072005
NOTE	32p.
PUB TYPE	Reports - Evaluative/Feasibility (142)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Authoring Aids (Programing); *Computer Assisted Instruction; Disabilities; *Educational Facilities; Expert Systems; Feasibility Studies; Individual Differences; Individualized Instruction; *Interactive Video; *Mainstreaming; *Teacher Developed Materials
IDENTIFIERS	*Workstations

ABSTRACT

This was Phase I of a three-phased project. This phase of the project investigated the feasibility of a computer-based instruction (CBI) workstation, designed for use by teachers of handicapped students within a school structure. This station is to have as a major feature the ability to produce in-house full-motion video using one of the presently-available video recording devices, such as WORM (Write Once, Read Many) drives, LaserFilm, or interactive video tape. A systematic evaluation of video storage devices was carried out, and resulted in the identification of several acceptable devices around which such a workstation could be designed. Studies of user needs for characteristics of authoring and delivery systems were also undertaken. It was found that expert systems should be incorporated into the design of the workstation to aid the teacher in designing CBI, and also to help in producing the instructional lessons. It was proposed that a new type of CBI be developed to enable the teacher to more easily design lessons structured in ways similar to the way the teacher would deliver the lesson in person. (Author/GL)

SBIR PHASE I: FINAL REPORT

FEASIBILITY OF AN INTEGRATED EXPERT VIDEO AUTHORING WORKSTATION FOR LOW-COST TEACHER PRODUCED CBI

prepared for

THE DEPARTMENT OF EDUCATION

CONTRACT # RR88072005

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February 28, 1989

This material is based upon work supported by the U.S. Department of Education under contract number RR88072005. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views or policies of the Department of Education.

PROPOSAL TITLE: **Feasibility of an Integrated Expert Video Authoring Workstation System for Low-Cost Teacher-Produced CBI**

Department of Education Solicitation Number 88-018
Topic Number and Name of Topic: Topic 10
Development and Integration of Videotaped Illustrations for Use by Disabled Individuals
Name and Address of Firm: IntelliSys, Inc.
6075 East Molloy Road, Syracuse, New York, 13211
Principal Investigator: Charles R. Dills, Senior Scientist

TECHNICAL ABSTRACT: This was Phase I of a three-phased project. This phase of the project investigated the feasibility of a CBI workstation, designed for use by teachers of handicapped students within a school structure. This station is to have as a major feature the ability to produce in-house full-motion video using one of the presently-available video recording devices, such as WORM drives, LaserFilm, or interactive video tape. A systematic evaluation of video storage devices was carried out, and resulted in the identification of several acceptable devices around which such a workstation could be designed.

Studies of user needs for characteristics of authoring and delivery systems were also undertaken. It was found that expert systems should be incorporated into the design of the workstation to aid the teacher in designing CBI and also to help in producing the instructional lessons. It was proposed that a new type of CBI be developed to enable the teacher to more easily design lessons structured in ways similiar to the way the teacher would deliver the lessons in person.

KEY WORDS: Computer-Based Instruction; Interactive Video; Expert Systems; Public Schools; Handicapped; WORM (Write Once, Read Many); Interactive Video Tape; Local Production; Video Storage; Expert Authoring Systems; CBI Authoring; Authoring Languages; Workstations.

SUMMARY OF ANTICIPATED RESULTS AND COMMERCIAL APPLICATIONS: The anticipated outcome of this multi-phased project is the design and manufacture of a video-based CBI workstation suitable for use by teachers of handicapped students. This station will include provision for inputting full-motion video from consumer-type camcorders in VHS format. This video would then be used in the in-house production of CBI. This CBI would be intended for use by teachers and students within the local area, and would be written and produced completely in-house to meet local needs and conditions.

This workstation could also be used by other teachers, and by businesses and companies for localized production and utilization. Such commercial uses would involve local sales, product and procedure demonstration, patient education in hospitals, and in other settings in which a small number of copies of the program are needed, in which local conditions must drive the lesson or image design, and in which the material is to be used only a few times before it is outdated or no longer needed.

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EXECUTIVE SUMMARY

Introduction

This is the Executive Summary for the Final Report for the Department of Education Contract # RR88072005, titled "Feasibility of an Integrated Expert Video Authoring Workstation for Low-Cost Teacher Produced CBI". This contract was for Phase I of a three-phase effort. This report consists of five sections. These are:

(1) Introduction,

(2) Project Overview,

(3) The Eight Specific Project Tasks,

(4) Presentation of Findings,

(5) Recommendations.

Summary of Project Findings

The data resulting from project activities indicated that only three of the approximately three-hundred video storage devices available or about to become available are capable of storing full-motion video in a manner suitable for in-house video CBI production in the public schools.

It was found that all three storage devices could be integrated with commonly-available micro-computers, using a suitable authoring and interfacing system, to produce a video-based CBI workstation.

Various studies indicated the extreme desirability of incorporating into the workstation design an expert authoring and delivery system and an intelligent user interface, but that an expert system designed to simplify the use of the video recorder was undesirable.

Recommendations

The prototyping of three versions of the video-based workstation is recommended. One version would be hosted on an Apple II$^{(TM)}$, one on a MacIntosh$^{(TM)}$, and one on an IBM or an IBM clone. One version would use the Panasonic WORM (Write Once, Read Many) recorder, one would use the TEAC WORM recorder, and one would use the Interactive Video Group (IVG) interactive video tape system. All versions would incorporate basically identical versions of the intelligent authoring, delivery and student management systems, and would include extensive help and expert advisory functions. System control, user interface, and inference engine would be supplied by InfoView$^{(TM)}$, an already developed software/hardware system from IntelliSys.

It is recommended that certain studies be carried out as part of the Phase II prototyping effort. Among these are a study of appropriate user interfaces for students having various types of handicaps; appropriate modes of instructional delivery; various ways in which the teacher might want to use the system; and instructional methods preferred by teachers at various levels for different goals.

SECTION I: INTRODUCTION

This is the Final Report for Department of Education Contract # RR88072005, titled "Feasibility of an Integrated Expert Video Authoring Workstation for Low-Cost Teacher Produced CBI". This is a Phase I contract for a three-phase effort. The contents of this report are defined in Task 8, Sub-Task (4) of the Statement of Work for that contract.

This report concludes that the prototyping of one or more systems for in-house video storage and an associated workstation, including an expert authoring and delivery system, is feasible in more than one version, using any one of five storage devices. This conclusion, together with how it was reached and what are its implications, will be discussed at length in the report.

First will be presented an overview of the project, its aims and expected outcomes (Section II). Next a discussion of the work performed under the individual task headings will be given (there were eight separate tasks, this will be Section III). The project conclusions will be presented in detail (Section IV), and recommendations will be made for follow-on efforts (Section V).

SECTION II: PROJECT OVERVIEW

The purpose of this project was to determine the feasibility of solving certain problems for the teacher of handicapped public school children through the use of computer-based instruction based upon teacher-made video. While much instructional material is available for purchase and/or rental commercially, and plays a significant role in public education, it is recognized by almost all theories of curriculum and instruction, as well as by most teachers, that to be maximally effective, instruction must be designed to meet local goals and must be customized to fit local conditions. It is further recognized that this instruction should be adapted to each individual learner so that each student can make optimal progress without affecting the rate of progress of the other students (Bass, 1974). This is doubly important for handicapped students when integrated into classrooms with non-handicapped students and/or with students having different kinds of handicaps.

This understanding of the desirability of locally-produced and adapted instruction, individualized for each student's particular needs, is not new. Teachers and curriculum experts have long advocated such approaches, and research has often shown the superiority of instructional outcomes produced by such instructional environments when compared to more traditional methods. Taylor and Tabba as early as the 1940's both clearly understood the need for locally-adapted instructional goals and materials and individualized presentations, as well as any of the current theorists.

Many obstacles have stood in the way of realizing such desirable instructional designs, however. Individualized presentation systems are a recent development, and instructional development of localized lesson materials is time-consuming and expensive. These problems are even greater if more than a paper-and-pencil approach using a mimeograph machine is contemplated. While it has been theoretically possible for a long time to produce slides, transparencies, poster sets, video tapes, audio tapes and similar materials within the schools, such things were usually considered to be supplementary to the teacher, involved hard-to-use equipment, and were often of limited effectiveness. They were often hard to use in individualized settings, especially with handicapped students and very young students.

New technology has begun to change those conditions that limited the local production of individualized and personalized instructional materials. Computer-based, computer-assisted and computer-managed instructional systems have all become widely available in the schools as vehicles for the delivery of individually-presented instruction, and sometimes for personalized instruction. Further, some of this instruction has been locally-produced, and has been designed to meet locally-derived objectives under locally-defined conditions.

Video tape and video disc have been widely introduced into the schools as instructional delivery systems, mostly using either commercially-made materials or materials produced at a district or regional media center. To an extent, video discs can be locally adapted, especially if the disc player is controlled by a program resident in an attached computer, and is accompanied by teacher-produced reading and workbook materials. Both video discs and video tapes lend themselves to individualized presentations, and to some extent to personalization. Students can also use these devices to produce their own presentations, using materials already resident on the discs or by shooting their own video sequences. Teachers are responding widely to these media and the opportunities they present. But because of the production costs, time involved, and the technical and complicated nature of the required production equipment, local video production is not as great as it could otherwise be, local video disc production is almost non-existent, and the local writing of computer programs to control the presentation and personalization of video and video disc based instruction is extremely rare in the public schools.

Other state-of-the-art computer-based instructional systems have been built for and demonstrated in schools, and these systems have also been shown to be effective individualized, personalized instructional systems which can be adapted to local conditions. These systems incorporate artificial intelligence, automatic counselling, audio, high-resolution graphics, non-obtrusive evaluation, control of auxiliary devices (such as projectors and lights), robotics, animation, and a capacity to engage the student interactively. These systems share with video tape, video disc and computerized instruction several characteristics which have prevented their widespread application in the schools.

Foremost among these characteristics is the cost of the system. A second characteristic is the extreme complexity of the production/development systems associated with them. A third characteristic is the time required for materials production. Further, in order to optimize the use of the materials by the student, good instructional design and development procedures must be followed in designing the instructional properties of the materials, and most classroom teachers have not been extensively trained in these fields. As a result, CBI materials and systems are only economically feasible when large numbers of students will use the system over a period of several years, and oly if the content is relatively stable over this period.

Recent developments show promise of changing some aspects of this situation. Primarily, there are two such developments that seem immediately useful in helping the classroom teacher: the rapid development of artificial intelligence and the emergence of many new forms of video storage. These developments offer the promise of simplified authoring of computerized instruction, possibly without the use of specialists in computer programming, and the production of inexpensive video discs in-house both rapidly and easily. Such developments would do much to bring the promise of interactive video into the classroom, and would allow the teacher more flexibility and serendipity in its use. These developments would also mean that individualized interactive video/CBI aimed at a small target audience of students might become feasible, even in cases in which use of the material over a period of many years is not anticipated.

The immediate need is to determine to what extent this promise can be fulfilled using equipment and technologies immediately available or available in the near future. This involves a survey of the existing technologies for image storage that have recently or will soon become available, to determine the feasibility of in-house, quick, inexpensive and simple production of interactive video in a format suitable for use with teacher-produced CBI and other computer-based products. Once it has been determined which formats and production systems are suitable to the school's needs, the feasibility of designing a workstation incorporating an authoring system for producing the video instruction and an expert system for simplifying the teacher/author's task should be explored.

Therefore the present project was proposed, with the task of examining the various members of the new generation of video storage devices and systems. The goal was to identify those devices capable of serving the needs of the classroom teacher interested in the local production of video-based CBI and CAI for handicapped children in the public schools. Once these devices had been identified, it became the aim of this project to define the optimal work environment for use of these devices by teachers in producing video-based computerized instruction. This included deciding whether an expert authoring system was needed, and if so, what its characteristics should be. It also included deciding what display characteristics the system should have, and how user-friendly the operating and support system must be in order to overcome teacher fear of technology and the lack of technical assistance to teachers at the school building level. Finally, this project aimed at producing a top-level, preliminary design for a workstation embodying all of these characteristics and abilities.

The specific technical objectives for the Phase I project, as stated in the proposal, were:

(1) Determine the characteristics of all video image storage devices, formats and production systems currently available on the market, or to be available in the near future.

(2) Determine from the characteristics of the devices a list of candidate devices and formats that may be suitable for in-house production.

(3) Determine which of these candidate devices and formats produce adequate video images for school use.

(4) Determine the feasibility of a workstation for the in-house production of interactive video using each of the candidate devices and systems.

(5) Determine the feasibility of incorporating the interactive video products into teacher-authored CBI under the assumption of the commonly available authoring systems and computer hardware.

(6) Determine the feasibility of incorporating an expert system program into the video production workstation in order to enable the teacher/author to produce interactive video in-house without the assistance of technical experts.

(7) Determine the desirability of prototyping workstations for one or more of the candidate devices and systems under consideration.

These goals were embedded within eight specific task statements. Each task was then divided into sub-tasks, with each sub-task providing an exact specification of a piece of work to be performed in reaching the previously-stated goals. These goals were defined in such a way that each task depended upon the completion of the previous task for its input. Thus, by going through the tasks from one to eight, the project is viewed both chronologically and in terms of its work-flow logic. The next section (Sections III), presents the eight sequential tasks and describes the progress made on each.

SECTION III: THE EIGHT SPECIFIC PROJECT TASKS

Task 1: Create the Project PERT Plan:

The purpose of this task was to organize the work to be performed on the project and to reduce project risk by providing a plan for the sequence and manpower loading of the individual tasks and sub-tasks. This plan was created using Project Manager software and data gathered from many people, including the proposal authors, in-house staff and consultants. Once created, this plan was consulted at each stage of the project in order to verify that work was progressing properly. At the end of the project, it was used as a QA (Quality Assurance) tool to ensure that all work had been properly completed.

Task 2: Analyze Specifications for Current Video Image Storage Devices

This task was to satisfy Project Objective One which was to determine the characteristics of all video image storage devices, formats and production systems currently on the market,or likely to come onto the market. It was critical, if the final goals of the project were to be met, that accurate information concerning each such image storage system be obtained.

This information was obtained in several ways. A thorough search was made of the professional literature, including academic journals, trade journals, books, automated data bases, advertising literature, and trade papers.

Although no travel funds were included in the budget for this project, IntelliSys personnel and consultants visited several conferences while working on other projects and for internal staff development purposes during the time period of this contract, and when they did so, they obtained useful information related to this project.

Over three hundred image storage devices were located through this process that, to one degree or another, had potential to serve as a replacement or substitute for standard video disc systems. These devices fell into several categories, as follows:

a. Aperture Cards

b. Virtual Storage

c. Video Tape

d. Laser Film

e. Test Versions of Standard Video Discs

f. Write-Once Read-Many Analog Video Discs

g. Write-Once, Read-Many Digital Video Discs

i. Write-Many, Read-Many Video Discs

j. Digital Video Interactive (DVI)

All manufacturers were contacted and asked to submit information concerning the suitability of their product for use in a video workstation designed for use in the public schools. Only about fifteen percent of the companies contacted responded. These responses provided information which was included with the data gathered from other sources, and was used to establish a data base.

The information contained within this data base was used as input to Task 3. In the meantime, the data base was kept up-dated through continual contact with manufacturers and through periodic searches of new and newly-uncovered literature relevant to the project.

Task 3: Select Candidate Devices/Technology for Detailed Evaluation

Task 3 was to satisfy Objective two of the project, which was to select appropriate candidate devices, media and production systems to be considered in the remainder of the project. Of the original set of over three hundred devices found for use in storage systems, it seemed likely that many would not be suitable for meeting the needs addressed by the project, and that this could be determined in many cases from an examination of the manufacturer-supplied specifications and in other ways not requiring the acquisition and field-testing of an actual device. Thus Task 3 was established, for the purpose of determining which devices were unsuitable and which deserved further consideration, based upon whatever tests could be applied short of device acquisition.

Task 3 had two aspects. The first aspect was to develop a list of characteristics and standards the candidate device must meet. This entailed a careful evaluation of the literature on school-based CBI so as to determine the characteristics such systems must have in order to meet the needs of teachers. This also entailed an examination of the potential of each system for in-house production, speed, cost and potential for integration into a completed CBI production facility.

The second aspect of this task was to evaluate the devices and systems located during the search conducted under Task 2 using the requirements and characteristics defined by the current task. The purpose of this evaluation was to eliminate unsuitable systems and to select those devices suitable for further evaluation.

It was considered undesirable to eliminate any device or system from consideration because of current unavailability or because of technical difficulties currently unresolved by their manufacturer, providing there was sufficient reason to believe that these problems would be resolved in the near future (i.e., within a year).

The evaluation process was made iterative, because it was considered undesirable to narrow the list of candidates to too great an extent at this point. To do so might indicate that premature decisions had been made. Therefore, it was decided that if the process of evaluation resulted in only a single candidate remaining, (or in no candidate remaining) the requirements and standards list would be re-examined to locate and revise those items that had been constructed too strictly. If, unlikely as it seemed, this did not solve the problem, and no suitable candidate device for further study could be located, the sponsoring agency was to have been contacted and asked to determine a course of action it felt to be appropriate.

Standards were developed drawing upon a variety of sources. The experience of IntelliSys personnel who had worked in CBI development and in the public schools was heavily drawn upon. The State Department of Education Educational Technology Laboratory personnel and experts from the New York State Division of Rehabilitation and Vermont Department of Home Services were interviewed, and in addition they supplied data from their state-wide data banks. Literature collected during the Task 2 effort was used, and special data searches were conducted to find articles, books, and papers dealing with using video and video devices in teaching the handicapped. Experts from the public schools in the Syracuse area were interviewed. Professors at Syracuse University from several departments dealing with media and with teaching of the handicapped supplied data.

A draft list of requirements and standards was produced, and was distributed to a panel of experts who had not been involved in the original standards generation effort. Panel members were drawn from the State Department of Education, the University of Central Florida, Shephards College (West Virginia), Syracuse Public Schools, and several independent consultants.

The requirements and standards list was revised in light of the comments received from the expert panel. The standards were then applied to the list of candidate devices, using the data on each device collected under Task 2. Ten candidate devices remained under consideration after all devices not satisfying the list of requirements and standards had been identified.

These were:

(1) TEAC LV-200A Videodisc Recorder

(2) Panasonic TQ3031S Videodisc Recorder

(3) Panasonic TQ2026S Videodisc Recorder

(4) Interactive Television developed by ACTV,Inc.

(5) Interactive Video Group (IVG) Authoring/Study Station interactive video tape system developed by International Training and Consulting,Inc.

(6) Glass, Plastic or Test Optical Laser Discs, such as produced by the Optical Disc Corporation and processed by Crawford Communications, as well as by other companies

(7) VFA Digital Video Graphics System developed by the A[illegible] Corporation

(8) LaserFilm(TM), produced by McDonnell-Douglas Electronics Co.

(9) Interactive Video Tape System developed by the University of Central Florida using the McGraw-Hill authoring system

(10) Interactive Video Tape System developed by Allen Communication using a version of the Quest authoring system

Task 4: Select Candidate Systems and Technologies:

The purpose of Task 4 was to meet Project Objective Three. Objective Three was to determine which of these candidate devices and formats produce adequate video images for school use. This task differs from the previous task largely in method, but little in purpose. Both methods have as a purpose the elimination from consideration of all devices not suitable for use in the project, and the evaluation and testing of all devices that are suitable. The previous method uses as a tool for accomplishing this purpose paper-based information, while the present task utilizes human observers and test signals. The present task takes as input those devices remaining under consideration after the completion of the previous task. Conceptually, therefore, these tasks could be considered to be compliments of each other.

Task 4 was met by comparing the visual signals from each of the candidate devices. In general, three steps were involved in doing this. First, standards for comparison were formulated. Second, a standard video tape was prepared using specially selected scenes and test situations (described below). Third, the video signal from the test tape was stored on each storage media. Then a panel of experts evaluated the playback signals from each of the storage media.

The resulting evaluations are valuable only if two conditions were met in making them. First, the comparison of the displays produced by the various devices must be judged using objectively-derived standards and must be produced under objectively-defined and controlled circumstances, or the evaluations will be invalid. Second, standards must be based upon both objective and subjective data concerning what is needed by and acceptable to the teacher/authors the project is ultimately designed to serve. Otherwise the results of the evaluations, whether valid or invalid, will be useless.

Thus this task involved not only the production of video and the encoding of that video onto the various optical storage devices, but it also involved constructing a video quality metric and validating this metric across the target population.

A panel of experienced CBI author/educators selected from various local and state educational organizations determined what indoor and outdoor scenes involving various kinds of lighting situations (e.g., backlighting, flourescent, dim lighting, etc.) would be necessary to demonstrate the performance limits of the various types of image storage/reproduction devices. Two standard VHS-format cameras (RCA and Panasonic) were obtained from local rental companies, and two brands of video tape (Scotch and Maxell) were selected from offerings available at a video tape rental store. The goal was to obtain equipment and tapes typical of those the average teacher would have for use, either through the local school building media/library or through personal ownership.

The scenes specified by the expert panel were then shot simultaneously by two novice photographers using the rented cameras and the randomly-selected tape. Each scene consisted of a person holding a grey scale/color chart and a resolution chart while standing in a specified lighting situation. Half-way through the shooting, the photographers and the tapes were switched between the cameras, so that each tape contains scenes from both cameras and each camera was used by each photographer. Thus, confounding variables were held to a minimum.

3 and 4, 1966; pp. 325-338) and widely used in astronomical mapping and similar metric-derivation problems, was applied to the current data. The Unrooted Evolutionary Trees method (Saitou, Naruya and Nie, Masatoshi; "The Neighbor-Joining: A New Method for Constructing Phylo-Genetic Trees;" Molecular Biology and Evolution; Vol. 4, No. 4, PP. 406-425; 1987) was also used. The version used was published by Studier and Keppler as a part of their work in bacterial evolution research (Studier, J. and Keppler, K; "A Note on the Neighbor-Joining Algorithm of Saitou and Nie;" Molecular Biology and Evolution; Vol. 5, No. 6, November, 1988; pp.729 to 731; 1988). These two methods are particularly well-suited for use with the type of data produced by the expert panel. They are geometrical methods rather than algebraic, and produce graphical outputs rather than decision tables. They are particularly simple to use and easy to interpret, and their data-distribution requirements are well met.

A content analysis of the panel members' open-ended replies was originally specified. This was not possible, however, because the replies were too brief and tended to focus upon too few concepts to permit such an analysis. Of course, the statements themselves were still analyzed for cognitive content.

An objective evaluation instrument was constructed based upon the multi-dimensional scaling data. This instrument was used by IntelliSys staff to re-evaluate the displays of each of the remaining devices. Again, all devices met minimal requirements.

Task 5: Develop Video Workstation Design Specifications

The purpose of Task 5 is to carry out those steps necessary to satisfy Project Objective Four. This was to determine the feasibility of a workstation for the in-house production of interactive video using each of the remaining candidate devices and systems. This task was essentially a systems design task, and required the development of a systems model for each of the remaining candidate devices. Each of these models were then to be evaluated in terms of feasibility of the entire system for use in the schools.

The first requirement was to objectively determine what was to be understood by the term "feasibility". A meaning for this term was determined through consultation with school media experts, teachers and those who write CBI for the public schools. These experts were drawn from the Department of Education of the State of New York, Syracuse Public Schools, University of Central Florida, Vermont Department of Services for the Blind, Michigan State University, ENABLE (A Syracuse-based organization for working with the handicapped), The University of California, San Jose State University, and several independent consultancies (Drs. Robert Baker and William Platt, both of Orlando, Florida, and Dr. Tish Cavaleri, of Hanover, Maryland).

It was determined that feasibility meant the following, in the context of this task:

a. Hardware affordable by the schools

b. Maintainable by the schools

c. Software affordable by the schools

A master tape containing a mix of the contents of the two original tapes was prepared, and each manufacturer was asked to use a copy of this master tape to encode the test signals onto the candidate device. In the case of both WORM recorders, the device was shipped to IntelliSys and IntelliSys personnel encoded the test signals.

Once the devices were ready, a panel of CBI/video experts drawn from various organizations involved in producing video and CBI for use in the schools was assembled at IntelliSys to view the video from the various devices. The device outputs were viewed simultaneously on identical monitors. Before viewing these signals, the participants calibrated their perceptual standards by viewing the original tapes.

One manufacturer, Aquila, Inc., of Albuquerque, New Mexico, and their marketing entity, VFA, promised, but never delivered, the digital video system we were to test. Three other systems were based on video tape, and so no viewing quality tests were necessary, since the original signals were also on video tape. All that was needed was to test the search times for these systems, and to verify that their control systems performed as specified.

IntelliSys personnel observed the operation of two of the video tape based systems, and verified that the operating systems worked properly and that search-and-access times were adequate. These observations were conducted in Florida, where one system was displayed at a convention IntelliSys personnel were attending, and the other was observed at the University of Central Florida, where it has been developed. The third video-based system, Interactive Television, developed by ACTV, Incorporated, of New York City, has yet to be observed working, since a demonstration version in a format suitable for use in this project has not yet been produced.

The other devices were viewer-tested by the expert panel using both objective and subjective evaluation instruments developed by IntelliSys. The objective instrument consisted of Likert Scale rating items, and the subjective instrument consisted of three open-ended essay-type questions. All items concerned the suitability of the displayed video images for use in school settings by handicapped students. Information concerning appropriate authoring and delivery system characteristics for use in this setting was also collected from this panel.

It was planned to eliminate from further consideration any image storage device that a majority of the panel found subjectively to be unacceptable. However, no member of the panel found any of the devices to be unacceptable. Therefore all candidate devices remaining from Task 3 passed this stage of the evaluation process, with the exception of the Aquila device and the Interactive Television system. It is recommended that these two systems be tested when they become available, but they have been eliminated from further consideration in the present phase of research.

The Objective Evaluation instruments were subjected to multi-dimensional scaling. Two scaling methods were utiliezed. The Classical Metric Multi-dimensional Scaling method developed by W.S.Torgerson (Theory and Methods of Scaling; New York; John Wiley, Inc.; 1958), renamed Principal Coordinates Analysis (J.C. Gower; "Some Distance Properties of Latent root In Vector Methods Used In Multivariate Analysis;" Biometrica; Vol. 53, Numbers

d. Operable without special assistance from technicians

e. Production must be fast

f. Must have "teacher appeal"

g. Fundable under state and federal programs

h. Must be "break proof" when in the hands of the students

i. Must be a turn-key system.

The manufacturers and/or distributors for each of the devices supplied IntelliSys with the data needed to establish system-level requirements. Using this data, for each of the devices, IntelliSys developed top-level production system requirements for a workstation incorporating the device. This design was then evaluated against the above operational definition of feasibility in order to determine which of the candidate devices can be incorporated into a practical and useful workstation.

On the basis of this evaluation, several of the candidate devices were eliminated from further consideration. The LaserFilm(TM) system failed to meet requirements for speed, cost, software cost and simplicity of operation. The production system requires special production facilities which cost many thousands of dollars, and few school systems could afford to purchase them. They are available through the manufacturer, but only at a large processing fee for the first disk (which in our envisioned application would be the only disk made). In addition, special timing controls and other signals must be present on the original tape that is sent to the production facility, and it is beyond the capacity of the typical teacher to add these signals to their tape. Also, the equipment to add these signals is expensive and not available to the teacher. In most areas of the country, these signals can be added by a local tape processing company, but at additional cost and production time. All of this tends to decrease teacher appeal. The total process at best requires at least a week for processing, once the teacher has recorded the tape. Thus LaserFilm(TM) does not seem suitable for the purposes of this project.

Glass discs, or test discs, also fail to meet the feasibility requirements, and for most of the same reasons as did LaserFilm(TM). Production time and cost are too great, special signals must be present on the master tape, the disc cannot be produced completely in-house, the technology is complicated, the first disc is expensive, and if some of the disc is left blank it cannot later be filled. The production process requires enough technology that a technician may be required. Many teachers might not want to use a process as complicated and as technical as this.

Four interactive video tape-based systems were evaluated, and three were eliminated at this stage. ACTV was eliminated because it really has never been developed in a version suitable for school use, and no plans exist to do so. Versions that do exist may in fact appear in special situations within the schools, but not in any situations envisioned by this project. The ACTV system consists of a video tape containing three video signals side by side, and a control device that switches from one signal to the other when triggered by an external command. Two applications have been perfected so far. In one, a cartoon character interacts with a child in a toy format. Questions are built into the toy's pre-recorded tape, and when the child speaks an answer to the question, the control device switches the video channel. Which channel is displayed depends upon whether the child said "yes" or "no".

The second application mentioned above does not involve video tape, but rather is designed to work with video signals delivered to specially equipped television sets over a cable system. Again, the signals have questions embedded within them, and the switch responds to verbal responses to these questions from the child.

Both applications have been shown to be effective, both as technologies and as instructional delivery devices. But neither is suitable for use with teacher-made video, or in teacher-produced CBI. Further, the video storage device for these is an ordinary video tape recorder. The new technology resides in the way the signal is placed upon the video tape, and the ingenuity of the programmer in designing the three video sequences. The word-recognition switching equipment is also not new, but its use in this context is novel The system could be adapted to other uses, such as CBI with built-in video simulations, or in pre-taped interactive interviews with famous people, but this has not yet been done and no plans exist to do so. Therefore this system fails to be feasible; the system has not been developed into a turn-key system for the uses being contemplated by this project.

The video-tape based interactive systems developed by the University of Central Florida (Using the McGraw-Hill authoring language) and the system designed by Allen Communication (using their Quest authoring system) are suitable for use in the production and delivery of interactive instruction based upon video. However, practical aspects of both systems make them unsuitable for the uses contemplated by this project. The authoring system used by the University of Central Florida is a very old system, as software is usually judged. It is slow, it is designed to work with electro-mechanical control devices which are slow, and it is not a turn-key system (the user must purchase the control devices from one company, the authoring system from another, the tape equipment from a third, and the computer from a fourth; then the user must assemble the system). This in turn causes the system to lack "teacher appeal" for many teachers. This system has potential for development, and if no other suitable candidates were to be found, this system could be updated and modified into a reasonably good video instructional system. But in its present condition, it is not a feasible candidate, and no plans for updating it exist.

The system developed by Allen Communication is also usable, if no other candidate were to have been found, but is unfeasible in its present state of development. Although it lacks some of the disadvantages of the University of Central Florida system (it is based upon Quest), a very good and fast authoring language. It also has some of the same disadvantages. It is not a turn-key system, it is not simple to use, and the available interface controls are slow. Further, it has an additional disadvantage: it works only with industrial quality tape players (the system from the University of Central Florida works with non-industrial models of tape players). Thus system cost is higher, maintenance is more complicated and more difficult to provide, and the equipment is more complicated to use. Since no plans exist to change these characteristics, this system was also judged not to be feasible for the uses proposed in this project.

The work performed under Task 5, then, has eliminated from further consideration five candidate devices/systems. These were:

(1) LaserFilm(TM) from McDonnell-Douglas

(2) Glass, Plastic or Test Discs from any number of sources

(3) Interactive Television by ACTV, Inc.

(4) Quest-based interactive video tape system developed by Allen Corporation

(5) McGraw-Hill based interactive video tape system from the University of Central Florida

Left under consideration were the interactive video-tape system developed by IVG Corporation and the analog WORM drives manufactured by TEAC and Panasonic.

Task 6: Feasibility Analysis for Integrating the Workstation as Specified with Existing Authoring Systems

The purpose of Task 6 is to satisfy Project Objective Five. This objective is to determine the feasibility of incorporating the interactive video products into teacher-authored CBI under the assumption of the commonly-available authoring systems and computer hardware. What is intended is to verify that the computers and computer-based authoring systems commonly available in the schools can retrieve and utilize the video stored by each of the remaining candidate devices for the purpose of producing and delivering interactive video-based CBI. In cases in which it is determined that the candidate system cannot interact appropriately with available systems, it was intended that the modifications necessary to enable the devices and school-based systems to properly interact be defined, and the feasibility of making these modifications be determined.

This involved, first of all, determining what hardware devices and authoring systems are commonly used in the schools by teacher/authors. Then it had to be determined what was required for each of these systems to interface with the candidate devices. It also required that minimal standards be established for the interface between the system and the authors, and between the system and handicapped students.

It was believed that much of this data was already available, and could be obtained from various state and national agencies, and also that the manufacturers of the storage devices and authoring languages could supply much significant data concerning their systems. This assumption proved to be well-founded. Almost all required information was obtained through these two types of sources.

It was found that schools use almost every micro-computer ever manufactured, and a great many larger ones as well, such as the various VAX and DEC mini-computers. CBI has been written and delivered using IBM 360s, Amdahl mainframes and other such mainframe systems. High-performance networked CBI systems have been introduced into the schools (e.g., PLATO and TICCIT). Typically, however, most computers used by teacher/authors in the public schools are one of the many models manufactured by the following companies:

(1) Apple

(2) Tandy Corporation

(3) IBM (or by a company producing IBM clones)

(4) Texas Instruments

(5) Atari

It was further found that little uniformity exists among schools as to what authoring languages are used. In fact, it was found that many teachers did not use authoring languages at all, but used word processing programs and other off-the-shelf software.

The candidate devices were examined, and it was found that the designs of these devices necessitated a change in the question being asked in this task. The wide variety of software and systems used in the schools precludes consideration of systems design on the basis of the authoring systems currently used in the field. The IVG device is a self-contained system having its own authoring and display software and hardware, and is designed to interface with either an IBM or an IBM clone computer using MS-DOS as an operating system. Thus, for this system, it doesn't matter what authoring system the school already has, to use the current version of the IVG device, the teacher/author will have to use the authoring system supplied with the system, and will have to use a computer compatible with the rest of the system. Both of the analog WORM drives examined are designed to be used either as stand-alone devices hooked directly to a tape player or camera, or interfaced to a computer. Both have internal programs designed to act as control systems through computers, and one (the TEAC) has a built-in connection to a VMS bus line. Both have provision for the connection of external timing generators. And both are designed for use with IBM-type computers. Thus, any authoring language available on the host computer can be used as easily as can any other language. No matter what the language, it must be interfaced with the WORM control system, and this is most easily done using the control displays generated on the host computer by the WORM recorder.

Thus it was found that the WORM systems themselves do not require modification, and any authoring system of sufficient sophistication to generate control signals can interface with the WORM systems. But in both cases, interfacing software must be written and installed, and this requires some sophisticated programming. It also requires the cooperation of the manufacturers of the WORM system and of the authoring language, since basic coding for both devices is required. Teachers cannot be expected to produce such integration, even if they possessed the coding data (which they are not likely to possess).

This would seem to eliminate from consideration the two WORM recorders, but this is not the case. While teachers cannot produce such systems themselves from components, an integrated workstation incorporating the recorders and an authoring language, already integrated and delivered as a turn-key system, is certainly feasible.

The IVG system, on the other hand, would seem to pose no problems, since it is already a turn-key system. This is partially true, but there are some difficulties here, also. First, many schools already have investments in other types of computers than the IBM-like PCs, and to change over would require the purchase of a great many units. Second, the authoring system lacks the usual degree of user-friendliness often sought by teachers (although it is still much friendlier than many authoring systems IntelliSys has had experience with in military and commercial circles). Third, limited user-friendliness currently available in the system precludes the use of more sophisticated authoring and testing without going to conventional programming modules; this will eventually restrict and frustrate the author/teacher who becomes proficient with the authoring system. This type of limitation is inherent in linearly-programed CBI systems, in which ease of use usually restricts versatility and power.

The problems attributed to the IVG system, like those possessed by the WORM systems, can be overcome. Further development of the authoring system, inclusion of more intelligence in the authoring and delivery systems, and improvement of the student testing and record-keeping functions would make the authoring system completely acceptable. Further, by modifying the interface boxes and re-writing some of the software, the system can be easily adapted to use with the computers of a wide range of manufacturers. Therefore this system, too, remains feasible within the school setting.

Properly developed, all three candidate systems were found to be capable of providing integrated video with CBI which meets the minimal classroom needs. All devices provide adequate access times, times for return to program control, types of video interactions possible, and adequate integration between graphics and video, that an adequate host computer and authoring system is used. Further, this appears to be possible without either mechanical or program modifications to the WORM recorders, and only interface and programming modifications to the IVG system. The effort to carry out these changes, while it may vary in detail from one computer or one authoring system to another, is of the same order of magnitude no matter which system is involved. Therefore a more exact determination of the nature of these changes is not necessary at this time. It has been determined, as required by the task steps, that it is feasible to integrate each of these systems into a turn-key video-based CBI authoring workstation meeting the needs and standards of the teacher/author in the public schools.

Task 7: Feasibility of Integrating Expert Authoring Tools/Systems into the Workstation Design

Task 7 is to satisfy Project Objective Six. Project Objective Six is to determine the feasibility of incorporating an expert system program into the video production workstation to enable the teacher/author to produce interactive video in-house without the assistance of technical experts. Such an expert system, if incorporated, would guide the teacher through the process of recording the video signals from VHS-format tape onto the storage device, then retrieving it from the device and incorporating the video into CBI lessons in an appropriately-interactive form.

Determining the feasibility of accomplishing this required estimating the amount of knowledge engineering involved, the type of host expert system shell or other software to be used, and the hardware required to host the software. The feasibility is expressed primarily in terms of the cost-benefit ratio of the proposed system, within the limits imposed by the financial and human factors requirements of the target population.

The degree of complexity of the tasks involved in storing, retrieving and programming video in each of the candidate systems was determined. In the case of the WORM recorders, this information was obtained from the accompanying operating manuals. In the case of the IVG system, the manufacturer provided a demonstration of the system, including the performance of these functions.

The parameters of expert systems capable of representing this set of tasks, and the degree of complexity of the associated knowledge engineering effort needed to automate these processes, were determined by the IntelliSys knowledge engineering staff. It was determined that a pseudo-natural language interface would be required. This program would interface with a system of control modules which in turn would control the recorder. Further still, an expert system advisor would have to be incorporated, and an extensive help function would have to be built. Further, an expert system authoring language would also be needed to allow for the construction of the interactive CBI lessons, and it would have to interface with the other expert systems listed above in order to incorporate the video into the lessons.

The amount of training required by a teacher/author in order to operate the video production system without the expert system was estimated using the data contained within the instruction manuals, the experience of IntelliSys personnel with the various demonstration systems, and the recommendations made by the expert panel upon their evaluation of the systems. It was estimated that very little training was required to enable teachers to perform basic functions on any of the systems, and that, at most, two days were required for a full utilization of all of the advanced features of these devices.

The cost of including any of the expert systems components in the workstation was calculated to be high. It was estimated that each of the above-described expert system components would add substantially to the cost and development time of the resulting workstation prototyped during Phase II.

Both a standardized cost-benefit analysis and a diffusion-of-innovation analysis were performed using the data collected as a part of this task. The cost-benefit analysis was performed to determine the economic feasibility of including the expert systems in the video workstation. The diffusion analysis was performed to determine the risk inherent in omitting the expert system from the video workstation in terms of product acceptance by the target population.

A consultant in the area of cost-benefit analysis was employed to identify the appropriate models to be used in conducting the analyses. The diffusion model chosen was that of Souder and Quaddus (1982). This model was chosen because it represents the integrated use of both historical data and expert opinions to forecast the diffusion pattern for an innovation. Further, it presents an approach for determining the ceiling on the number of potential adopters of an innovation. A further advantage of this model over other models for use in this project is that the coefficient of diffusion, called g(t) in the Fundamental Diffusion Model, is expressed as a function of time rather than of the number of previous adopters (this is important, since for this project, there are no previous adopters).

As this study is one of forecasting, with no present adopter data available, this model allows the parameters to be set through the collection of historical data, expert opinions and potential user judgements. Attributes deemed important to the technology can be judged for each alternative, and weighted. By substituting attributes that may be more important to the teacher/author, this model may be used for both forecasting potential adoption by individuals and by school systems.

The choice of a model was limited by various factors. The pure external, the pure internal, and the mixed influence types of models were rejected because previous adopter information is necessary in order to formulate their parameters. The flexible diffusion models require this information as well, and in addition demand that additional parameters be set for which this project has no data. Other refinements and extensions of the Fundamental Diffusion Model, such as multi-stage, multi-innovation and models incorporating influential change agents, appear not to be relevant to this project because of the types of questions they are designed to answer.

The model chosen for the cost-benefit analysis was the Benefits Causal Model version of the Standard Cost-Benefit Model (Wilkenson, 1978). In this model a cost analysis is performed to determine the resource requirements for producing the expert systems. It is assumed that only efficiency comparisons are of interest; effectiveness is assumed to be constant, or fixed. Once this analysis has been performed for each alternative design, the Benefits Causal Model will link pertinent input attributes of the systems to outcomes of the program. Coefficients (+1, -1) will be assigned to causal links as value weights, and weights will be assigned to alternative attributes. The alternative system configurations can then be ranked in decreasing order of the ratio (sum of benefits):(sum of costs). In this case, sum of benefits is taken to be the number of adopters predicted by the diffusion analysis, and sum of costs is taken to be the monetary cost of producing the expert systems.

These models could not be as completely applied as had originally been planned. Historical data on the use of computers, CBI and video systems (discs and cameras) in the schools for various years could not be obtained in the detail that would be needed to fully implement these models. This data, while collected by the New York State Department of Education, is not available in the form required, and no alternative source was discovered for a better data set. Expert opinion was acquired, however, and the two models were used in conjunction with this data.

It was found that the benefits obtained through the design of expert systems and natural language interfaces for simplifying the tasks of inputting and retrieving data from the WORM recorders, and for performing the other functions solely concerned with operating the WORM systems, were too small compared to the development costs.

However, it was also found that the benefits derived from the incorporation of an expert authoring, delivery and student management system, likewise using a pseudo-natural language interface, greatly outweighed the costs for developing such an intelligent system. It was also found that the inclusion of an intelligent interface between the student and the delivery/student-management system greatly increased the benefits over the system development costs, especially when the CBI lesson included or totally consisted of a video-based simulation exercise or an interactive graphic.

The percentage of adopters at the ceiling point, as calculated in the diffusion model, could not be quantitatively determined with any significant degree of accuracy, because of the absence of large amounts of historical data. Using expert opinion alone, it was estimated that the number of adopters at the ceiling point would be increased by at least one, and possibly three, orders of magnitude for a system incorporating an expert authoring and delivery system and an intelligent, natural language interface over a system lacking these items. It was also determined that only a very small, and not statistically significant, increase in percentage of adopters at the ceiling point would be obtained by including an expert system for operating the recorders themselves, and that this increase might be lost through the required increase in purchase cost for the system necessitated by the high development costs of such a system.

It was determined that a similar situation, but of lesser absolute magnitude, held for the IVG device. Significant improvement in the authoring system would result in a larger percentage of adopters from among the target audience than the present system can hope to gain. Further, the adaptation of the system for use with other computer models would result in a significantly larger number of adopters, provided the high-end computer systems are not considered (such as the mini computers and sophisticated workstations, which typically are not found in the schools). When the adaptation of the system to various computer models is coupled with improvements in the authoring system, the two effects are partially additive, and the number of adopters at ceiling increases by an order of magnitude.

Thus, it has been shown through the activities of this task that, for all three remaining candidate systems, it is not only feasible, but highly desirable, to include expert systems in the design of the integrated video-based CBI authoring workstations. The functions of these expert systems should be limited to authoring, delivery and intelligent display, interaction and student management functions, however, and should not involve basic video recorder operations except to the extent these are involved with authoring and presentation functions.

Task 8: Final Report

Task 8 is designed to satisfy Project Objective Seven. The project objective is to determine, for each of the video storage devices under consideration, the desirability of prototyping CBI authoring workstations incorporating the device. This task involves judging which, if any, of the devices under consideration holds promise as a solution to the problems addressed by this proposal. This judgement is to be made in the light of the data resulting from the work performed under all the preceding tasks.

Three candidate devices remain under consideration. Each has been determined to be integratable into a complete workstation. Each has been determined to require an expert authoring system and an intelligent user interface. Further, it has been determined that it is desirable that any system used in the schools be available for use with the particular model of computer already widely available in the particular school. This has been determined to be either some version of Apple(TM) computer, an IBM or IBM-clone, a Texas Instruments computer, an Atari or a Tandy computer. It was also found that in many cases these units have been networked within either the school media center, the school building, or the school district.

From a technical point of view, it therefore seems desirable to prototype one version of the workstation for each of the three video storage systems. An expert authoring and delivery system, an intelligent interface, and an intelligent student management system should be developed for use with each workstation. Each workstation /video device combination would be built in several versions, with each version utilizing a different model of computer as a host. Thus, all combinations of host computer/video storage device would be available for field testing and comparative study in a fully prototyped form incorporating appropriate expert system technology.

However, from the economic/business perspective, such an effort is not feasible, and probably would be no more useful, ultimately, than would projects on a lesser scale. Therefore, taking both technical and economic factors into account, it seems desirable to prototype workstations utilizing all three video storage devices, with one workstation per system; and to design one expert authoring/delivery system and one intelligent interface. This interface and expert system would be produced in three variations, one for use with each host/device combination, but would be written at a high-enough level that the systems themselves would not require extensive modification from one system to another. Only support coding would be required for each system. It is recommended, on the basis of surveys of computers available in schools, that some version of IBM, the Macintosh and the Apple II(TM) be chosen as hosts for these prototypes. The execution of these recommendations should form the core of the Phase II efforts of this project.

SECTION IV: PRESENTATION OF FINDINGS

The findings of the current project support very strongly the prototyping of three versions of the video-based CBI authoring workstation. These versions would incorporate expert authoring systems, intelligent display interfaces, and intelligent student management systems. Each version of the workstation would be built around one of the three video storage systems found to satisfy project requirements: the IVG video-tape based system; the Panasonic WORM recorder/player; and the TEAC WORM recorder/player. Each version of the workstation would be hosted on a different computer. The Apple(TM), MacIntosh(TM) and IBM/IBM-clone systems are recommended as host computers. The systems would accept as input video from VHS-format tapes shot on home camcorder-type cameras, or directly from the cameras themselves. Peripheral devices (optional) could provide other types of input, such as from still photographs, slides, drawings, movie films and so on. The main purpose of the workstation would be to provide the teacher with an easy-to-use, in-house production facility for CBI incorporating full-motion video for use in interactive 2-D simulation.

These findings are based upon a variety of types of data. Over three hundred devices and systems were originally located which could provide an in-house capability to record and play back video data. Most of these were eliminated from consideration because they were unable to record and play back full-motion video. Others were eliminated from consideration because they required some portion of the recording process to be performed at an outside location, or because the production facility and the first copy of the recorded product were too expensive for the schools to afford. Still others were eliminated from consideration because they have not yet been and are not planned to be produced in formats appropriate for use in schools, or because they only exist as laboratory experiments at the present time. Only three storage devices were found which met the project requirements. These were the Panasonic and the TEAC WORM recorders, and the interactive video tape system of IVG.

It was found that all three of these storage systems could be interfaced without considerable effort with popularly-available computer hosts. The most popular computers in the schools, it was found, were manufactured by five companies (Tandy, Apple, IBM and IBM-cloning companies, Texas Instruments, and Atari), and that of these, the computers manufactured by Apple, Tandy and IBM (and clones) were more often found than were the others. Thus it was recommended that these three computer families be chosen as hosts for the prototypes. No modifications were found to be necessary to either the computers or to the storage devices, beyond software changes, for this integration to occur.

Significant increases in the teacher-derived benefits and in the number of workstation sales were found to result from the incorporation of expert authoring systems and intelligent user interfaces into the prototypes. It was further found that the actual operations of storing and retrieving video signals from the recorders was easily learned, and the development of a natural language artificial intelligence system to simplify these operations would add little to user benefit and would probably result in loss of sales because of the added cost such systems would produce. These outcomes were arrived out through the consideration of the opinions of a large number of experts coming from differing backgrounds, and was confirmed by both a diffusion-of-innovations analysis and a cost-benefits analysis

For these reasons, it was deemed not only feasible, but also desirable, that the project be continued into Phase II, along the lines described in the opening paragraph of this section of the report.

SECTION V: RECOMMENDATIONS

A complete description of the prototypes to be produced during Phase II of this project should be reserved for the Phase II proposal. However, it is appropriate to describe how the recommendations made in the previous section of this report would best be implemented. Therefore this section will concern itself with the recommended prototypes, and with studies required to develop them.

The workstation should function in several modes, depending upon the type of task being performed. One mode would be employed during the storage and retrieval of video from external sources, such as cameras or tapes. A second mode involves the design and authoring of instructional sequences. A third mode is the authoring of segments within sequences. A fourth mode is the authoring of graphics and of video overlays. A fifth mode is the playing back of authored CBI. A sixth mode is the playing back of authored 2-D video simulation exercises. A seventh mode is the operation of the student management system. And an eighth mode is as a simple computer, running an externally-supplied software package.

Each mode would require its own software, and to some extent each of these software packages would be independent of the others. This presents some advantages. First, modularized packages simplify the task of installing updates as the system ages. Thus, systems would not become obsolete; it would be possible to update them as new software or hardware is introduced. Second, this simplifies maintenance, since all configurations would remain identical. Third, it could potentially reduce in-service training needs; as teachers move from building to building or district to district, or even state to state, the workstation they find at their new school would work exactly like the one they have been using.

The need exists for a new kind of CBI, one that is not frame-based, and one that does not consist of a linear sequence of pages.

The new type of CBI should free the author from the need to code each instructional stimuli, by being instructional-event driven, not code driven. This requires that an expert authoring system be designed which is capable of taking as input a sequenced list of instructional events and delivering these events to the student in a sequence and manner designed to optimize the student's benefits from the lesson.

The new CBI system should allow the student to control as much as possible of his own learning, and should allow the student to interact with the system through various instructional modes. The use of templates, the freedom of the author to develop new templates, the use of both structured and non-structured, and of student-directed and author-directed learning strategies, should be features of the new system. Further, the system should be both empirically grounded in the methods teachers actually use in teaching various topics and theoretically capable of advising the teacher on the use of instructional design theory.

The new CBI system must be capable of aiding the instructor in the production of graphics and of interaction scenarios. It must be capable of great flexibility in its responses to the needs of authors, while allowing the student the maximum possible freedom to direct his or her own learning and still apply the laws of reinforcement, feedback, and sequencing in a manner optimally consistent with the particular student's learning model.

The new system must be expert system-based if it is to achieve these characteristics, but it must not only be intelligent, it must be simple to operate, instructionally powerful, and flexible enough to allow the student to employ a wide variety of problem-solving strategies and other higher-level cognitive functions.

IntelliSys has already developed an intelligent system, called InfoView(TM), which is capable of performing some of these functions. The incorporation of InfoView into the authoring station proposed here would have several advantages. Design and development time and costs should be decreased. InfoView provides powerful interfaces with the student, a characteristic of the system sorely needed if severely handicapped students are to use the system to its fullest potential. One special application, for example, would be to interface the system with the text reader currently under development at IntelliSys, so that non-video based interactive CBI could be authored for use by blind children, who would interact with the system through voice synthesis equipment. In this manner, the instructor may incorporate off-line reading assignments that the blind student completes through the same facility over which the on-line material is delivered. Furthermore, the system prototyped for Phase II would automatically have a capability to be integrated and expanded to the more powerful InfoView workstation environment for those few locations (such as a commercial development facility) which have a need for specialized programming capabilities.

An intelligent authoring system should be structured to automatically select instructional events based upon the specifications entered by the teacher. The authoring of video-based 2-D simulations should be performed in a similar manner but there are some added complications, including:

- the nature of the video segment,
- the need for the specification of rapid and complete responses to student actions, and,
- to provide a variable amount of cueing.

The video stimuli is supplied from the video recorder, of course, and the nature of the recorder effects the nature of the possible interactivity. Less interaction is possible when using the IVG video-tape based system than when using either the TEAC-based or Panasonic-based systems. What follows is based upon the use of the WORM-recorder based systems.

The author will specify the disc containing the video stimuli, and will specify the parts of the video recording to be used during the simulation. The video may be played continuously from point to point, or it may loop through a specified segment time after time until some specified event or amount of time has occurred. Or the exercise may jump from spot to spot on the disc. Video overlays may be specified at this time. They may be displayed either from point to point within the exercise, or by frame numbers. They may also be made conditional upon certain student responses. And other responses of the delivery system to student actions may be specified in the same manner, either at certain frames or over specified segments of the video. These responses may be student feedback, branching, the recording of scores or the setting of flags which may control later actions of the system, the changing of the density of the cueing that is provided to the student, or the changing of the reinforcement schedule the student is on. The action may be frozen (still-framed) in response to student actions or at specified points in the interaction, either by frame number or elapsed time, for the purpose of providing feedback, eliciting thought, testing, changing the simulation rules or for whatever other purpose the teacher may have. In some cases, this freezing may be to provide a time-out to the student to avoid sensory overload or other problems.

The graphic overlays of the video may take a number of forms, including animated partial graphic figures overlaid upon the full-motion video, captions, visual cues, and feedback displays. Other types of stimuli that may be presented along with the video in the 2-D simulation mode include sound effects, auditory cues, and verbal instructions or feedback.

Graphic authoring should be performed using an internally-resident graphic authoring language. This system should be intelligent, in that it will be able to produce limited graphic designs. The use of the graphic system in the intelligent mode will be icon-driven from a menu page. An extensive help/advisory function will be included.

The design and development of the prototyped versions of the workstation as described in outline above requires that certain studies be undertaken in Phase II. These will be described and discussed more fully in the Phase II proposal, but the need for conducting certain of these studies has been identified through various Phase I activities, and these particular studies will be listed here. These are:

a. A need to determine the appropriate interface device and/or method for students having specified disabilities;

b. A need to determine the instructional approach preferred by teachers at various levels for teaching certain types of material and/or skills;

c. A need to determine the various ways in which teachers would like to use the HyperCard type of database.

d. A need to determine the appropriate method for delivering the completed instruction to the student (through networking, transportable storage discs, etc.).

e. The integration of a HyperCard-like data base for use with expert systems as devices for use in learner-implemented activities and as knowledge structures for holding the cognitive content of the authored CBI lessons.

Other needed studies will be identified in the Phase II proposal, and the description of the prototyped systems will be given in greater detail there. Also, as with all prototyping efforts, but especially with those involving expert systems and artificial intelligence, descriptions and requirements will change somewhat as the system is developed and becomes better understood. The results of the present study strongly indicate a system meeting the above description is both feasible and desirable. It is therefore recommended that such a system be prototyped in Phase II of this project, in the three versions listed in the previous section.