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IDENTIFICATION OF PROBLEM VARIABLES
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DURING LEVEL THREE INTERACTIVE VIDEODISC
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IDENTIFICATION OF PROBLEM VARIABLES
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By

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ABSTRACT

IDENTIFICATION OF PROBLEM VARIABLES WHICH CREATE A TIME AND COST IMPACT DURING LEVEL THREE INTERACTIVE VIDEODISC COURSEWARE DEVELOPMENT

By

Clara Steier

Interactive videodisc (IVD) is the very latest instructional technology. The medium is complex and requires a multi-disciplinary team to achieve a reliable product. Training and knowledge about the processes and procedures are primarily being generated through trial-and-error in actual IVD projects and at great cost to both contractors and client. Cost overruns appear to be the norm rather than the exception. Both developers and users are under increasing pressure to produce more realistic cost estimates in order to ensure that funds are available to complete the product. The means for making adequate estimates are presently not available.

The major purpose of this study was to develop a baseline knowledge of the problem variables, processes and interactions in the analysis, design, development and production of Level 3 IVD for training and/or education in industry and government which affected the time and cost and contributed to the project cost overruns. Twelve specific research questions were developed from the review of literature. The questions focused on the time and cost effects and/or extent of the effects of (a) knowledge required to make cost estimates, (b) client IVD knowledge, (c) contractor agency size and capabilities, (d) functions of team members, (e) team organization and

personnel, (f) phase activities, (g) phase most likely to cause an effect, (h) effects of hardware, (i) effects of software, (j) unintended and unplanned events, (k) unexpected costs and related circumstances, and (l) unexpected time delays.

To explicate the problem variables, a case study methodology was used. An interview guide containing 65 questions was developed to guide the interview and help ensure that similar data were collected from all of the cases in the study. One-on-one, audio-taped, guided interviews were conducted with project managers, instructional designers, information programmers and video producers for three cases which had reported cost overruns in producing an IVD. Records, documentation and reports were also examined where available to further verify and cross check the data gathered during the interviews.

The findings of the study clearly show that time delays and cost overrun factors are predominantly related to (a) the complexity of the design, (b) hardware and software deficiencies, (c) client knowledge, (d) contractor experience and (e) team functioning and communications.

DEDICATION

This dissertation is dedicated
to my Mother and Late Father

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CHAPTER I

PROBLEM

Introduction

Interactive videodisc (IVD) is the very latest instructional technology which interfaces microprocessor responding or evaluating devices with a videodisc player. The interactivity of this video is a program style which allows the learner to proceed in a variety of ways through the program and respond to the program material in a substantive manner. The sequence and selection of material will vary depending on the viewer's response. For example, in a simulated equipment repair task the learner may be asked to select and attach test equipment through a touch screen mode. The student who makes a mistake in any part of the performance could be branched to remediation or to outcomes appropriate for the error made, while the student who performs correctly would proceed in the logical sequence. The visuals would be coded onto a videodisc and played back by commands given to a microcomputer.

To the uninitiated, an interactive videodisc system seems nothing more than the marriage between a computer and video, with the video being stored in a new format -- a flat laser disc. However, this is not the case. Interactive videodisc systems must be accepted as a unique technology. Walker (1979-80) writes that the strength of videodisc lies in its flexibility in manner of presentation (most important are motion and still frame capabilities), its tremendous information storage capability when single framing is employed and lastly, its rapid access to any playing point which is usually three seconds or less. Walker also writes that when a videodisc is joined with some form of computer data processing, it provides the lesson designer with unparalleled resources for blending still and motion pictures, sound, text and graphics for instructional purposes. Thus, it goes without saying, the development of an interactive videodisc system requires the combined skills of instructional designers, computer programmers, and video technologists. DeBloois (1982), Floyd (1980), Gayeski (1984-85), Hon (1980), and Worcester (1983), indicate the challenge to each team member is to understand one or more media and furthermore to understand their application and relationships in a very unique manner which requires the modification of old skills and processes and the acquisition of new skills and processes to achieve reliable results. As the review of literature will show, at the present time all of these skills and processes are being defined through individual experimentation, which may be costing those who are designing and developing training in this medium large losses in time and resources which in turn translates to a dollar loss to the contractor. Unfortunately, there has been little empirical research on which to base decisions about IVD costing data and methodologies or the development of adequate cost models.

Background of the Problem

Since the use of interactive videodisc technology is fairly new, coming to the forefront as a viable instructional system in the last five years, little or no research has been done on the subject. The few studies which do exist (Bright, 1983; Maxwell, 1985) look more at the potential uses of the medium. The effectiveness is well established. However, these studies allude to high cost factors in terms of time and dollars required to develop highly interactive videodisc training. A concern is expressed by both Bright and Maxwell that unless a means is found to control and/or lower costs, the medium may not be used to its fullest potential. Merrill (1980) states the concern more succinctly:

> The videodisc cost picture offers both good and bad news. The good news is that disc replication costs are low, and videodisc player costs are competitive. The bad news is that production [including development] and mastering costs are relatively high. (p. 93)

Merrill continues:

> Total costs for developing and producing educational videodiscs are very difficult to obtain .... In some cases, production costs are reported but development costs are ignored. When data on specific costs are available, we find that the costs vary widely because of different development and production procedures and different instructional strategies. Very few educational discs have been produced to date, and the cost associated with their production includes a lot of trial-and-error learning costs. (p. 93)

Merrill's sentiments are echoed by Gayeski (1984-85), Hon (1981), Kirkpatrick and Kirkpatrick (1985), Kribs (1979-80), and Winslow (1981).

In talking with videodisc developers at conferences and through business contacts, an increasing number of people are venturing into interactive videodisc production. Many of these are even venturing in at Level 3 which has the potential to be the most interactive, complex and versatile of the videodisc technology. Level 3 marries the audio and visual capabilities of the videodisc technology with the flexibility and sophistication of an external computer. By controlling the videodisc player with an external computer, more sophisticated branching can be achieved. With this sophistication and increased complexity, the ability to predict accurate time and cost for development and production of interactive videodisc programs has decreased. Many complain that at the present time complete costing models do not exist to assist the contractor in making a realistic estimate or for the client to determine what funding should be allocated for an IVD project (Gery, 1987; Merrill, 1980; Parsloe et al., 1983). As with any innovation, time is required to build a base of experiences from which principles and concepts can be drawn and applied to other efforts. Presently, a systematic approach to deriving a set of variables which could be validated and provide the knowledge base upon which to build a predictive cost model for Level 3 interactive videodisc projects has not been undertaken.

Statement of the Problem

There has been little substantive research on which to base the development of adequate cost models for Level 3 IVD systems. It is paradoxical that while many writers (Klotz, 1983; Kirkpatrick & Kirkpatrick, 1985; Maxwell, 1985; Merrill, 1980; Parsloe et al., 1983) involved in IVD since the late 70's, have strongly advocated the need for more and better costing data and methodologies, researchers seem to have ignored the topic.

Level 3 IVD is a fairly new medium requiring a modification of old skills and procedures and the acquisition of new skills. Training and knowledge about the processes and procedures are primarily being generated through trial-and-error in actual IVD projects, apparently at a great cost to contractors (Allen & Erickson, 1986; DeBloois, 1982; Gayeski, 1984-85; Worcester, 1983).

IVD cases reported in the literature (Dennis, 1984; DeBloois, 1982; LaGow, 1979-80; Manning et al., 1983; Platt & McConville, 1982) are usually very large projects which are atypical and which do not have time and costs adequately documented for development and production. Further, the documentation and description of the courseware and software development is general and of little value to the designer or programmer.

The available literature on analyzing, designing, developing and producing IVD is at a very general level saying more "what to do" rather than "how to do." Further, where "how to" instructions are given, the recommended procedures are more appropriately applied to the simpler Levels 1 and 2 IVD of the Nebraska scale (Cambre, 1984; Lindsey, 1984; Parsloe et al., 1983; Tennyson & Breuer, 1984).

Another aspect is that problems currently identified in Level 3 IVD cases which might provide assistance to the contractor or client in planning are usually described too generally or grouped too broadly (i.e., programming) from which to draw any conclusions or gain insight.

The central focus of the first research efforts in developing a useful cost model for Level 3 IVD must be the development of baseline information derived from problems occurring in current Level 3 projects.

Therefore, the problem statement of the current study might be summarized as follows: How can a Level 3 IVD project be viewed, planned and costed? A more fundamental question is: What specific unknown variables unique to Level 3 IVD, which will affect time and cost, are presently contributing to the cost overruns in current contractual efforts?

Purpose of the Study

The major purpose of this study was to develop a baseline knowledge of the problem variables, processes and interactions in the analysis, design, development and production of Level 3 interactive videodiscs for training and/or education in industry and government which affected the final cost and time to produce the product. The main objective was to collect and document empirical data about variables within analysis, design, development and production which affected Level 3 IVD time and cost contributing to cost overruns. This baseline information is important for further study in the development of costing models for interactive videodisc efforts.

Research Questions

The specific focus of the investigation was delineated in terms of the following research questions:

1. What type of knowledge is needed and when does it have to be available to make time or cost estimates for an IVD project?
2. To what extent does client IVD knowledge, as reported by the contractor, have an effect on time and cost of an IVD project?
3. What effects, if any, do contractor agency size and capability have on time and cost of an IVD project?
4. What functions does each team member perform in the process of carrying out an IVD project?

5. What effects, if any, do project team organization and personnel IVD training and experience have on time and cost of an IVD project?

6. What activities in a phase have a time and cost effect on subsequent phases of an IVD project?

7. Is one phase more likely than any other to affect time and cost of an IVD project?

8. What effects, if any, does IVD hardware have on time and cost of an IVD project?

9. What effects, if any, does IVD software have on time and cost of an IVD project?

10. To what extent do unintended events and unplanned events create a time and cost overrun in an IVD project?

11. When and under what circumstances do unexpected costs occur in an IVD project?

12. When and under what circumstances do unexpected time delays occur in an IVD project?

Assumptions

The following assumptions were made in this study:

1. The study would generate presently unconsidered variables which affect time and cost in IVD development efforts.

2. The case methodology applied would meet the objectives of this study.

3. The subjects interviewed would cooperate and honestly describe the activities and actions taken during the analysis, design, development and production of the interactive videodisc process.

4. The bias of the researcher could be controlled through the use of formal interview techniques and examination of existing case documents.
5. The projects selected for study adequately represent Level 3 IVD technology.
6. There would be three IVD Level 3 projects at such a stage of completion as to make them valid for study.

Limitations of the Study

The present study is subject to the following limitations that serve to narrow its focus:

1. In view of the situation in industry and the willingness of people in industry to discuss their specific losses by item but not necessarily reveal figures related to profit and overhead costs, this study relates only to items of direct costs and losses.
2. Because of the methodology employed (case study), the outcomes of this study cannot be generalized to the population from which these cases have been drawn. Instead, the results of this study should inspire appropriate follow-up research, focusing on specific hypotheses using appropriate sampling methods.
3. Because of the time and cost involved in conducting case and field research, only a small number of cases could be studied. Therefore, every possible type and approach to Level 3 IVD may not have been sampled. As a result, it is possible that some Level 3 IVD problem variables which may

affect total project time and cost may not have been identified.

4. The results of this study are only related to Level 3 IVD and, therefore, may or may not include problem variables which affect time and cost in Levels 1, 2 and 4.
5. This study is purposefully limited to cases involving losses in final time and cost, and, therefore, may or may not include all the problem variables which affect time and cost in cases which ended the project on schedule and within the overall dollar limit.

Definition of Terms

Definition of terms used in the study are presented in this section.

Development Phases

These represent the processes of instructional development. There are generally four phases related to the development of IVD. These are:

1. Analysis: A careful study of the desired behavior required for an instructional program. This analysis helps determine the cause of performance problems, what must be done to correct the performance, and the best technique to provide the training (Iuppa, 1984, pp. 15-16).
2. Design: The process of writing objectives, organizing the material into instructional

sequences, arranging the sequences into a proper order, and defining the presentation and testing formats (Iuppa, 1984, pp. 21-22). Also recognized as preproduction in some of the literature.

3. Development: The process of writing test items, narrative elements and a description of the pictorial elements in the program (Iuppa, 1984, p. 71). Also recognized as preproduction in some of the literature.

4. Production: The phase in which video and film footage is shot, editing and preparation of the tape or film for reproduction as an interactive tape or disc is performed, and the computer programs are written (Parsloe, Hoffos, & Epic team, 1983, Daynes, 1982). Also recognized as post-production/ premastering in some of the literature.

Research Methodology

Terms related to the research methods employed include:

1. Case Method/Study: A recognized method of inquiry defined as an "in-depth investigation of a given social unit resulting in a complete, well organized picture of that unit" (Isaac & Michael, 1979).

2. Case Record: The compilation of the voluminous data organized into a comprehensive, primary

resource package. It includes all of the major data which will be used in doing the case analysis and case study (Patton, 1980).

3. Interview Guide: Outline of a set of issues or topical areas that are to be explored with each respondent before interviewing begins. The interviewer is required to adapt both the wording and sequence of questions to specific respondents in the context of the actual interview (Patton, 1980, p. 198).

4. Purposeful Sample: A strategy used when one wants to learn something and come to understand something about certain select cases without needing to generalize to all cases. To do purposeful sampling, certain pre-established information must be known about the case before it is studied (Patton, 1980).

IVD Terminology

Special operational terms for this study generally accepted by professionals using the IVD medium include:

1. Authoring: The preparation of a computer program, often using an "author language" or "authoring system" that allows people without formal training in computer programming to prepare applications programs for computer-based systems

(Parsloe et al., 1983, p. 248).

2. Authoring Language: A high level computer program, itself often based on a computer language like BASIC or Pascal, that facilitates the preparation of computer programs by reducing the number of instructions involved and translating these into a language resembling everyday English (Parsloe et al., 1983, p. 249).

3. Authoring System: A collection of authoring programs that allows users without formal computer programming skills to prepare application programs, often working in everyday language, and without the painstaking detail of computer programming proper (Parsloe et al., 1983, p. 249).

4. Courseware: That part of an interactive video training or teaching course comprising the video program (content on disc or tape), and its complementary computer program(s), including those generating text and/or graphics (Parsloe et al., 1983, p. 253).

5. Frame: A single, complete picture in a video or film recording. A video frame consists of two interlaced fields of either 525 lines (NTSC) or 625 lines (PAL/SECAM), running at 30 frames per second (fps) (NTSC) or 25 fps (PAL/SECAM). Film runs at 24 fps (Miller &

Sayers, 1986).

6. Information Programmer: The person on an interactive video production team who translates the work of the instructional designer into a computer program (Parsloe et al., 1983, p. 259).

7. Instructional Designer: The person on the interactive video team who, given the aims and objectives of the project, analyzes the content of the program and arranges that material in a way that can then be used by the information programmer (Parsloe et al., 1983, p. 259).

8. Interactive: Involving the active participation of the user in directing the flow of the computer or video program. The opposite of interactive is linear (Parsloe et al., 1983, p. 259).

9. Interactivity: A reciprocal dialogue between the user and the system (Miller & Sayers, 1986).

10. Interactive Video: The convergence of video and computer technology: a video program and a computer program running in tandem under the control of the person in front of the screen. In interactive video, the user's actions, choices and decisions genuinely affect the way in which the program unfolds (Parsloe et al., 1983, p. 259).

11. Linear: A video program which plays straight

through from start to finish without interruption (Parsloe et al., 1983, p. 262).

12. Search: The facility in interactive video systems to request a specific frame, identified by its unique sequential reference number, and then to instruct the player to move directly to that frame, forwards or backwards, from any other point on the same side of the disc or tape (Parsloe et al., 1983, p. 269).

13. Software: The programs which actually make the computer run. Software represents the intellectual side of computer-based technology, hardware the physical side (Parsloe et al., 1983, p. 270).

14. Still Frame (SF): Information recorded on a frame or track of a videodisc that is intended to be retrieved and displayed as a single motionless image. Playback is achieved by repeating the play of the same track, rather than going on to the next - as opposed to a freeze-frame that stops the action within a motion sequence. (Miller & Sayers, 1986)

15. Still-Frame Audio (SFA): A method of digitally encoding and decoding several seconds of voice-quality audio per individual disc frame, resulting in a

potential for several hours of audio per disc. By using a buffer to store the audio information, a limited amount of audio may be delivered to accompany a still-frame. (Miller & Sayers, 1986)

16. Videodisc: A generic term describing a medium of video information storage which uses thin circular plates, usually primarily composed of translucent plastic, on which video, audio and various control signals are encoded, usually along with spiral tracks. Optical disc systems use a laser beam to read the surface of the disc; they are so far divided between reflective and transmissive systems. Capacitance systems employ a sensor or stylus; they are divided between "grooved" and "grooveless" disc systems. A magnetic videodisc is used in broadcast television, and for information storage (Parsloe et al., 1983, p. 273).

IVD Levels

The Nebraska Scale, devised by the Nebraska Videodisc Design/Production Group to describe interactivity in videodisc players, defines the following for levels of IVD:

1. Level 1: The first practical level of the Nebraska scale. Level 1 represents the basic features expected even on domestic

equipment: remote control, the "search" facility, freeze frame, forward and reverse motion, quick scan, slow motion and step frame replay (Parsloe et al., 1983, p. 261).

2. Level 2: The midpoint on the Nebraska scale. Level 2 player is one which, using only its own onboard microprocessor, can offer multiple choice, the branching facility and score keeping (Parsloe et al., 1983, p. 261).

3. Level 3: Effectively the top of the Nebraska scale. Level 3 represents a video player, industrial or domestic, linked to an external computer (mainframe, mini or micro). This level offers the greatest versatility of any interactive configuration (Parsloe et al., 1983, p. 261).

4. Level 4: In a practical interpretation, a complete workstation comprising video and computer equipment and furniture. This level still represents conjecture into the future of interactive technology, rather than actual applications (Parsloe et al., 1983, p. 261).

<u>General</u>

Other terms used in the study include:

1. Client: A person, company, or agency which contracts with another company or agency

for the acquisition of training materials and systems.

2. Contractor: A business, organization or person who contracts to supply certain materials or do certain work for a stipulated sum.

3. Direct Costs: Costs which are incurred in the performance of the work to include labor, material and travel. Excluded are profit and overhead percentages.

4. Project: A contracted training program development and production effort using interactive videodisc.

5. Training: Learning experiences or activities that are designed to facilitate, strengthen or improve performance on the job.

Significance of the Study

As a review of the literature in the next chapter will show, the systematic study of specific cost factors related to the development and production of Level 3 IVD systems has been almost non existent. While a Level 3 IVD system has powerful instructional capabilities and features, the basic high costs of development and production for such a high technology system, the learning by trial-and-error on the part of the IVD developers, and the inability to forecast, predict and control the cost of the finished product indicate an urgent need to develop adequate cost models for use in planning and implementing IVD projects. If potential IVD users in the future are not to be discouraged, clients and contracting agencies need some hard facts and knowledge about the variables affecting Level 3 IVD time and costs. Such knowledge will help to optimize the quality and efficiency of IVD projects and products.

The primary significance of the present study is its contribution toward the building of an empirical knowledge base concerning the variables which affect Level 3 IVD time and cost. The development of this baseline data is of value to future researchers in the development of costing models and cost efficient processes and procedures for interactive videodisc efforts.

This study should also be of prime interest to IVD development and production agencies of Level 3 IVD for training. In particular, this study should provide valuable inputs and guidance for costing of IVD projects for industry and government which, in turn, will help reduce the dollar loss presently incurred by many contractors.

In addition, this study should be of interest to the client tasked with assessing and judging proposed budgets for IVD projects. The variables identified should provide guidance to assist the client in the process of evaluating proposals and budgets for an expression of adequate understanding and allowance of the potential pitfalls by the contractor. Further, it should provide guidance in establishing realistic funds for the execution of a project as well as indicate the information a contracting agency requires to more accurately bid a contract and prevent a dollar loss.

Organization of the Remainder of the Dissertation

In Chapter II a review of selected literature and research pertinent to this study is undertaken. Reference is made to the finite body of research and literature concerning IVD systems, problem areas in IVD systems, costing procedures for IVD and case study and field research. New evidence and more recent research applicable to the study are reviewed.

Chapter III is a description of the methodology of the study, including the research design, the research sample, the instrumentation, the data collection and recording procedures, and the data analysis procedures.

The results of the investigation and a discussion of the results are set forth in Chapter IV.

Chapter V summarizes the study findings, and then presents the conclusions, and recommendations.

Chapter Summary

Interactive video is a relatively new instructional technology which shows great promise as an effective training medium. The most severe problem facing the use of this technology is the difficulty in estimating the cost of developing IVD courseware since the courseware includes an interactive video disc and both computer operating and instructional software. The objective of this study was to identify empirically the problem variables which affect the time and cost of producing Level 3 IVD courseware, and to create a baseline of information from which to conduct future research toward the development of Level 3 IVD cost models. Further, this study should provide insight to both IVD developers and clients on cost elements in IVD which may cause overruns.

CHAPTER II

REVIEW OF LITERATURE

This chapter, which is divided into four sections, presents (a) a general review of the literature related to interactive videodisc systems, (b) a review of the literature related to problem areas in interactive videodisc systems, (c) a review of present time and costing procedures for the generation of an interactive videodisc system and (d) a review of the literature related to case study and field research.

Interactive Videodisc System

There is a large body of literature that describes the interactive videodisc technology. An interactive videodisc system is defined by Parsloe et al. (1983) as a:

> Video program which can be controlled by the person who is using it. Usually, this means a video program and a computer program running in tandem. The computer program controls the video program - and the person in front of the screen controls them both. (p. 1)

Maxwell (1985) defines the videodisc system as "a multimedia delivery device which combines pictorial, audio and digital information" (p. 16).

The interactive delivery system may employ either videodisc or videotape under the control of a microprocessor either built right into the video player, or as a separate computer. As explained by

Parsloe et al. (1983):

> The computer program which controls the video program can actually be encoded on a videodisc or loaded temporarily into a videodisc player through its remote control keypad, or stored on the magnetic tape or floppy disk of an external computer. (p. 2)

A main feature of interactive videodisc systems is the quick access time of getting from one frame to another. One side of a disc can store up to 54,000 frames of information. A frame is a single complete picture in a video or film recording. A video frame consists of two interlaced fields of either 525 lines (NTSC) or 625 lines, (PAL/SECAM), running at 30 frames per second (fps) (NTSC) or 25 fps (PAL/SECAM). In a laser disc player, the longest access time to any frame is a matter of seconds, which is usually under three seconds, while in a videotape player, access can take several minutes. Other features of IVD include the ability to hold a frame in place without loss of picture quality for hours and frames may be viewed as "stills" or in sequence as motion. In addition, with the stereo/audio capability, it is possible to give the user a choice of narrator track as in a dual language program.

There are two major videodisc systems: optical and capacitive. Within each of these major types are variations. The systems are incompatible because players differ in the way information is picked up from the surface of the disc for playback. <u>Optical</u> players are produced as optical-reflective and optical-transmissive. Optical-reflective players use lasers to write (record) and read (playback) a videodisc. Light reflected off the disc's surface is converted to electrical signals from which video and audio signals are derived. The optical-transmissive players use a translucent disc, so the reading laser passes straight through the disc allowing the disc to be read on both sides consecutively simply by repositioning the laser beam. The <u>capacitive</u> system players are also of two types. Both systems use a pickup stylus or sensor to transmit recorded video and audio information. However, the two systems have incompatible formats. The Radio Corporation of America (RCA) uses a grooved disc with the stylus riding on the disc. The Japanese Victor Company (JVC) is essentially a grooveless system which has the stylus gliding across the surface of the disc without making actual contact. It is generally felt that this reflective-laser system is the most durable since the essential information is recorded well beneath the tough protective coating on the disc. The RCA capacitive system is viewed as the least durable since discs are worn by the stylus and easily damaged by scratches, marks and dust. Further, the capacitive systems lack the same flexibility of speed, freeze frame and audio quality of the laser discs.

Interactivity of videodisc has been categorized by the Nebraska Videodisc Design/Production Group (Parsloe et al., 1983). It is a five point scale which generally can be applied to both videodisc and videotape. Level 0 indicates a home use system and is generally not seen as having any interactivity. Level 1 contains: remote control, a search facility, freeze frame, forward and reverse motion, quick scan, slow motion and step frame replay. It is the simplest level of interactivity.

Level 2, the midpoint of the scale, offers the first true interactivity. The equipment contains a small computer in the videoplayer which allows for branching away from the main body of the program into loops or tangents. Additional features to Level 2 are scorekeeping and multiple choice. The instructional program cannot be changed in any way in Level 2 because the video, audio and computer programs are mastered on the disc; therefore, once the information is recorded on the disc it is impossible to make changes without re-mastering the disc. This is a serious disadvantage if changes are required. The hardware consists of a videodisc player, its monitor and keypad. Level 2 usage is mostly in commercial application such as point-of-sale (Parsloe et al., 1983).

Level 3, the subject of this study, "represents a video player of any kind linked to an external computer-mainframe, mini or micro" (Parsloe et al., 1983, p. 17). This level offers the greatest versatility. A more sophisticated level of branching may be used and the shelf life of a disc may be increased by careful planning. The video material can be used with any number of programs and the computer programs are easily changed. Furthermore, the computer can generate text and graphics which can be used to enhance or supplement the material recorded on video. Level 3 is used in full scale simulation where an added computer is required to coordinate responses from disparate parts. In a more modest manner, it is employed in teaching and training where computer-generated graphics and text are required (Parsloe, 1983).

Level 4 is defined as the workstation comprising the video and computer equipment, and the furniture. It also is seen as the "speculative level of technology as yet unattained by existing equipment." (Parsloe et al., 1983, p. 17). Parsloe's speculative level includes enhancements in hardware as well as the theory of use such as artificial intelligence. Dyane & Butler (1984) also define Level 4 as "... a theoretical domain in which all things are possible" (p. 13).

Problem Areas in IVD

There has been a paucity of research on problem areas in IVD systems. At the present time, only one major study (Klotz, 1983) has been conducted which systematically investigated the problems and complications involved in producing interactive videodisc systems. In this study, Klotz (1983) conducted a survey of people who had attended an interactive videodisc symposium or workshop at the University of Nebraska ETV Center. The greatest areas of difficulty in producing an IVD were in computer programming, shooting, scripting, editing, and single frame edits. When Klotz reviewed the degree of difficulty in relation to levels of design, the data suggested the more sophisticated the level, the more likely problems will occur. This is logical since programming sophistication increases by level. The particular problems identified were in editing and single frame edits for Levels 2 and 3 because of the nature of editing for videodisc and the complexity of the program material in various projects.

Time was reported as being most heavily impacted by scripting, single frame edits, and computer programming. Other problems related to time were: turn around time for disc mastering, and delays in hardware or promised new features in hardware by the manufacturer (Klotz, 1983).

Additional problems identified by Klotz referred to:

1. The client's lack of knowledge and inability to explain all the possibilities and problems.

2. Assembling a multi-disciplinary team that could communicate and work together.

3. Deciding what to put on disc and what to put on the computer.

4. Planning enough at the outset of the project to keep the details coordinated.

The solution to the problems encountered usually were to put more time and money toward the effort and continue finding solutions through trial-and-error. Klotz did not collect any data on costing though many comments by his respondents reflected a high concern about the cost. Many of his respondents reported their companies have made a commitment to IVD and presently view the high cost and non-profitability of the medium as an investment in the future.

A review of other published literature revealed that some authors tend to oversimplify. For example, Clement (1981) wrote:

> Videodisc producers generally agree that creating a videodisc program is relatively easy. Organizations with the skills to produce a videotape or film should have little problem making a videodisc. Authoring systems now available greatly aid the process of creating program interactivity. (p. 13)

Although Clement states that the production may be relatively easy, it isn't clear what Level of production he is defining. Nor can we judge what he determines to be adequate "skills to produce a videodisc." Such writings are often misleading to the uninitiated in IVD. Further, it is unclear how many producers agree with him. It appears from Winslow (1981), Gayeski (1984-85), Gayeski and Williams (1984), Floyd (1980), Etherington (1981), and Hon (1983) that the opposite is true. They write of the complexity of IVD, not so much in terms of the hardware involved but the program content and programming required for sophisticated branching.

Etherington (1981) describes the complexity of IVD and decision making as follows:

> Options is the only word that comes closest to describing what it is like to produce for videodisc. Assuming there is a micro-computer coupled with the disc player, options may be left open from the shoot all the way to viewing the disc. It is like working with a piece of putty that can be molded to your specific need at any step along the way. The layout of the program breaks down into various segments which can be individually accessible, or can be combined in any order to conform to the desired presentation. Add some new menus with a character generator, or enter a new series of commands into the micro-computer, and the whole structure of the program can change. (p. 37)

Parsloe et al., (1983) elaborate on problem areas of flowcharting, documentation and record keeping, and scripting. New personnel to IVD are frequently cautioned to speak with experienced people in the process to avoid costly errors. This researcher knows of an instance where a government agency undertook the production of a videodisc without prior experience. After identification of the tasks, they proceeded to shooting of each task in a sequence. Seven weeks were spent in shooting and fifteen months in editing before the project was aborted and started over. The lack of planning and record keeping made editing of the disc impossible. There was no immediate means of tracking pictures, a lot of needless duplication in shooting occurred and shooting time increased dramatically. Unfortunately, while this approach may have worked for linear video, interactive video requires a different type of planning.

Another difficulty addressed in the literature refers to the establishment of a production team. Parsloe et al. (1983) explain:

> The size of the production team, like that of the budget, ought to reflect the scale and complexity of the project. Not that it always will -- getting the numbers right is a problem in jobs of all kind ... Anyone who works in [the] field knows of jobs that went wrong -- of very small companies producing monumental work, of teams so large that talented people sat idle, of projects so mismanaged that the full weight of the project fell on one person ....." (p. 205).

Besides the team size problem, team composition in terms of talent and skill is another major factor. Professionals with CAI or video experience have old skills which need to be modified and new skills which need to be learned (Gayeski, 1984-85; Floyd, 1980; Hon, 1980 and Parsloe et al., 1983). The extent of the problem is explained by Parsloe et al. (1983):

> Teamwork is a combination of talent, hard work and good planning, and is a function of management and personality as well as experience and training. Interactive video is still on such a growth curve that there are not enough people with qualifications such as formal training and practical experience to meet the demand. This may be the case for a few years yet ... [creating] a danger of some clients' falling into the hands of production companies who can't deliver the goods. (p. 205)

Parsloe goes on to say:

> From the production company's point of view ... Those people with genuine interactive production experience have the pick of jobs (and salaries) and the rest have to fall back on a combination of relevant experience and a willingness to learn the trade. (p. 205)

The problem of team members is greater on small projects since people have to develop all around experience rather than become specialized. It is difficult, if not impossible, to find the right combination of skills.

The types of personnel on the team typically are (Parsloe et al., 1983):

- System Analyst or Problem Analyst = the architect of the program. A person who sees how something is done or ought to be done and then designs and implements new and better ways of proceeding.
- Instructional Designer = the person who knows how to arrange and present the information in a way that its audience will enjoy and understand.
- Information Programmer = translates the work of the instructional designer into computing terms.
- Audio Visual Production = employs a typical video production team of a producer, director, production assistant, subject matter expert, art director and possibly a script writer.
- Project Management = involves a production secretary tasked with the administrative work and the project manager responsible for all administrative and material considerations.

A final problem addressed in the literature is the cost factor. To date, no clear guides exist to tell what an interactive videodisc program will cost. While the literature on costing is sparse, the authors (Bright, 1983; Floyd, 1980; Gayeski, 1984-85; Kirkpatrick & Kirkpatrick, 1985; Klotz, 1983; Kribs, 1979-80; Maxwell, 1985; Merrill, 1980; Parsloe et al., 1983) agree that there is a real need for better definition of the cost to make IVD a more viable medium. When looking at the medium there is a difference of opinion on what drives the cost. Parsloe et al. (1983) say:

> The cost of the project will reflect both production expenses which do not differ greatly from those of conventional linear video, and costs run up in a design stage which is considerably longer and more complex than the traditional medium.
>
> The time taken to select and develop delivery and authoring systems, to research a project and to analyze its component parts, to prepare draft flowcharts, scripts, storyboards, computer programs and documentation, can account for more than half of the production schedule before a foot of video is shot. (p. 221)

Merrill (1980) concurs that production costs are the same as for standard film or video tape. Bright (1983), on the other hand, indicates the cost of actually pressing a disc is prohibitive, along with the necessity for large staffs of people with varying skills. Winslow (1981) comments on the hardware associated with IVD as very costly:

> This kind of videodisc application begins with a player for "$2,500 to $3,000 then adds $1,500 and up for mastering and replication of each 30-minute program side -- and all of this is before we get down to the really serious, above-the-line costs involved in designing, scripting, computerizing, testing, validating, and installing a given instruction, training, and information program. (p. 38)

While cost and control of cost is a major issue, the procedures for costing an IVD project is seen as an even greater problem as discussed below.

Costing Procedures for IVD

The preparation of a proposal with detailed cost figures to cover the span of a project presents a challenge given the varying degrees of content as well as design complexities which can be pursued. To date, no research has been done on cost models which directly relate to interactive videodisc. While some use costing models for computer aided instruction (CAI) and join them with cost models for linear video production as a base, numerous cost items are not accounted for. Further, many of the cost models in CAI are calculated on some common rule of thumb such as "100 to 200 hours of development time for every hour of instruction developed" (Kearsley 1983, p. 56). Of course, this general rule is then modified by Kearsley with the explanation, "The amount of time required (and hence costs) will vary considerably with the type of CBI involved, the capabilities of the system and the experience of the personnel" (p. 56). Gery (1987), argues that the concept of hours of development time per hours of CBT is invalid "because in extensively branched, learner-controlled, or inquiry-based instructional programs, we can't define 'an hour of CBT [Computer Based Training]'" (p. 178). Like Kearsley, Gery says time and cost depend on situational variables which must be determined on a case-by-case basis. Gery further writes that the ratios quoted of 25:1, 150:1 or 400:1 are usually unsubstantiated industry averages. Translated into dollars the ratio figure for CAI development are quoted anywhere from $10 per minute to $600 per minute. This provides little guidance for CAI development much less for IVD development. To this base calculation must be added the cost of hardware and software acquisition and if the project entails implementation, the operational costs, as well as expenses associated with personnel and facilities (Kearsley, 1983).

In a 1985 Society for Applied Learning Technology (SALT) workshop on CAI, Research and Planning, Inc., provided CAI costing worksheets with relative values (See Appendix A). Gery (1987) in her work has identified and summarized all of the general CBT variables referred to above into four major categories: courseware, technical, human and other. Within these she has identified more discrete variables which affect time and cost. These variables are then plotted on a scatter diagram from low to high in terms of development time and development cost. Then, defining an hour of CBT as"...a course that is linear in nature, includes conditional feedback, and restricts the use of conditional branching to review segments" (p. 188), Gery shows a development graph of 85-150 development hours per CBT hour as low cost and time, 150-300 as medium cost and time, and 300+ as high cost. The cost of the project is then estimated based on where the preponderance of the variables fall for each project. Adjustments would have to be made to the hours if the CBT being developed was more interactive and complex than the definition outline. Gery readily admits, to estimate accurately using this model, you would have to be a highly experienced and seasoned CBT developer.

Most of the other CAI literature refers to cost benefit models (Heath & Orlich, 1977; Kearsley, 1982 and 1984; Kielt & Spitzer, 1977), which do not provide the guidance required by developers, or acquisition models for existing software (Pressman & Rosenbloom, 1984).

Production costs in interactive videodisc systems are often based on linear video costs. Whitney (1980) cited the following costs:

- Edited material on 16mm costs - $500-$700 for premastering
- Mastering costs equal about $1,500
- A computer program added to the disc adds another $500-$1,000
- Cost of the disc is $10 ($5 per side).

Since Whitney does not elaborate on the length, details, level and number of discs for the program, one can not use the data as a formula for costing IVD projects.

Daynes (1984), when questioned on the use of costing projects by cost per running minute, indicated the following figures:

> For a computer-controlled interactive videodisc with every available option, including a touch screen, computer graphic overlay, still frame audio, and a very high level of production value, the production cost could run as high as $10,000 per linear minute. For a 30-minute disc that is a pretty expensive program. However, costs, in my experience, average around $3,500 per linear minute. This includes both design and production costs. (p. 32)

Kulvicki (1985), at a SALT workshop for interactive videodisc, disseminated a costing equation for the mastering of a disc:

Cost/Hr. =

$$\frac{1}{\left[.5 \bullet \left(1 - \frac{\%\ SF}{100}\right)\right] + \frac{\#\ SF}{360}} \bullet \left[\frac{(SF)(SFC)+(MF)(MFC)+\text{Mastering Cost}}{\text{Market Size}} + \text{Cost Per Disc}\right]$$

SF = number of single frames
SFC = single frame production costs (Bennion estimates $10)
MF = number of motion frames
MFC = motion frame production costs (Bennion estimates $.20)
360 = number of still frames for one hour of instruction (10 sec .1 frame)
% SF = percentage of disc space containing still frame instructions

No further explanation is provided on application and usage. Kribs (1979-80) provides costing information on the videodisc delivery system by capability. A consumer model with passive audio-visual programs, some programmed instruction, and without an authoring feature is estimated at $700. The range then extends to a full video resolution color graphics with NTSC color overlay which can be used for interactive equipment simulation. This version allows for full video resolution color graphics to be developed and modified without disc mastery. The price estimated is $20,000. Into these figures must be added the cost of development and production.

Merrill (1980) breaks the costing into development and production, mastering and replication, and equipment. Merrill sees the basic cost of producing master sequences as ranging from $1,000 to $4,000 per minute. The production of still frames using original art and revisions will cost $100 per frame. These figures do not include the front-end instructional design costs. If the videodisc is to be controlled by a microcomputer, the production costs would require computer programming. The standard costs for programming PLATO courseware extend from $50 to $200 per hour of instruction depending on the skill of the author (Merrill, 1980). Kalba (1978) reported that different authors estimate the development and production costs as ranging from $5,000 to $700,000. The low end estimates involve assembling materials from existing sources with minimal front-end costs, while the latter includes expensive original motion sequences. Thus, we can conclude it is extremely difficult to estimate the development and production costs with the large number of variables.

Merrill (1980) found that mastering and replication costs for IVD by Disco Vision Associates cost $3,500 for two-sided video disc with 30 minutes per side. The more discs produced, the lower the overall price, i.e., 3000 copies could cost $33,000 or $11 per disc.

Equipment costs vary with the sophistication and complexity. Merrill estimates costs from $500 to $3,000 per unit. These prices are consistent with figures given by Winslow (1981), Kirkpatrick and Kirkpatrick (1985), Kribs (1979-80), and Daynes and Butler (1984).

Parsloe et al. (1983) provide more guidance on the elements which make up the cost of an IVD project. They divide the cost and labor into three phases. Phase I involves only people. This phase covers all aspects of the research and design. It is labor-intensive and considered to be the most difficult to estimate. All team members may become involved in this phase. Phase II requires cost and labor estimates to cover people, facilities, equipment, stock, goods, royalties, incidentals such as travel, in-house administrative items and production costs. This phase requires the listing of every single activity in the production schedule, citing the individuals whose work is needed, the time allotted to each task and all the required facilities equipment and supplies. Phase III is the information programming, where it all comes together. In this phase, the fine detailing in the design of both individual computer screens and the branching pattern as a whole take place. Once completed, instructions to the computer are input and then linked to the video player. The last aspect is testing the product. In this third phase, the delivery system equipment and entire team of people are again included in the cost. Parsloe et al. indicate this is also "a labor-intensive phase, but easier to budget than Phase I since the team now have a reasonable idea of the general size and scope of the work involved" (p. 228).

Several aspects surface in the Parsloe, et al. model. First, no guidance is given on how to cost design variables or to judge time. The guidance is merely that of content categories. Secondly, the authors presume costing will be accomplished in phases, thus providing insight to management on cost variables and a more accurate assessment of time as the project progresses. However, most projects for industry and government often require the submission of a firm-fixed price for the total project before any work is begun. Such costing is prone to severe errors in judgement because it is often undertaken without benefit of a content analysis or a design specification which could provide some insight.

Case Study and Field Research

Case study as developed by anthropologists and sociologists is a qualitative method of research which is well documented in the literature. Franklin & Osborne (1971) show that the early literature reflects a conflict between qualitative and quantitative research by citing such works as Lundgren's Case study vs. statistical methods done in 1941. In that particular work, Lundgren wrote that each method has a purpose and may supplement or contribute to the other. While the debates still linger on today over quantitative vs. qualitative, it has come to be an accepted fact that both types of research are important, often complementing each other in a research design (Campbell, 1979; Isaac & Michael, 1979; Patton, 1980; Reichardt & Cook, 1979). Campbell (1979), a recognized guru of quantitative research, goes to great lengths to correct his excesses against case studies. He indicates that qualitative research, like quantitative research, has weaknesses but often times quantitative findings can only be explained by qualitative research. Specifically, Campbell cites research where results in quantitative research cannot be replicated in subsequent research. It is often only through qualitative study that the confounding variables can be learned to provide a premise for further quantitative research. He stresses that quantitative research often generates what is happening without being able to explain why, while qualitative research may help to generate the theory or explanation behind the phenomenon. Campbell cites qualitative research as the common-sense knowing upon which quantitative research should build and go beyond. Campbell suggests the use of both qualitative and quantitative methods to clearly study a phenomenon. Where the results of the qualitative research are "contrary to the quantitative results, the quantitative results should be regarded as suspect until the reasons for the discrepancy are well understood" (p. 52).

While researchers concur that both quantitative and qualitative methods combined make for a stronger research design, Reichardt and Cook (1979) admit this is often difficult since it makes a study more costly, requires more time to do and most researchers are not sufficiently trained in both methods. Thus, one can conclude that the driving force for selecting a research method should be the research question, and a research methodology should be selected which can adequately answer it.

The case study approach is defined as "... an intensive, detailed analysis and description of a single organism, institution, or phenomenon in the context of its environment" (Anderson, Ball, Murphy & Associates, 1979, p. 46). Isaac and Michael (1979) describe it in a similar manner, "[an] in-depth investigation of a given social unit resulting in a complete, well-organized picture of that unit" (p. 20). Franklin and Osborne (1971) approach the definition a bit differently:

> The case study ... is not a specific technique. Rather, it is a method of organizing data for the purpose of analyzing the life of a social unit ... [using] both the historical and functional approach in an effort to see the social unit as an integrated whole. (p. 184)

Franklin and Osborne define the historical approach as the use of existing documents, records, life histories and statistical records which may provide critical information. The functional approach involves the collection of data through observations, interviews, questionnaires, and surveys. Essentially, the functional approach generates all of the information for interpretation while the historical approach interprets existing information to explain a phenomenon.

All of the literature agrees that the case study approach allows for the gathering of information about a select unit to define some characteristics about that unit of interest to the researcher. Isaac and Michael (1979) indicate the purpose of the study will determine if all or only selected segments of a unit will be studied.

Most of the researchers agree the greatest benefit from the case study is the determination of "important variables, processes, and interactions that deserve more extensive attention" (Isaac & Michael, 1979, p. 20). Glaser and Straus (1970) and Patton (1980) concur indicating case studies are a valid means of research to derive concepts and interrelationships to form a set of hypothesis for a given area. Foreman (1971) sees the use of case study for the purposes of illustration, concept and hypothesis development, hypothesis testing, prediction or postdiction, methodological testing or refinement. He clearly points out the use of the case study is best in new fields of research with little prior accumulated data or when the research problem demands conceptualization.

Weaknesses of the case study method center on the lack of representativeness and consequently the inability to generalize the findings to other units (Campbell, 1979; Isaac & Michael, 1979). While this is an accepted weakness by this researcher, it also is believed if the purpose of the study is to generate findings so that others might generate hypotheses for further study, the inability to generalize is not a negative factor. A second weakness discussed by Campbell (1979), Isaac and Michael (1979) and Patton (1980) is the vulnerability to subjective biases. Much of this bias can be controlled through sampling, and the procedural methods adopted for data collection and data analysis (Foreman, 1971; Patton, 1980; Whyte 1982).

By establishing prior criteria for sampling, a researcher's bias can be circumvented or at the very least minimized. To do this, the statement of the problem must be clear and the research questions outlined. Sampling may be random if generalization to a larger population is desired. Purposeful sampling "is used as a strategy when one wants to learn something and come to understand something about certain select cases without needing to generalize to all such cases" (Patton, 1980, p. 100). This is generally the sampling procedure which is used for the development of baseline data.

Bias during data collection may be controlled through the use of interview guides (Patton, 1980; Whyte, 1982). The guides ensure similar data is collected from all respondents while allowing for a free flow of information. An additional method for control of bias during data collection is to cross-check information with more than one respondent or with other researchers (Patton, 1980; Foreman, 1971; Whyte, 1982). In addition, all qualitative researchers indicated bias can be controlled through the use of research interviewing techniques such as the use of a tape recorder to prevent researcher misinterpretation or forgetting of key information; the use of open-ended questioning; and conscientiously refraining from judging the responses which might lead the respondent (Patton, 1980; Whyte, 1982). Finally, by writing notes and compiling data as soon after an interview as possible, selective recording of data will be circumvented and a more accurate record will be generated.

Bias during analysis can be controlled in several ways. Foreman (1971) suggests controlling bias by doing a comparison across cases. To conduct such comparisons between cases as well as within cases Patton (1980) and Whyte (1982) construct and reconstruct patterns, categories and typologies to ensure that the best fit to the data is achieved. To check the validity of the data analysis, an analysis of the case data can be conducted by independent researchers (Foreman, 1971) and the results compared for agreement. Patton (1980) recommends checking the validity of the data analysis by having the people described in the data analysis react to what is described. Patton suggests from this reaction, there is "a great deal which can be learned about accuracy, fairness, and validity" (p. 338).

The entire issue of bias can best be summed up through Campbell's (1979) discussions with Becker. Becker found that invariably the researcher undertaking an intensive case study ends up finding out that his prior beliefs and theories were wrong.

Chapter Summary

A search of the literature shows that there is a paucity of reliable cost models which apply to IVD development and production projects. The study by Klotz clearly shows there are problems in IVD development and production. Further, writings of Floyd, Gayeski, Kribs, Parsloe et al. and others indicate considerable trial-and-error experimentation with the medium.

Present writings are too general to provide the guidance required to avoid the present trial-and-error approach. A better understanding of the requirements to produce a Level 3 IVD will help a client to more accurately fund and the contracting agency to more accurately cost a project. This in turn will better assure that clients will receive the product for which they contracted and that the contracting agency will not suffer a dollar loss in producing that product.

The case study approach is cited in the literature as a viable qualitative research methodology to derive important variables, processes, and interactions. The results of qualitative research are then subjected to more indepth study using other research methods. The case method is particularly good for study in areas where little prior data exists and there is a need for conceptualization, such as found in the costing of interactive videodisc.

CHAPTER III

METHODOLOGY

As indicated previously, the study was designed to collect baseline data on the variables associated with time and cost overruns in Level 3 interactive videodisc (IVD) development and production. In this chapter a description is provided of the study design, sampling plan, data collection instrument, data collection procedures, preparation of data, and the data analysis.

Study Design

This study used a case method approach to derive the key problem variables which affect time and cost in Level 3 IVD projects for industry and government. The case method is recognized as a legitimate method of inquiry to pioneer new ground and uncover variables which deserve further research. Anderson, Ball, Murphy and Associates (1975) define a case study as "... an intensive, detailed analysis and description of a single organism, institution, or phenomenon in the context of its environment" (p. 36). Isaac and Michael (1979) define a case study as an:

> In-depth investigation of a given social unit resulting in a complete, well-organized picture of that unit. Depending upon the purpose, the scope of the study may encompass an entire life cycle or only a selected segment; it may concentrate on specific factors or take in the totality of elements and events. (p. 20)

Isaac and Michael further explain:

> Because they [case studies] are intensive, they bring to light the important variables, processes, and interactions that deserve more extensive attention. (p. 20)

Glaser and Straus (1970) and Patton (1980) indicated case studies are a valid means of research to derive concepts and interrelationships to form a set of hypotheses for a given area.

Since the literature to date is sparse and general on the processes and procedures used in all phases of IVD development, and little research on costing IVD is published to date, the case method provided the most viable means to build a bank of baseline data to meet the objective of this study, answer the established research questions and provide data for the establishment of hypotheses in future research. Data from three Level 3 IVD projects for industry and government were collected and analyzed. Each case selected met the criteria established and outlined in the sampling plan.

The data were collected by the researcher through in-person guided interviews and examination of project documentation and products. Complete cases were built by interviewing various project personnel from the contracting agency so as to obtain the perspectives and facts from the project manager, instructional designer, information programmer and video producer. On some teams a single individual filled the requirements for more than one position on a team, while in other cases several individuals performed discreet tasks of a single position. In some situations, one position was held by several different people at varying stages of the project because of expertise or because of staff turnover. In each case, enough personnel were interviewed to adequately cover all the project aspects. The study focused on the problems or processes which created a dollar loss to the contractor and only contractor personnel were interviewed.

All subjects and agencies in this study were provided confidentiality. Each case has been coded by numbers and by letters for the subcontractors within a case where necessary. All other identifying information has been screened and/or coded in an appropriate manner.

Research Questions

The specific focus of the investigation was delineated in terms of the following research questions:

1. What type of knowledge is needed and when does it have to be available to make time or cost estimates for an IVD project?
2. To what extent does client IVD knowledge, as reported by the contractor, have an effect on time and cost of an IVD project?
3. What effects, if any, do contractor agency size and capability have on time and cost of an IVD project?
4. What functions does each team member perform in the process of carrying out an IVD project?
5. What effects, if any, does project team organization, and personnel IVD training and experience have on time and cost of an IVD project?
6. What activities in a phase have a time and cost effect on subsequent phases of an IVD project?
7. Is one phase more likely than any other to affect time and cost of an IVD project?

8. What effects, if any, does IVD hardware have on time and cost of an IVD project?
9. What effects, if any, does IVD software have on time and cost of an IVD project?
10. To what extent do unintended events and unplanned events create a time and cost overrun in an IVD project?
11. When and under what circumstances do unexpected costs occur in an IVD project?
12. When and under what circumstances do unexpected time delays occur in an IVD project?

Sampling

Sample Selection

The final study sample consisted of three cases. All cases were selected by the researcher from a list of nine Level 3 IVD projects secured through contacts of the researcher, contacts of the Editor of Videodisc Monitor and contacts of the Director of the Society for Applied Learning Technology (SALT). All projects selected represented purposeful samples (Patton, 1980) so as to ensure that the objectives of the study would be met.

For purposeful sampling and the conduct of basic research, as few as one case may constitute a legitimate study. A minimum of three cases was established to cover possible variability due to content, staffing, hardware and project size. The established minimum of three cases allowed for a means of comparison and enough data from which to derive more definitive variables. Of the nine projects identified, eight projects met the following established criteria:

1. A Level 3 IVD training project as defined by the Nebraska Scale.
2. A completed or nearly completed project so data could be collected from the analysis, design, development, and production phases.
3. A contracted training development project for government or private industry.
4. A fixed price contract which experienced a cost overrun.
5. The availability of more than one team member for interviewing, covering the major positions of project manager, instructional designer, programmer and video producer.

After the initial phone contacts to verify the projects against the criteria, two of the eight companies were unable to participate because of litigation or an inability to get approval from company management. The remaining six projects were accepted as valid cases for the study.

During data collection interviews, it became evident that three projects were actually a part of one large project for a client and a fourth company was a subcontractor to one of the three within this same project. Although there were differences identified between these four companies in such aspects as project management, team composition and contractor organization, the client established methods, procedures and equipment to be used by all the contractors producing discs. To avoid bias, the data from the three projects were treated as one case for purposes of this study. The net result was a total of three cases for the study.

Sample Case Description

Case 1 was undertaken by a large state university in 1985 to produce six double sided Level 3 IVDs with accompanying print materials for a large firm in private industry. This project was a conversion of an existing audio-tape and print program to interactive videodisc. The contract required mainly development and production phase work.

Case 2 was a contractual effort undertaken by a private training consultant and development firm for a branch of the military. The effort was begun in 1984 and is presently being readied for delivery. This project was for the development of maintenance training for highly sophisticated equipment. All phases from analysis through final production were a part of the contractual effort.

Case 3 was undertaken by several private training development firms to produce eleven Level 3 single-sided IVDs for a manufacturing company to teach maintenance and repair of their product. Five of the discs were conversion efforts from Level 2 IVDs. The remaining six were new discs. The project had three separate contractors. Contractor A produced four single-sided discs, Contractor B produced one single-sided disc and Contractor C produced six new single-sided discs plus the computer managed instructional (CMI) system which supported all of the discs in the project. Each contractor within this case took the disc from design through development and production.

Data Collection Instrument

The literature was reviewed and an interview guide, to include demographic data, was developed. The interview guide approach as defined by Patton (1980) "involves outlining a set of issues that are to be explored with each respondent before interviewing begins" (p. 198). Both Patton (1980) and Whyte (1982) agree that the issues are not covered in any particular order or with any standard wording. The actual questions to elicit the information are generated during the time of the interview. The guide merely serves as a checklist to ensure that similar information is collected from all the people interviewed. Whyte (1982) explains best the reason for the guided interview:

> In research we want the informant [respondent] to talk about things of vital interest to him, but we also need his co-operation in covering matters of importance to the researcher, though possibly of little interest to the informant [respondent]. (p. 112)

The interview guide approach was used in this study to help ensure the systematic collection of similar data across cases and from individual subjects within cases; establish an initial organization of content for analysis purposes; provide topical areas within which to explore, probe and ask questions that would elucidate and illuminate a particular subject; and keep the interviews focused. The interview guide included the collection of direct case related content, demographic information such as experience and training of team members, and contractor organization size, age, description, and experience in the medium.

The final 9-page interview guide included an orientation to the subject regarding the purpose of the study, an assurance of confidentiality, and an elicitation of the project description to set interviewees at ease. Sixty-five questions were developed and grouped under the following topics: (a) General Information, (b) Analysis Phase, (c) Design Phase, (d) Development Phase, (e) Production Phase, and (f) Budgeting Phase. The interview guide used in this study is presented in Appendix C.

Data Collection Procedures

Data for this study were collected through audio taped in-person guided interviews, follow-up telephone interviews, and examination of documentation and products made available by the subjects of this study. Documents provided varied between cases. Some of the types of documents included Requests for Proposals (RFPs), proposals, instructional and system specifications, trade-off analyses and monthly progress reports. In several instances, correspondence and personal progress logs were provided. The study was conducted over a four month time period extending from November 1986 to March 1987.

A list of potential cases for study was obtained as outlined in the sampling plan. The identified contracting agencies were contacted by phone to enlist their cooperation and determine whether the case met the established sample criteria. If it did, an appointment was made for a personal interview on-site. Each phone contact was followed with a letter and explanatory sheet (Appendix B) about the research study, confirming the appointment and outlining the time requirements.

Pilot Interview

A pilot interview was conducted with one of the sample cases using the interview guide. Since no substantive changes were required to the interview guide or overall interview process, the pilot interview remained as a part of the sample in this study.

Interviews

On-site, audio taped interviews of contractor personnel using the

Interview Guide were conducted. It was calculated that from eight to eighteen hours of interviewing time were required per case depending on the size, complexity and number of personnel on the team of the contracting agency. Each initial interview lasted from two to three hours. The interview notes and content were reviewed immediately following each interview to expand notes into more comprehensive detail. Thank you letters to agencies participating in the study were sent.

Case Record

A case record, or compilation of data, was developed for each case by transcribing interview tapes, organizing field notes, and editing redundancies and ordering the content. Once this was accomplished, follow-up interviews were conducted for content clarification and collection of additional data overlooked at the first interview. One project manager, instructional designer and programmer were contacted for additional information in each case.

As expected, using this data collection methodology, more information was available from some individuals than from others. These differences were of concern to this researcher since one cannot always be certain how the findings are influenced by these qualitative differences in the depth and breadth of information received. Patton (1980) explains that for the conduct of basic research one is attempting to understand the whole so differences such as these are not as much of an issue. However, the differences were minimized as much as possible through the application of interview principles, use of the interview guide and conduct of follow-up interviews before the analysis began.

Principles for Interviewing

To ensure the success of the interviews, the principles of interviewing as outlined by Patton (1980) were applied by the interviewer in this study. These principles include:

1. Use of open-ended questions. The use of open-ended questions avoids a predetermined response. Open-ended questions allow the respondent to answer in their own terms taking whatever direction they want in order to represent what they want to say. It is known that a series of closed questions is likely to lead the interviewee to giving what they expect the interviewer wants to hear, making the data unreliable.
2. Use of singular questions. Asking a single question at a time will avoid confusing the interviewee and will help ensure a clear and complete response. In addition, it will avoid problems interpreting the response during the analysis process.
3. Use of neutral questions. Patton defines neutrality as meaning "... that the person being interviewed can tell me anything without engendering either my favor or disfavor with regard to the content of their response" (p. 231). To do this, Patton suggests developing rapport by conveying empathy and understanding without judgment. Both neutrality and rapport can be handled by asking illustrative questions which show the interviewer that no response will be a surprise.
4. Use of clear questions. To ask clear questions, the interviewer must use mutually understood terminology and labels. This includes using language and terminology that is understandable and part of the frame of reference of the person being

interviewed. Questions using the respondent's language are more likely to be clear to the respondent. Patton further suggests using prefatory and transitory statements to help the interviewee focus on the subject of immediate interest to the interviewer.

5. <u>Maintain control of the interview</u>. Time is precious and can be used most effectively by knowing the interview guide, asking the right questions to get the desired answers, and giving appropriate verbal and non-verbal feedback to the person being interviewed. To accomplish this requires the interviewer to listen carefully to make sure the response received provides the answer to the question asked.

Beyond the direct questioning principles, Patton (1980) makes some suggestions for recording interviews. The following as abstracted from Patton were applied in this study:

- An explanation was given to each interviewee as to why the interviews were being taped.
- Notes were jotted down in key phrases and lists of major points were made to help in formulating questions, pacing the interview and capturing the interviewee language.
- Recordings were conducted by:
  - Checking the working condition of equipment prior to and again at the beginning of an interview.
  - Selecting a quiet area for the interview.
  - Turning the recorder off during irrelevant discussions.
  - Labeling all tapes properly with the name of the interviewee, date, company and position. Code numbers and

letters were assigned to each case before analysis began.

- Expanding notes after the interview by recording impressions and adding information observed during the interview.
- Checking each tape immediately after the session to make certain the recorder functioned properly during the recording so that notes could be made from recall if necessary. There were no recording failures either during recording or subsequent transcription of the tapes.

Data Analysis

The following general procedures to analyze the case data collected were used. This researcher would like to caution the reviewer at this point, that case method analysis procedures are driven by the resulting content from the interviews. Patterns, categories and themes were experimented with until the best fit evolved from the data. Essentially, the following rules or guides were established by this researcher for the analysis:

- The data in the analysis were to be tied to behavioral facts which are more easily observed and verified.
- The facts gleened from the data had to be verifiable through a cross check with other people on the project.
- Researcher derived facts from the data had to be verifiable against facts derived by a second researcher.
- Two dimensional matrices would be used to develop an understanding of the data and to present the data.
- Examples were to be kept at a minimum for presentation of the data to avoid a lengthy and cumbersome report which would be difficult for the reader to follow and understand.

Case records were built for each case to serve as the major source of documentation. Each case was constructed in accordance with the phases of analysis, design, development and production. Within these phases the data were organized by chronological order of events and by team members to better determine when problem variables occurred and which team member(s) were involved.

Each case was examined and problem areas highlighted. Problem areas were further examined to determine whether a cause was evident or whether the problem identified was a symptom. For example, if a programmer indicated major time was lost because of bugs in the authoring or programming language, the interview data were further scrutinized to support, refute, or identify a different cause. The real reason for time loss could have been the programmer's lack of familiarity with the language, equipment incompatibility, or one of many other possibilities. These variables were listed as primary or secondary and categorized into phases in accordance with the established effects.

An attempt was made to develop matrices and differing comparison processes to cross check information and identify variables which might not be evident in any one type of classification or category system. The exact type of matrices and comparisons were determined by the data collected. The most suitable fit for the data appeared to be in accordance with the IVD process phases, team position and research questions. This allowed for some comparison and assessment of the similarities and uniqueness of each case. Data matrices were analyzed to arrive at a preliminary set of findings.

Another researcher, familiar with IVD and schooled in instructional development, was asked to review the raw transcripts and suggest possible matrices for the data. Since this second researcher arrived at the same types of matrices as the author of this research, copies of the author developed matrices were provided to the researcher for analysis. The findings and conclusions of the researcher were compared to those of this study's author. Differences were discussed and resolved either by the collection of more supporting data for the finding or the item was dropped if sufficient evidence could not be found. The result was a final set of findings.

Chapter Summary

The Case Study research methodology used to abstract the variables which may cause Level 3 IVD project time and cost overruns has been described in this chapter. The methodology involved a researcher developed interview guide and audio-taped, in-person interviews with project personnel on each of three cases.

Three cases were selected for the study in accordance with preestablished criteria. All interviews were conducted applying the interview principles and taping procedures outlined in Patton (1980). Personnel holding the key positions of project manager, information programmer, instructional designer and video producer were interviewed for each case.

The data analysis involved several attempts at development of matrices and comparison procedures built from the interview transcripts until a good fit was achieved. The data were best analyzed by phases and team position. Validity in the case data analysis was achieved through the use of another researcher who independently reviewed the interview transcripts, suggested matrices and comparisons and derived findings. Where differences occurred in findings between this author and the validating researcher, additional data were collected to either support or refute the finding in question.

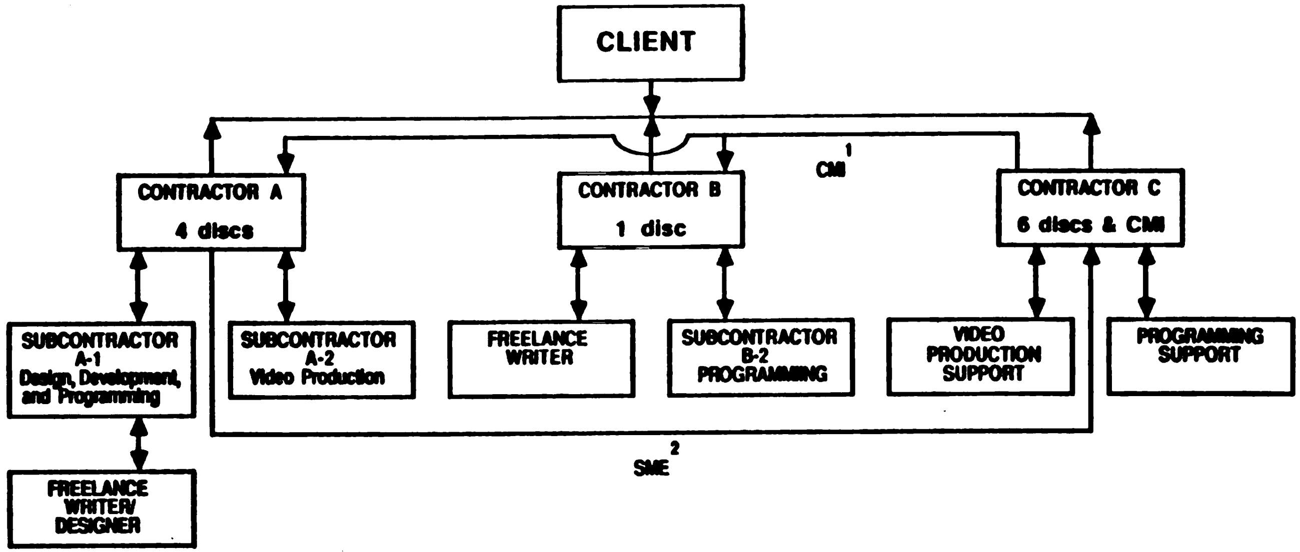
CHAPTER IV

DESCRIPTION AND RESULTS

In this chapter, the results from analyses of the data for three interactive videodisc Level 3 projects for industry and government are presented and discussed. This chapter is divided into three sections: (a) case descriptions, (b) results, and (c) summary of findings. The results section is further subdivided in accordance with the research questions of the study.

Case Descriptions

Three cases were selected for study. Case 1 and Case 2 were individual contracting agencies, each with a client for whom they produced a product. Most of the work required to produce the product was performed by personnel within the contracting agency. Facilities and/or services consisted of hired vendor services for audio recording, video production and editing. However, each agency remained very closely involved, frequently performing the work themselves using the hired facilities and equipment. Case 3 consists of three contracting agencies working on a single project for one client. The individual contractors each had subcontractors for the work. The relationship of the client, contractors and subcontractors within the Case 3 project are as diagrammed in Figure 1.



1. Computer Managed Instruction
2. Subject Matter Expert

FIGURE 1. Case 3 Client and Contractor Relationship

The amount of project work performed by each major contractor within Case 3 varied greatly. Contractor A subcontracted all of the major activities, acting more in a role of administrator and procurer of materials. In contrast, Contractor C performed most of the effort internally, contracting for added personnel and facilities in video production to supplement their in-house capability. Contractor B had some in-house production capabilities, subcontracting mainly for writers and programmers. As in Cases 1 and 2, the individual contractors (A, B, and C) in Case 3 were required to go outside of their organizations for audio recording and tape editing facilities. The equipment and facilities required to perform audio recording, tape editing and video lighting and shooting are highly specialized and often are not a part of a general training contracting agency.

Key Case Elements

The basic elements of each case are presented in Table 1. Because of the nature of IVD, the size of the project cannot be judged by the number of discs produced or by the timeline within which it was produced. The amount of disc instructional content varies by nature of the format. For example, both motion and audio require large amounts of disc space in proportion to the instruction presented.

Case 1 used audio extensively and no motion. Case 3 used both audio and motion extensively, while Case 2 used almost no motion and no audio. The product in Case 2 is composed of still frames and computer generated graphics. Motion is simulated through the programming of the still frames, thus allowing for more instructional content. In addition to the effect of presentation format on the disc, one must note the differences in the amount of disc space used.

TABLE 1. Case Description

Elements	Case 1	Case 2	Case 3
Contractor	A University College of Education Department	Military analysis and training firm, software engineering, technical engineering services	Private industry training development firms with subcontracting to production and programming houses
Client	Equipment manufacturer and training developer companies	Department of Defense (DoD) training agency	Auto manufacturer
Purpose	Convert filmstrips, audiotape and print materials to Level 3	Develop a Level 3 IVD for equipment maintenance. Train SMEs in IVD development and production. Develop an authoring language for limited editing.	Convert Level 2 IVD to Level 3. Produce new programs.
Product	6 double sided discs: still frame, audio, graphics, student work journal, or installation guide	1 double sided disc: 80 maintenance tasks, very small amount of motion sequences, still frame, no audio, graphics, CMI package, author/editing package, student workbook, author/editor documentation	11 single sided discs (5 = level 2 conversions, 6 = new discs): Computer Managed Instruction package, mostly motion, minimal still frame, audio, graphics
Timeline	10 months (1985-1986)	Approximately 42 months (3 1/2 years) (1983-1987)	4 - 9 months varied by contractor (1985-1986)
Estimated Instructional Time	50 Hrs of IVD 50 Hrs of CBI without video	Figures were not available. Estimates are between 30-50 hrs.	Forty-five minutes to 1 1/2 hours per disc
Phases	Minimal design and development, production	Analysis, Design, Development, Production	Design, Development, Production
Staff	Project Mgr. (financial) Inst. Designer/Producer Inst. Designer/Programmer Student Graphic Artists (8) Student Programmers (8)	Project Mgr./Inst. Developer (2) Project Mgr./Programmers (2) Analyst/Editor (1) Programmers (3) Subject Matter Experts (SME) (3 - 4) at a time Note: Staff changed throughout the project. Usually 3 - 4 contractor personnel were on the project at a given time.	Three separate contractors Contractor A Project Mgr. Subcontractor A-1 Project Mgr./Designer 3 Programmers 1 Designer/Writer Subcontractor A-2 1 Producer/Director, support staff Contractor B Project Mgr./Designer/Producer Subcontractor B-1 Writer/Designer Subcontractor B-2 3 Programmers Contractor C Project Mgr Producer/Director plus 5 people Inst. Designers/Writers (3 1/2 - 5) Editors (2) Programmers (5)
Training Equipment Configuration	IBM PC touch screen keyboard	Sony View 2000 light pen bar code reader keyboard (editors only)	Sony View 2000 touch screen light pen
Contractor Purchased Equipment & Software	All provided by client	3 systems, 3 software packages	4 systems, 2 software packages, and graphics software
Final Software	PC Pilot	MS PASCAL, Lumena (Graphics)	Lattice C, Lumena (Graphics)
Initial Cost Bid Range	$100,000 - $130,000	$450,000 - $550,000	Combined total of all 3 contractors $600,000 - $700,000
Percentage of Cost Over Initial Bid	15% - 20%	40% - 45%	35% - 40%

CBI = Computer-Based Instruction

Case 1 did not use all of the disc space, and Case 3 discs each contained the same parts of the Computer Managed Instruction (CMI) program at the beginning of each disc, thus requiring less individual production and programming. Further, each disc in Case 3 was a one sided disc while the other two cases produced double sided discs.

Timelines in each of the cases were compressed or expanded through variations in the number and amount of staff assigned to the effort. Staff members did not spend 100 percent of their time on the project in any of the cases. The number and type of staff varied by project phase and criticality of the deadline. Video producers and directors usually only joined a team during the end of the development and early portion of production phases. Each case used the services of only one programmer at the onset of the project. This usually increased to three or more programmers near the latter half of the production phase of each project. Case 3 had a great variance of time spent between the contractors on the project. Contractor C required a full nine months to produce the new discs, develop the CMI package, and produce the design guidelines for the other contractors. Contractor A essentially developed and produced the four discs in four months. Finally, the timelines in the table reflect the calendar time spent from contract initiation of the project to delivery of the discs. These timelines include large delays due to changes of equipment, software or instructional content in some cases.

Equipment and software purchases were required in Cases 2 and 3. These costs ranged from $10,000 to $14,000 per system with software and required peripherals. The acquisition of equipment had not been planned for in the original budgets and constituted a capital investment for each of the companies.

The percentage of cost estimates over the initial bid included the actual costs itemized in the financial records, plus the tremendous amount of additional labor above the 40 hour week worked by professionals which was not compensated or accounted for in the record system. The overtime labor estimates were mostly self estimates by interviewees except for free lance writers who maintained careful records.

Results

The results of the data analysis are presented for each of 12 research questions addressed by the study. Data judged relevant to each research question has been organized and presented in matrices appropriate to the question asked. A brief discussion follows each question. This organization should facilitate the drawing of conclusions regarding the problem variables that affect the time and cost for producing an IVD.

Research Question 1: What type of knowledge is needed and when does it have to be available to make time or cost estimates for an IVD project?

To study this question, the individual case data were reviewed to determine what the contractor knew and understood the requirements of the project to be when the initial bid was developed. This perception was then contrasted with what the contractor learned after the project was underway. This information was provided by project managers and instructional designers and corroborated by other project staff. As can be seen in Table 2, each contractor either lacked critical information or assumed certain elements which were not clearly

TABLE 2. Information Known Before and Learned After Contract Which Affected Time and Cost

Issues	Case 1	Case 2	Case 3
Information known before contracting	Transfer a tested and validated program of filmstrips, print and audio tapes to IVDs. Little or no contractor design work. Client designated authoring system. Project due six months from time of initial talks. No requirement for motion sequences. Extensive art work to be converted to a video format. Original audio tapes available. Little audio studio time required. Equipment and software client furnished. Prototype equipment. Project labor by students and 2/3 of an instructor's time.	Prototype project. IVD instruction for maintenance tasks. Equipment for which instruction was being planned was new. No available instructional materials to use. Required a task analysis to identify and analyze alignment and maintenance tasks. Some of the manpower for all phases was to be provided by client. Cost bid to be made in three phases: a) analysis, b) design, c) development and production. Client to furnish four systems for courseware development. Client to furnish a full-time programmer for the project duration. Produce an editing program for client use as added project feature. Provide client training for use of the editor and instructional program. Install the program.	Project was to be done by team of contractors. Client designated Sony View system. Client designated Lattice C language. No new motion video allowed. Only existing Level II video to be used. Original Level II scripts with frame numbers available. CMI package to be developed by contractor C and used by the other contractors. Contractors A and B to do Level II conversions and to create new discs. Timeline to be nine months. Client to furnish equipment for development. SMEs were to be client furnished. Contractors knew the content of discs they were converting or creating. Sony to provide hardware and software consulting support. Contractor C to produce design guide for other contractors.
Information learned after contracting	Authoring language would not support design features required by client. Original audio tapes unavailable. Second and third generation poor quality audio tapes required unbudgeted audio studio time to edit audio tape music track. Extra studio editing costs to provide client required demo. Only two systems made available for the production work. Final timeline could not be changed or delayed by more than 1-2 months. Timeline required expensive shipping charges for expediency. Reliability problems with prototype equipment. Client requested design features were distracting and had to be redone. Disc production not according to specifications causing equipment problems. Project required a full-time experienced staff.	Identified 80 tasks which was far greater than anticipated for prototype project. Tasks were more complex and interrelated than expected. Not enough client furnished manpower to do the labor. The contractor had to provide it. Task complexity and client designated design features required change from planned authoring language. Required larger computer storage space for the size of program and graphics requirements. The program had to be designed to use a cache hard disc. Client decided on an equipment change from Sony SMC-70 to Sony View system during project. Third software change made because supplier of the second software withdrew support. Programmer not furnished by client as promised. Client equipment not acquired. Contractor had to purchase and/or lease four systems for development work. Equipment acquisition delays forced change from automated to manual storyboarding.	Cost estimates and timelines based on Level II IVD experience proved inadequate. Still Frame Audio required. Equipment to be contractor purchased. Amount of required code greater than estimated. Original scripts did not match Level II discs. Discs had to be reviewed frame by frame. Sony View system was a new system which was not completely debugged. Sony software delivery delayed, causing late programming starts. Assistance from Sony neither adequate or available as expected. Available disc mastering technology was new. Discs had to be remastered several times. Coordination between all three contractors was unplanned and caused numerous changes and project delays. Design guide did not cover all contingencies. Extensive and rigidly formatted documentation was required by client. Graphics packages had to be identical by all contractors to provide similar look and to be compatible with the CMI. Client design changes occurred throughout production phase.

stipulated in the request for proposals (RFP) or the final contract.

In all three cases, the contractors received one or two page Request for Proposals (RFP) or a single page letter requesting a proposal for a contract. Each contractor, or primary contractor as in Case 3, had met with the client prior to contracting and were provided some general information and guidance upon which the contractual bid was made. As shown in Table 2 under "Information Known Before Contract", each contractor accepted information which when compared to "Information Learned After Contracting" does not always match. It appears some information was inaccuracte (e.g., design features), some verbal agreements were not met by the client and new client requirements surfaced which had an effect on the cost of each project either in time and/or direct costs.

In Case 1, two pieces of information proved unworkable and greatly affected costs. The first was related to the authoring language. About two months into the project, the contractor discovered that: (a) the client-designated authoring language could not support the client-designated design features, and (b) the amount of code required by the authoring language could not be accommodated in the memory space available. This led to the selection of another language which in turn required the reprogramming of templates to be used by the programmers. In addition, the original cost estimates were based on student labor using a fairly simple authoring language. The language change required the programmers to program in a more complex language which slowed their speed and increased labor costs.

The second and perhaps most costly knowledge factor in Case 1 was the requirement for unplanned audio recording studio time because the original audio tapes that were to be provided could not be located. The production tapes made available had background music which is a problem for the stop and go format of the video disc. About $5000 was spent in audio studio time to edit the music to fade up when initialized and fade down after the words. This audio editing in turn created a requirement for check discs valued at a cost of about $3500 - $4000 to confirm the accuracy of interactive program encoding.

Information unknown at the time of contracting in Case 1 concerned the requirement for a demo piece with some special effects. Having learned of this requirement after contracting and hoping to produce good relations, the contractor agreed to produce the demo within the contract before inquiring about cost. The demo created an additional expense of $4000.

Finally, in Case 1 the compressed timeline for the size of the project lacked tolerance for any delays. An error in shipping the disc caused a need for reshipment by Federal Express at a cost of $300 - $500. To an already strained budget, this became a big expense. Equipment failures and client requested changes for given design features throughout the project also added time and labor costs to the project.

Case 2 was different from the other cases. The project extended over several years, covered all phases of the process, was designed to teach complex and detailed maintenance skills, and was costed in three phases. As shown in Table 2, the three bid phases were to be for (a) analysis, (b) design, and (c) development and production. According to the literature, this should have allowed for a more accurate costing. However, it appears that the size of the project, the client changes in labor and equipment support, the change in equipment and software, and client designated design features are the items which most directly affected the time and cost estimate in each phase of the videodisc development.

The Phase I analysis (Case 2) resulted in a total of 80 maintenance tasks. This was far greater than had been expected by the contractor. The sheer volume and complexity of the tasks for the program affected the amount of labor and equipment required to complete each phase. The expected client manpower was usually under-supplied from original estimates or withdrawn, leaving the contractor with the need to supply the additional labor to complete the project. This became particularly costly to the contractor during the development and production phases of the contract. Actual costs could not be provided since much of the labor was completed by the contractor's professional staff working long hours to complete the effort. This overtime labor is non-compensated labor.

Since Case 2 was bid in phases, the equipment recommendations made in Phase I were accepted by the client. Because of delays in government procurement, the contractor purchased one of the designated systems, plus related software, to facilitate some of the automated design and development work. The government did not procure the requisite systems as expected, so added labor occurred later when manual processes were used for design and development work. The contractor-acquired equipment had to be reconfigured with a cache hard disc to accommodate the necessary lines of code.

During the Phase III production effort in Case 2, the government switched from the Sony SMC-70 system to the Sony View 2000 system.

Again, the government could not procure the equipment in a timely fashion and the contractor was forced to purchase two systems at $10,000 to $14,000 per system and lease a third system to complete the project. The equipment change required reprogramming since the Sony SMC operating system was different from the Sony View operating system. The net effect of the equipment change was new equipment costs, considerable time delays and added labor costs.

In addition to the equipment changes, the software used in the Case 2 project was changed twice. The first software change was made to support client requested features which were only provided to the contractor after the programming was well underway. A version of PASCAL, still under development, was selected to accommodate the features requested. This language change caused delays, reprogramming costs and labor hours for debugging of the developmental software to make it perform as required. A second software change was required when the software supplier withdrew the support of the developmental PASCAL software. Again, delays and extensive reprogramming costs were incurred along with the acquisition costs of another software. These costs, although much larger due to the volume of reprogramming, were similar to those experienced in the software change in Case 1.

Case 3 includes three separate contractors and is a project which was preceded by a research phase. Contractors A and C had been involved in some initial work with the client using prototype equipment. The research work with the prototype system was intended to lay the groundwork for the project contained in this study. However, all of the equipment and programming were lost when Sony recalled the prototypes. The case as presented here does not account for the early research since several of the contractors and subcontractors of that phase were either dismissed by the client for poor performance or the companies failed financially and the data could not be collected. The case as presented here includes the team configuration as given in Figure 1 of the Case Descriptions.

The contracts in Case 3 were much less definitive with the client than in either Cases 1 or 2. As shown in Table 2, each contractor was aware that they were a member of a team of companies and aware that the client expected team cooperation and similar discs from each contractor. However, each one was caught with added costs created by having to make client directed changes to their discs to produce products similar to the products of the other contractors. The design guide, which was to be used by all contractors, arrived too late to be of assistance. Further, the document did not anticipate all of the difficulties which would be encountered in a conversion effort. For example, the placement of icons could not be as specified since they often covered critical portions of the visuals of the pre-existing video which had to be used. Menu treatments, user interactions, color choices and graphics package choices were some of the problems not addressed by the design guide. Design problems such as these caused individual contractor delays and reprogramming costs.

Again, as in Case 2, Case 3 contractors were required to purchase the equipment and software at a cost of $10,000 to $13,000 per system. The equipment and operating system were newly released by the manufacturer and caused time delays to resolve problems. The lack of adequate printed specifications and/or explanations caused many of the subcontracted programming companies to spend labor hours in experimentation to resolve these equipment and software problems. Some contractors delayed most of their work efforts until the software arrived. Where designs had been created, changes were required to more readily fit the lack of remaining programming time.

The disc mastering was one of the first performed by Sony and had to be redone several times for each contractor. Problems such as frame numbers being off or sections of the tapes being dropped were common. These problems incurred added travel to disc production facilities and caused production time delays.

The expectation of what was available of the original work, such as the original print scripts and the ease of using existing Level 2 motion, caught the contractors in a bind in Case 3 as it did in Case 1. Additional labor was required to correct original print scripts, produce still frames and still frame audio. The labor for correcting the scripts was required before the conversion could be designed. The still frame and still frame audio was undertaken to allow the development of a more interactive program.

In summary, in all three cases, key information available at the time of contract award was both inadequate and in some cases inaccurate. Basing cost estimate bids on the available information, without some type of written stipulations in the contract about the assumptions and client responsibility, seemed to create rather large unexpected costs to the contractor when the assumptions proved incorrect or could not be executed. The result was rather significant cost overruns.

Research Question 2: To what extent does client IVD knowledge, as reported by the contractor, have an effect on time and cost of an IVD project?

As reported by program managers, instructional designers, and information programmers, the client's knowledge about IVD is judged by the clients actions and requests of, or directives to, the contractor. Table 3 itemizes by case the client actions, requests or directives which either did or could have had an effect on the time and cost of the project.

Overall, the client knowledge about IVD as reported by the contractor was generally low. Some serious difficulties were averted through education of the client at contracting. In Case 1 the client was helped to understand that the existing artwork was inadequate for the video medium and would create problems in programming the text for each screen. Both Cases 1 and 2 successfully negotiated the client to accept a longer timeline. In addition, Case 2 convinced the client to proceed contractually by phases. Typically, specifications by the client on program design, features and requirements were either never provided as in Case 2, or made well into the project as in Case 3 after the client became aware of the possibilities.

It appears that the greatest cost impact was felt by contractors in situations where the client had materials or products which they wanted used in the IVD. In both Cases 1 and 3 the contractors were restricted to using existing audio tapes. In Case 3 the client did come to understand that the audio had to be re-recorded. In Case 1, expensive studio time was taken to adjust the background music. This expense was equal to or greater than that which may have been required for new recordings. In both instances, the client seemed to lack a

TABLE 3. Effect of Client Knowledge on Time and Cost in Producing an IVD

Issues	Case 1	Case 2	Case 3
Client Requests, Directives, Actions	Suggested a timeline of 4 - 6 weeks. Use existing audio tapes (which had background music). Requested contractor to shoot visuals from existing print materials which were not in video format and also had print on the copy. Requested contractor to use computer generated graphics overlayed on the print. Make a straight conversion from the existing medium to IVD without design changes. Requested specific programming effects in design. Required an authoring system which did not support the requested design features.	Suggested total project time of nine months. Assigned SMEs were not experienced teaching with or designing visuals so did not know what could or could not be seen or realize the need for visual transition. SMEs assigned to the project were not all experienced in the maintenance content. SMEs did not accept original content. Inserted design features seen in other IVD demonstrations well into the programming phase.	Required rigid adherence to rules on development of documentation materials which were provded to contractors several months into the project. Would not allow redo or additional new motion filming or re-recording of audio. Selected design features from each primary designer and asked the other contractor's to include the features but they did not provide the accompanying code.
Effects of Request, Directives, Actions	Contracted to deliver product for field test in six months. The final was delivered in nine months Editing time in an audio studio to lay sound track with music fade up and fade out and production of check discs. Cost about $8,000 - $9,000 plus some project labor cost. Contracted to produce 1500 pieces of art work in video format. Programming changes had to be made after the client viewed the disc and (a) saw the effect of some of the requested features, (b) became familiar with new features and (c) the authoring language was changed to P.C. Pilot to achieve client requested features. These actions required 30 - 40% reprogramming of content.	Contracted by phases and did not make a total project time commitment. Project took 3 1/2 years. SMEs were trained and assisted by contractor to write the scripts. It took longer to produce the scripts than initially anticipated. Delay of 1 - 2 months. Reprogramming (10%) occurred to correct errors made in flowcharting and storyboarding uncovered by the addition of SMEs experienced on the equipment. Reprogramming (5 - 10%) required to insert new design features.	Required extensive and time consuming redo of documentation materials to meet the client specifications. Change of concept from the style guide required extensive reprogramming of subroutines. Required to insert still frames and audio to provide interactivity. Eventually re-recorded all of the aduio. Reprogramming and extensive experimentation occurred to achieve design features directed by the client to achieve a similar look across the contractors.

SME - Subject Matter Expert

clear understanding of the effect of using existing linear audio tapes for a non-linear video disc medium. The contractor, on the other hand, seems to have assumed the client understood the technical aspects of the request, and/or did not understand it themselves, at least initially

In all three cases, the client began making design changes during the programming stage, which is the final stage of the project. These suggestions or changes usually followed demonstrations of the product or other IVD project products which helped the client begin to realize the potential of the medium. However, what the client failed to realize in most cases was the amount of reprogramming required to achieve the new effects or features desired. In addition, design changes at this stage have a ripple effect. A change in one part of software or courseware may cause a required change in numerous other parts of the software or courseware. Since no formal agreements were established when the instructional design and programming designs were "locked in," clients were able to make design changes up to the point of delivery for the field tests with resultant eleventh hour time and cost impacts on the projects.

Case 1 experienced added difficulties when the client specified an authoring system and some design features. The client was unaware at the time of contracting that the designated software system could not support the design features. The contractor learned the desired design features, critical to achieving the product, took precedence over using the client specified authoring system. This had not been the impression given at the time of contract award. The late switch to another language lost time and added cost in reprogramming of templates and program code.

Another aspect of client knowledge that affected Case 2 was the qualifications and knowledge of the subject matter experts (SMEs). While the SMEs were not expected by the contractor to be knowledgeable or experienced in IVD, the contractor did expect them to have some experience in designing visual media for instruction and to be experts on the equipment maintenance tasks. Since the SMEs were neither visually oriented nor experts on the equipment, it took longer than planned to create the storyboards. Secondly, reprogramming had to occur to correct content and create more accurate visual transitions between frames of content during the production phase.

In summary, IVD project time and costs appeared to be more directly affected by the client IVD knowledge level in projects where conversions were being made of existing materials, as occurred in Cases 1 and 3. Further, all of the cases experienced reprogramming costs as the client grew more knowledgeable about the potential of the medium and requested instructional and programming design changes. It seems these changes are an inevitable part of the process.

<u>Research Question 3: What effects, if any, do contractor agency size and capability have on time and cost of an IVD project?</u>

The type of contractor agency varies considerably between cases, as shown in Table 4. Case 1 is an academic institution geared toward the education of professionals who will be employed by agencies such as those described in Cases 2 and 3. In an academic institution, a contract is held by a relatively small nucleus of people and heavily staffed by graduate student labor which costs far less than the professionals hired by private industry (Cases 2 and 3). Typically,

TABLE 4. Factors of Contractor Size and Capabilities Related to Time and Cost in Producing an IVD

Issues	Case 1	Case 2	Case 3		
			A	B	C
Type of Contractor	Academic institution training for instructional system developers and producers. Typically contract for research and development to provide experiences and means of support for both faculty and graduate students.	Military training and engineering company with: Training analysis and curriculum design and development Software development Technical Engineering Services	Graphic design and production Technical manual publication Illustration services	Production and Instructional Design	Training development for: Marketing communication Motor vehicle industry Other industry
Number of Employees	6 - 8 professional staff in the department with access to professionals with other expertise throughout the institution.	225 - 275	150 - 200	50 - 75	250 - 300
Company Personnel Organization	Academic departments	Three major divisions: training, software engineers, and technical engineering with cross support between divisions, i.e., training used programmers from the software division. Projects are staffed in accordance with the skills required to provide a team.	Specialized areas listed under "in-house skills" section of this table	Unavailable	Three development groups, subject content supported by video, CBT and artwork departments
In-House Skills and Support	Instructional Designers and Developers Curriculum Designers Media Technologists Graduate student labor in all areas Programmers Video equipment	Instructional Designers and Developers Curriculum Designers Training Analysts Technical Engineers Software Engineers (Programmers) Graphics and Word Processing Support Limited type setting	Technical Writers Artists Illustrators Support Personnel in: Keylining Typesetting Photo Reproduction	Instructional Designers Video and Film Producer/ Director Instructional and Technical Writers	Writers Training Designers Video and CBT support Programmers Production support Art and creative design support Subject Matter Experts (SMEs) in motor vehicle and other areas
External Services Required	Art department for graphic artists Audio studio and recording artist Video production and tape editing Disc mastering	Video production services which included a producer, director, lighting engineer and all of the related video and lighting equipment as well as editing services for the videotape. Disc mastering. Leasing of additional videodisc equipment.	Instructional Design and Development IVD Writers Software Programmers Video production and tape editing Disc Mastering	IVD writer Video production services in terms of equipment, lighting and other support Audio recording studio Tape editing Software programming Disc mastering	Writers Additional support for video shoot and related equipment Audio recording Tape editing services Programming Disc mastering

contracts are undertaken for generation of research and experience for graduate students rather than for profits as in Cases 2 and 3.

Case 2 is distinctive from Cases 1 and 3 in that the client is the government, specifically the Department of Defense (DoD). Government contracting requires more accounting and administrative support than appears to be evident in either Cases 1 and 3. Further, this is the only case which has a highly qualified staff of software programmers and technical engineers for support within the company.

Case 3 is made up of three primary contracting agencies specializing in the development of very different types of training for private industry. Contractor A is noted for technical publications, Contractor B is predominantly production of print and film, while Contractor C has a broader range of training development experience. All three contractors develop training for manufacturing in the auto industry. Companies B and C have provided supervisory, management and other auto related training development services.

As is evident from Table 4, all of the cases in this study required capabilities external to the organization. Usually, video and audio production and editing services were hired or subcontracted. The Case 3 primary contractors also required programming services. Contractor A, unlike any other contractor, had to subcontract all of the services to complete the project. Also in Case 3, all of the primary contractors relied on writers external to the organizations.

Disc mastering and all the facility requirements for editing of the tapes were external requirements across all cases. This is normal since the state of the technology is so new that only a few companies presently have the capabilities for mastering discs. Because of the technology, disc mastering costs will continue to be external requirements by all contractors for IVD.

The number of internal staff identified in Table 4 in each case did not appear to be significant since both large and small staffs required external services. Case 1 required artists and used student programmers. Case 2 did not have a producer/director or video expert available to the team during a major portion of the project. In Case 3, Contractor A required all of the services to be subcontracted to produce the product while Contractors B and C required programmers experienced in Lattice C.

From the available data, it appeared that company size and capability did not have an effect on time and cost since all of the required professional services could be secured externally. All of the contractor agencies in this study performed general training services, hiring specialized professional services where and when required, for a set fee. Hiring specialized professionals may be more cost efficient to the total operation, particularly where a large capital investment would be required for equipment and facilities such as required in video production and audio recording.

Research Question 4: What function does each team member perform in the process of carrying out an IVD project?

To answer this research question, personnel assigned to the projects of each case studied were interviewed to determine what roles they had in the IVD process. The results of this analysis are shown in Table 5.

The project manager was either the financial manager (Case 1) or

TABLE 5. Functions of Team Members During IVD Process

Team Member	Phase of Project: Analysis	Design	Development	Production
Project Mgr.	Financial Management (1)* Analysis (2&3)	Financial Management (1) Design (2 & 3)	Financial Management (1) Development (2 & 3)	Financial Management (1) Production (2 & 3)
Instructional Designer	Quality Control Requirements Analysis (2)	Quality Control Flowchart Courseware Features Objectives/Test Items Control Sequence	Quality Control Storyboards Scripting Written Materials Design	Quality Control Video Production (2) Programming (2) Redesign w/programmer (2 & 3)
Writer		Content Analysis (3) Courseware Design (3)	Storyboards Written Materials Scripting Design	Monitor Programming (3) Redesign w/programmer (3) Programmed using routines (3)
Producer		Flowcharts (3) Courseware treatment (3) Content Analysis (3) Objectives/Test Items (3)	Storyboards (3) Scripts (3) Design (3)	Video Production Editing Mastertape
Editor			Storyboards (3) Written Materials (3) Script (3)	
Information Programmer	Pre-design Flowchart of Content (2) Teach Flowcharting (2) Develop Automated Routines (2)	Flowchart (2) Develop Templates and Routines (1) Instructional Design (2)	Storyboard (2) Automate Storyboards (2)	Develop Video Production Shot Sheet Program Courseware Develop Templates Routines (2)

*NOTE: Numbers refer to the case in which the member fulfilled the role. No number behind the item means it occurred in all cases.

was a multi-skilled person (Cases 2 and 3), participating in all phases of the work. Instructional designers were the most active people in all three cases. With few exceptions, they were most heavily involved in the project courseware design, which included sequencing of content, flowcharting, writing and developing objective and test items, scripting, storyboarding, and outlining student flow and screen conventions. They also performed the specific role of quality control for all phases in all three Cases. In Case 2 the instructional designer was also responsible for the conduct of a requirements and task analysis to determine content and design, as well as participating in the video production and programming activities. In both Cases 2 and 3, instructional designers assisted the programmers in redesign of the courseware to make it fit within software or hardware parameters.

The role of information programmer was not always confined to the production phase although this is the phase in which all software programming was done. In Case 2, the third and fourth project managers were experienced programmers. Further, they were involved with all phases of the project. The third project manager also assisted in training subject matter experts in flowcharting of the task to be trained during the analysis phase. In addition this manager was responsible for system selection, development of automated data processes and record keeping for storyboarding. During the analysis and design phase, he began a study of the programming language and began developing routines and the computer program design. In Case 1, the lead programmer was involved early enough in the project to develop software templates and routines in the design phase to be used by less experienced programmers as production tools.

The role of video producer was usually defined much as it is for linear video. Often the producer was not involved in the process until the preproduction activities began. However, in Case 3, one of the primary contractors and manager of the conversion of one disc was also an experienced producer. Because the staff was small, this same manager also acted as the instructional designer, wrote scripts, and developed storyboards, objectives and test items.

Writers in Case 3 not only did scripting, but many were involved in content analysis and design. Further, some were required to work closely with programmers during the production phase to clarify scripts, change the graphic complexity and in general facilitate the programming process. One writer coded touch points and performed other editorial type activities for the programmer using routines written for the purpose.

Only Case 3, Contractor A used an editor in a traditional manner to fulfill all the documentation requirements as specified by the client. No other contractors used a designated editor.

In summary, team members for IVD projects fulfilled multi-dimensional roles in all three cases. The most versatile were the instructional designers and manager/programmers. It appeared that it was a requirement by all except the producer to participate in all phases throughout the project to ensure a successful product within the constraints of the timeline.

<u>Research Question 5: What effects, if any, do project team organization, and personnel IVD training and experience have on time and cost of an IVD project?</u>

To answer this question, the contractor team in each case was examined by review of the size, content and organization of each. Then the training and experience of the individuals in key roles were examined on each team. Both intrateam and interteam communications were examined to determine patterns and unique characteristics. Finally, problems from the work effort were examined to determine those which emanated from one of the above factors. Table 6 summarizes the results of this effort.

Table 6 shows each contractor found it necessary to use instructional designers and programmers. Case 2 used an instructional designer as an editor to sequence training or establish interactivity requirements of the program. Case 2 also made extensive use of Subject Matter Experts. Case 1 had a need for several artists to redo original art work and Case 3 used artists and writers for the major portion of the production effort. A large portion of the writing for Case 2 was done by SMEs.

Training and experience varied greatly across projects. Case 1 had the most degreed and experienced project management group. Case 2 experienced the widest range of degrees among project management personnel. Case 2 also changed project managers most often. Case 3 had the largest group of team members and most overall experience in media production related to, but different from, Level 3 IVD. Case 2 had the least experienced staff for any role on the team.

Communication patterns varied widely in flow and methodology. Case 1 used one-on-one, group meetings, a file folder system and a

TABLE 6. Effects of Project Team Organization and Personnel IVD Training Related to Time and Cost of an IVD Project

Issues	Case 1	Case 2	Case 3
Staff	Instructional Designer/Producer Instructional Designer/Programmer Instructional Designer/Project Mgr. Students/Graphic Artists Students/Programmers	Instructional Designers/Program Mgr. (2) Programmer/Project Mgr. (2) Training Analyst/Editor Three Programmers Air Force Technicians/Subject Matter Experts (SME)	Contract A plus two subcontractors (A1, A2) Project manager from Contractor A • Subcontractor A-1 Project Mgr./designer 3 programmers 1 designer/writer • Subcontractor A-2 Producer/director and supporting staff Contractor B plus 2 subcontractors (B-1, B-2) Project manager/designer/producer from contractor B • Subcontractor B-1 Writer/designer • Subcontractor B-2 3 programmers Contractor C Project manager Producer/director plus 5 staff 3-5 Instructional designers/writers 5 Programmers 2 Editors
Personnel Organization	Project Manager - Finance Budget Co-Director - Producer - Programmer Lead programmer - Management of eight student programmers - developed routines and templates	Project Manager - Managed the project activity Editor managed data base and developed instruction and used programmed routines for interactivity Programmer - Programmed the courseware and developed routines and templates SME - validated content	Hardware/Software manufacturer acted as a consultant to all members of group Committee approach to project - chaired by the client Each contractor and subcontractor had a manager, and each had its own organization Each subcontractor had one or more consultants
Training of Team members in IVD	Project Manager - PhD in ISD. Co-Director -PhDs' in ISD. Both had extensive experience in CBI. Producer had extensive experience and some workshops in IVD. Students had training on use of the authoring systems in college Student experience in programming was mostly courses in college. Minimal training provided during the project.	Project Manager - MA in ISD (Analysis Phase) Project Manager - PhD in ISD and experience in video (Development Phase) Project Manager - BS in Computer Science, had some IVD and extensive programming experience. Last Project Manager was a system analyst with experience in training system design and programming. Editor had an education masters degree and experience in classroom instruction. Two programmers had masters degrees in computer science and experience programming and experience in scientific code One programmer had a bachelors degree in computer science with some data base programming but no IVD experience. Client SMEs had 12 week instructional developers course, and two had a one week school in video production	Contractor A Project manager of the overall effort had a degree in Vocational Education. A-1 Project Mgr. had a degree in Instr. Design A-1 Programmer had a degree in Finance and minor in computer science A-1 Designer/Writer had degree in Instr. Design A-2 Producer/Director and Staff had some IVD but no Level 3 Contractor B Project Mgr./Designer/Producer - BA in Business Mgmt. and experience in IVD B-1 and B-2 personnel had degrees in computer science and video production Contractor C Project Mgr. - degree in Education Staff consisted of various degrees, with no pattern to educational background. Some IVD experience.

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TABLE 6. (Cont'd)

Issues	Case 1	Case 2	Case 3
Communications Patterns	There was some interaction and problem solving between student programmers There was a system of file folders to leave messages A bulletin board was used to post changes in methodologies Student schedules precluded having many group meetings	Daily contact between contractor personnel and SMEs since all worked in same facility. Initial SME communications were good while work done on site Final SME comm. infrequent because work moved to contractual facility Upper management did all negotiations and decision making even though contractor and client upper management did not work on the team contractual effort.	Committee approach to distribute information to contractors Intercontractor communications was strained because they were competitors, but necessary to get consistent products Each contractor was small, but they had difficulty keeping consistent communications with their consultants
Effect of Factors	Several programmers worked without latest data or information and had to redo their products Inconsistent work by programmers required a lot of cleanup by each lead programmer (daily) Wrong frame numbers were used to start and end audio sequences - had to all be redone at the end (several days) Took longer to program because student programmers lacked experience Had to develop software templates and routines to facilitate the use of student programmers Verbal agreements by client and contractor upper management were not always passed on to team in time to prevent unnecessary work. There was no formal resolution of problems.	Negotiations were done by upper management with some input from IVD team. Recommendations of team often overridden by cost and schedule issues. Produced inefficient code which had to be reprogrammed Client inexperience caused redo of work because of inconsistencies in storyboards and writing produced by client personnel Mix of client-contractor team and different reporting procedures and organizations gave mixed signals to all concerned. Because of the lack of Level 3 IVD experience by the team members, they did not properly adhere to a careful media design process, causing many extra hours for programming and redesign of courseware. Limited memory required very efficient coding. Inexperienced programmer did not use libraries or files but repeated code and ran out of space. After his departure, very experienced programmers joined the team and spent 15-20 days modifying and rewriting the program code to allow it to fit in the given computer memory space.	Committee approach made decision making very costly because of long frequent sessions (every two weeks) and decisions were frequently changed causing much reprogramming. Contractors ended up inventing their own routines to get the desired results because competitors would not share secrets. Lack of constant communications with consultants resulted in many hours of wasted or overtime effort to redo. Lack of Level 3 IVD experience caused extra time/cost for reprogramming and specific problem resolution such as SFA, or making changes to meet the requests.

SFA - Still Frame Audio

bulletin board. Case 2 was mostly word of mouth but the project was heavily influenced by verbal agreements made at the upper management level which were not always passed along or were not evaluated by technical people. These agreements appear to have had a serious cost effect by influencing time and changing requirements. The majority of Case 2's communication between client SMEs and contractor team members was over a long distance, usually by phone, and was relatively infrequent.

Case 3 communications were complex because they involved required discourse between contractors, contractors and consultants, and contractors and clients. All communicated directly with the hardware and software manufacturers. All of the communications were accomplished through scheduled meetings, telephone and one-on-one discussions. There were different levels of communication between groups such as upper management, analyst/designer and programmers. Frequently the communications between groups did not include information which was pertinent to the tasks or efforts of another group. Because of the organizational nature of this project, intercontractor communications and discussions were critical to exchange required information for product development. However, because they also had to continue to be competitors, the information was often cryptic and limited. This often caused lost time and labor to either correct or add what had not been shared during earlier communications.

The lack of experienced programmers was a major time and cost factor in Cases 1 and 2, which caused an undetermined amount of effort in Case 1 and at least 5 months of reprogramming in Case 2. Time was lost in Case 1 because of misunderstandings, changes of methodology not communicated to the cadre of programmers, and programmer inexperience with the language used. Templates and routines developed by experienced programmers were used by less experienced programmers in all three cases to assist editors and lessen experienced programmers time requirements.

Client supplied team members for Case 2 were not experienced in IVD, and could not be managed by the contractor. Several man days were lost because they did not spend the agreed upon hours on the project. Further, differences in the client's internal reporting procedures and organizational structure caused problems for the SMEs unrelated to the IVD project. These problems did delay the design and development efforts. The lack of IVD experience by the initial client SMEs for the analysis and design caused repeated redesign and reprogramming throughout the project.

The Case 2 effort was further complicated by the absence of the project manager/experienced programmer for long periods of time. He worked in another office of the company which was located in another city and typically visited the work site either at the client's location or at the contractor's project location in two week intervals. During the remainder of the time, communications were conducted and directions were given to all team members by phone. This appears to have allowed the efforts of the client SMEs to slow and appears to have been part of the cause for the inefficient coding by the programmer to go unobserved until well into the programming effort.

Verbal agreements between client and contractor management in

Case 2 caused additional unexpected work by changing the design requirements after major portions of the work had been completed.

In Case 3 the committee approach to problem solving led to frequent changes of direction and reversals of previous decisions. The fact that team members were also competitors in Case 3 led to minimal communications about technical accomplishments and the need for each contractor to develop its own routines for the same problem.

In summary, team member experience was usually minimal at all levels of management and throughout the team. Inexperienced managers appears to have led to poor planning and lack of insight about potential long range problems. This in turn led to long hours of work to redo or modify the products. The lack of training or experience on the part of the designers or programmers led to poorly designed IVD sequences or inefficient use of code, both of which led to rework and extra cost and time. Communication breakdowns caused problems and extra cost in time and labor in all three cases.

Research Question 6: What activities in a phase have a time and cost effect on subsequent phases of an IVD project?

To examine the issue of what activities in a phase affect costs in subsequent phases, the case data were reviewed to identify cost and time overruns. These overruns were then traced back to the activity and phase which appeared to be the probable cause for the problems identified. The results of this analysis are shown in Table 7.

The data seemed to suggest that the lack of clearly defined client expectations and specifications at the time of contracting was a significant time and cost factor. All three cases experienced changes or added requirements directly traceable to some contracting

TABLE 7. Activities in a Phase Which Affect Time and Cost

CASE	COST & TIME EFFECT	PHASE IN WHICH EFFECT OCCURRED	PROBABLE CAUSE	PHASE OF PROBABLE CAUSE
Case 1	Production & programming for a demo tape	Development/ Production	Client added a requirement for a demo disc during development/production	Contracting
	Programming took 50% longer than planned	Production	Client specified design features which required a change of software from a simple authoring system to PC pilot	Contracting/ Design
	Audio studio fees & audio editing time to accommodate use of existing production tapes	Production	Original sound tracks unavailable. Required by client to use existing production tapes which had a mixed track	Design/Contract-ing
	Audio studio time to redo sound effects	Production	Poor quality sound effect on client production tapes	Design
Case 2	Programming took longer than planned	Production	A written instructional design & computer program design had not been locked-in with the client	Design
	Reprogramming to accommodate client content corrections	Production	Storyboards were not validated by a SME	Development
			Storyboards & interactivity planning sheets were not updated after the master tape was done	Development/ Production
			Storyboards & related documentation was to be automated	Design
			The change in software & equipment, resulted in a loss of access to some records and the potential to automate the storyboards. Manual processes resulted in a loss of ISD records	Development
	Reprogramming to meet client technical documentation changes	Production	Specifications to be used for the courseware were not stipulated when project was costed and signed	Contracting
			Specific documents were never identified or presented during analysis	Analysis
	Instructional & programming design changes	Development/ Production	Demonstration discs prompted clients to request design changes to the original design in later phases. Suggests client either didn't understand the design or was unaware of the potential	Design
	Graphics requirement exceeded computer storage capacity & had to be reprogrammed as data & stored in data files	Production	Courseware design used all SF to maximize interactivity of program by retaining all the content on one double sided disc. A lot of graphics were required to enhance the visuals.	Analysis/ Design

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TABLE 7. (cont'd)

CASE	COST & TIME EFFECT	PHASE IN WHICH EFFECT OCCURRED	PROBABLE CAUSE	PHASE OF PROBABLE CAUSE
	Redesign of instructional sequences	Production	Design too complex for the software or to be achieved in a reasonable amount of programming time	Design
Case 3	Client/contractor meetings with representation of a variety of team members where few decisions were made	All phases	Client requirement to have weekly coordination meetings	Contracting
	Remaster discs & reprogram due to problems with SFA	Production	Conversion of Level II. Motion was interrupted with SF to provide interactivity	Analysis/ Design
			New audio was needed. Technicians were not precise during production	Production
	Rewrite of scripts and documentation	Design/ Development	Client guides were unavailable & the client changed the requirements during reviews	Contracting/ Design
			Writers did not meet with the client & often did not understand the requirement	
	Redesign of course content during programming because existing designs couldn't be accomplished within a reasonable amount of time	Production	Intructional designs too complex for the software or could not be accomplished in a reasonable amount of time	Design/ Development
			Timeline too short to produce the product by delivery date	
	Reprogram to improve choppy sequences	Production	Too much interactivity with SF at end of linear sequences	Design
	Test redesign & reprogramming to meet CMI specifications	Production	CMI & CMI specifications were made available during production	Design
	Writers/designers required to work with programmers during programming	Production	Storyboards & scripts did not provide detailed programming directions	Design/ Development

SF = Still frame
CMI = Computer Managed Interaction

decision or information. Case 1 had to produce a demo disc, Case 2 did not have clear design specifications, and Case 3 lacked the design guides. The effects rippled through the design phase, the scripting during development, and continued on through the final programming during production. It would seem that some of the changes were a result of not obtaining client sign-off and/or the guidelines at the early stages of the project, as in the situation of the design document and CMI software.

The overall design aspects also were changed throughout the projects (Cases 2 and 3) either to circumvent software deficiencies, lack of computer storage, or a lack of available time to complete the effort and make the pre-established delivery date. Most often the designs were too complex to be achieved with the software being used or would have required far more programming time than was available to complete the job. Both Cases 1 and 2 made a software change to overcome some of the difficulties. However, this did not alleviate all of the problems in Case 2. Both Cases 2 and 3 continued to make design changes during the final project phase. In Case 3, the design also had to be altered to alleviate the overly choppy affect created by excessive still frame (SF) insertions in linear video to provide for interactivity.

Storyboards and scripts produced during design/development, proved to be inadequate, incorrect or incomplete and affected the activities of the programmers during production in both Cases 2 and 3. Each of the entries in Table 7 which were traced back to the development phase as the phase of probable cause related to a problem or situation produced by the storyboards or scripts.

Still frame audio (SFA) decisions made during the design phase translated into added costs during development and production. Matching of SFA tracks proved to be a particularly difficult problem in Case 3, while the use of poor quality production tapes with a mixed track affected costs in Case 1.

Case 2 had unique problems with cost and time because they did not maintain a current instructional design document, requirements continued to change, and graphics storage became a problem. The instructional design documents became obsolete when changes in hardware and software were made. These changes eliminated an electronic storyboard capability designed at the start of the project to facilitate the tracking of changes. Without this capability, the project team did not continue to keep the documentation current. It appeared that subsequent changes in project personnel for both the contractor and client and the lack of current documentation left the contractor without adequate means to stop client change requests. These requests were a result of the clients gain of IVD knowledge. The knowledge gain generated corresponding changes in expectation for their own IVD program.

Too many meetings and/or lack of meetings surfaced frequently as a cost factor in all three cases, as was shown earlier when the communications patterns were discussed in Research Question 5, Table 6. In Case 3, the client required weekly meetings with all three prime contractors as well as appropriate representatives from each sub-contractor's staff. Meetings typically extended over a half day. All interviewees in this study viewed the meetings as excessive and costly for the outcomes achieved. It was not uncommon to have design decisions made during a meeting of programmers and programming decisions made during a meeting of instructional designers throughout all phases of the project, ultimately affecting the amount of labor expended to correct poor decisions.

It appeared from all the analysis that the activities involved in designing the program and developing the storyboards had the greatest effect on activities in subsequent phases, particularly the programming aspect of the production phase which in turn affected time and costs.

Research Question 7: Is one phase more likely than any other to affect time and cost of an IVD project?

To determine which phase if any is more likely to affect time and cost in an IVD project, case data were examined in a similar manner as for the Research Question 6.

In looking at Table 7, presented under Research Question 6, one can clearly see that time and cost effects are evident predominantly during the production aspect of the project. However, when examining effects for probable cause, it is apparent that the activities of the design phase are most likely to generate the increase in production costs. Out of twenty two entries on Table 7, fourteen of the entries are identified under the "Phase of Probable Cause" column as being either all or partially related to activities in the Design Phase. Both contracting and development phases have been identified five times each as being the phase where the problem was originated.

To determine the greatest effect on time and dollars, one has to examine the time and dollars expended in relation to the cause phase. In Table 7, Case 1, the greatest cost ($8,000-$9,000) was incurred for audio studio time and check discs. This was a direct result of the contracting arrangements. Case 2 incurred extensive programming and reprogramming costs. These costs were somewhat evenly induced by incomplete contracting specifications, design specifications left somewhat open and inadequate documentation processes throughout the project. These problems created an increase of about 20-25% in reprogramming time and labor.

In addition to the information presented in Table 7, several time and cost overruns were caused by factors which were not a result of previous activity. These costs appear to be directly related to equipment and software problems. The problems were usually evident during production and were due to unexpected and unplanned activities. Case 2 experienced a software change created by the dropping of manufacturer support for MT+ Pascal. This change required extensive reprogramming of the work completed up to the time of the change. Cases 2 and 3 each incurred heavy costs in equipment acquisition which were to have been client costs. Further, all of the equipment used was new on the market. Each project spent large amounts of time debugging the systems and resolving manufacturer problems.

From the information in Table 7, it appears that the Design Phase has the greatest effect on time and cost in terms of labor. The complexity of the design seems to be the central issue. The Production Phase evidences the cost overruns created by Design. However, equipment and software problems as outlined above and discussed in greater depth in the remaining research questions appear to have an equal effect on time and cost overruns.

Cases 2 and 3 incurred repair costs for light pens, and XEBEC disc failures. Similar types of difficulties were incurred in Case 1. While no exact dollar figures were available, Case 2 estimated a loss of about one to two man months for resolution of equipment problems. Case 3 incurred an equal or greater amount.

Research Question 8: What effects, if any, does IVD hardware have on time and cost of an interactive videodisc project?

The data from each of the three cases were reviewed to determine what kind of equipment related problems occurred during the conduct of the project. This information was then examined on an event by event basis to identify whether or not there was a time or cost related effect on the project as a result of each problem.

As shown in Table 8, there were problems common to all three cases. Equipment just out of prototype stage was a source of difficulty in all cases. The new equipment appeared to be the first of its kind for each manufacturer. Contractors in many cases could not explain what the problems were for purposes of this study since the equipment was frequently shipped to the manufacturer for repair. For each problem, the manufacturer took from several days to several weeks to resolve the issue.

Manufacturer related problems ranged from a limited number of available machines for acquisition by contractors (Case 2) to situations where light pen and cursor misalignment produced student evaluations which were so improbable they were disregarded. This latter problem, caused by size of touch points (Case 3), forced programmers to space answers to test questions on the screen so accidental choices would not be made. This problem was never resolved

TABLE 8. Effect Of Hardware on IVD Development Time and Cost

Issues	Case 1	Case 2	Case 3
System Used	IBM System IBM Laser disc Touch screen Color monitor	(Initial) Sony SMC-70/Sony Laser disc player/Sony color monitor (Final) Sony View (Computer/Laser disc machine/monitor) Graphics board Light pen Touch Screen Optical character reader XEBEC hard disc Expanded to 512 K memory (10 megabyte memory peripheral hard disc)	(Initial) Sony prototype system (Final) Sony View system Touch screen Light pen
Problems With Selected System	Machines were in final prototype stage and had design problems Laser disc and computer storage space were limited. The graphics/sound storage requirements caused them to use several discs as well as change software. Laser discs warped during storage. Laser discs separated or were too thick and would not run in the machines. Limited equipment due to system failures and need to ship for repairs.	Client mandated change from SMC-70 to View System caused reprogramming of software. New compiler on View System caused reprogramming. XEBEC hard disc was not reliable, lost data and had to be reformatted 6-7 times. System was too small for size of program and during production clusters of data were lost. Differences in operating languages between video systems caused difficulty in programming. Manufacturer was slow to solve unexpected problems with new machines. Manufacturer was still debugging new View system after delivery causing slow response to resolution of known problems: Light pen failures, Optical character readers not acquired.	Changed equipment from prototype to Sony View. Sony hardware did not support the compiler. System could not support light pen interaction on motion video (cause was delay between cue and interaction). Light pens failed or were erratic. Cursors and light pen did not match up at same point on the screen. Limited compiler data storage space. Writing/compiling done on an AT did not run on Sony View. Check discs would not play SFA.

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TABLE 8. (Cont'd)

Issues	Case 1	Case 2	Case 3
Effect of the Problems	New machines were not fully operational. Many problems were new to the manufacturer. When they were called, usually one day per week was required to resolve the machine problem. This went on for three months for a loss of about 12 days or 2 1/2 weeks of time. The graphic requirements, coupled with the audio, took up a lot of disc space. This caused added expense to produce more discs. Also, because graphics had to be stored for word balloons and alphanumerics, computer data storage was at a premium. The result was to help cause a shift from an authoring language to a version of Pilot which used less space in the computer memory. This caused about three months extra programmer time in the project. Some laser discs warped during storage and some were produced out of specifications. Both problems caused discs not to work in the laser disc player. Delays were experienced while discs were redone and/or players modified to use the discs. Delays were often caused because equipment would fail, losing code, and had to be shipped back to the manufacturer. While this equipment was gone, no work could be done. This happened infrequently but caused five days of downtime each time and required a lot of manager time on the phone with the manufacturer.	The change of hardware from the SMC-70 to the View System had a corresponding change in operating systems, compilers and interface components for peripheral equipment. This caused a need to reprogram all software done to that point in time. The team took five months to reprogram the software plus about 200 hours of overtime. Functions had to be redone for OCR port and light pen taking up a portion of the time. The View System memory was expanded to 512K, but this was too small for the requirements of the project. Data were lost and had to be redone. A XEBEC disc was installed to accommodate the program, raising the cost of equipment and time to do the project. The new machines were not perfected before delivery. Unexpected problems took several days to resolve with the manufacturers because they had to debug them first. Manufacturer known problems were not resolved prior to delivery and the solutions took several days or weeks to resolve causing delays for reprogramming and/or repair. The manufacturer was always unexpectedly slow to resolve problems and repeated calls were necessary with each problem. Light pens had to be replaced and/or repaired. Student workbook codes could not be tested with the disc or computer code during final development.	Change to the Sony View system caused all participants to have to buy new Sony View Systems at 10% of budget. Sony hardware had several unexpected problems: - Sony hardware would not support the compiler for the programming language (Lattice C). This was because the hardware was using an 81-86 computer chip, and the compiler was built for an 82-86 chip. About a week of time was lost resolving this problem. - Hardware would not support interactivity between the video and the light pen during motion sequences. This cost time and money to develop SF sequence for interactive work. - In some cases the light pens had to be insulated to be used, causing indeterminant time to change them or solve the problem. - The hardware did not match the cursor and the video screen touch point. This was a problem which took hundreds of manhours to resolve. - The computer did not have all the required storage space for the programs. All full machines had to be modified by the client. - To save time, some writing and compiling was done on an IBM PC/AT. This programming would not run on the Sony. This problem took several days to solve. Check discs would not play SFA requiring discs to be remade. Incurred travel cost and 2-3 days at the studio to ensure proper editing and recording.

SFA = Still frame audio

by the manufacturer.

Other problems which caused direct interface with manufacturers included debugging machines when they behaved in a way the manufacturer's engineers "did not know they would", as in the case of the system not supporting the light pen interaction for motion (Case 3). Hardware components were not as reliable as initially expected by the client, e.g., new XEBEC hard discs caused many days of work to reformat and recover lost data (Case 2). The XEBEC discs had to be returned to the manufacturer for repair, causing an equipment shortage for production. As cited in Table 8, each verbal interaction with the manufacturer caused at least one day of down time on the affected computer. A similar loss of time was expressed by programmers in Cases 1 and 3.

Memory space in the computers was a universal problem. Each contractor solved the problem differently. In Case 1, a shift was made from an authoring system to a lower order language which required less operational space. In Case 2, the memory was expanded through the use of a cache disc in one situation and in another situation a 10 megabyte hard disk was added. Inefficient programming was also corrected and made more efficient to reduce the code to fit the available machine memory. In Case 3, both client's and the contractor's machines had to have the memory increased to accommodate the program. These were all direct costs in machine purchase or labor.

There were also many unique problems for each case. Laser discs caused additional costs in Case 1. Incorrect storage caused some check discs to warp, other discs separated and still others were too thick and caused a shaving build-up in the disc player which jammed the players. The discs had to be remade. The contractor learned the blank discs had not been manufactured to specifications, which is a separate issue from the disc content mastering process in which a master disc is made from which all subsequent discs are cut. Finally, in Case 1, the aspect ratio (3 x 4) of the video caused almost all original artwork supplied by the client to be redone. This did not affect labor hours, but project time was extended.

In Case 2, as shown in Table 8, a change from one kind of system to another had a significant effect, causing five months of reprogramming time. The incompatibility of the operating systems required a reentry of data.

Still Frame Audio (SFA) was a significant problem in Case 3 which came to be noticed on playback of the check discs. An investigation showed that not enough precision had been used in recording the master tapes and the audio track. Contractor personnel had to be sent to the recording studios to carefully monitor the entire production of the check disc. Two to three days of labor per disc were incurred, as well as related travel costs.

Light pens caused delays and problems in Cases 2 and 3 when they did not operate or were erratic. Pens were taped with electrical tape to cut static electricity or were returned to Sony for repair. Another light pen problem arose in Case 3 when the interactivity could not be supported on motion video sequences. The problem was caused by a delay between the appearance of the cue and the machine's ability to process the students response from the light pen. Resolution of this problem entailed more production and programming. Still frames were required between motion sequences to achieve interactivity. A final significant problem arose in Case 3 when the programming or compiling done on the IBM PC/AT would not run on the Sony View. These problems took several hundred hours to resolve.

Two basic generalizations can be drawn from the data related to hardware. First, all three cases used newly issued machines or models which appears to be the basis for many unexpected problems and costly delays or labor expenditures. Secondly, each case experienced a requirement by the client to accommodate a machine with a memory smaller than needed for the program eventually produced. The data showed other troublesome problems, but these appeared to be a result of normal machine breakdown or incompatibility that is not unusual in the computer production environment.

Question 9: What effect, if any, does IVD software have on time and cost of an IVD project?

To determine the answer to this question, several people from each case were interviewed to determine the effect of software problems on their project. The problems were documented on an event by event basis and described in detail. The impact of each problem was then examined to determine if more time or labor hours costs were incurred for each problem than expected, and the totals were compared to budgeted time or labor hours for each project.

It was not unusual to document several weeks or months of additional time because of software problems. Problems ranged from a failure of the software to support project requirements (Cases 1 and 2) to nuisance issues such as repeated recoding of transitions from CMI to courseware (Case 3). Each project had major software problems. As can be seen from Table 9, frequent software changes and

TABLE 9. Effect of Software on IVD Development Time and Cost

CASE	SOFTWARE TYPE	PROBLEMS	EFFECT OF THE PROBLEMS
Case 1	(Initial) Client supplied authoring language (Final) Pilot Language	Change from authoring system to Pilot language because the authoring system took up too much memory space.	Balloons were used to contain the alphanumerics on the screen. Movement of balloons from one place to another caused a 30% increase in programming time.
		Placement of alphanumerics on the screen was time consuming and was a subjective exercise. Client wanted changes throughout the project.	
Case 2	(Initial) Pilot Plus (for demo) (Next) Pascal MT (Final) Pascal MS, Lumena (Graphics)	Change from Pilot Plus to Pascal MT+ because Pilot Plus could not perform all routines.	Change from Pilot Plus to Pascal MT+ was of some impact due to preliminary programming alredy done. Several days of programming required.
		Change of machines from Sony SMC-70 to Sony View caused changes from CPM to MS-DOS operating system. This required a switch to another version of Pascal MT+.	Change from CPM to MS-DOS caused reprogramming of all software. This took 5-6 months of time to recode.
		Change from Pascal MT+ to MS Pascal because MT+ was not going to be supported by Sony.	Change from Pascal MT+ to MS caused 3 1/2 days of reprogramming time to write a conversion code.
		Several special functions required by the project had to be written in assembler language.	Assembler language used to write functions took from two hours to three days per function. About 175 functions were required for this project.
		Programming code took up too much space. Had to redo it to fit on hard disc. Redo consisted of reduction of space in code lines & elimination of unnecessary code.	70% of the initial programming had to be redone to reduce it to fit on the hard disc. Reprogramming took several weeks of work.
		Graphics files needed a lot of space. Lumena was used to manage graphics from the file.	Graphics files were stored like code files to be called as required by Lumena along with graphics.
		Editor program required by the client needed to be made more use friendly than planned.	Increased sophistication requirement of Editor language took 4-5 months code.
Case 3	Lattice 'C' Lumena	Graphics required were so extensive that they were produced and overlayed on the master tape.	Putting graphics on the tape instead of keeping them in memory required resorting to animation, finding an agency to do it, and the time to ensure their proper placement on the master tape.
		Icons were redone many times due to client's wishes.	The redoing of Icons time and again was a continual cost impact. It took from several minutes to several hours after each meeting with the client concerning the color, placement and size of the Icons.

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TABLE 9. (cont'd)

CASE	SOFTWARE TYPE	PROBLEMS	EFFECT OF THE PROBLEMS
Case 3 continued		Still Frame Audio (SFA) was a problem because the lengths of video and audio tracks were not compatible.	SFA problems were resolved, in part by developing a special utility program for designers. The cost of this was offset by time it saved. Recording of SFA on the first frame of a video disc took several days to resolve.
		Compiler in Sony View not compatible with Lattice C.	Developing custom routines so Sony View could use its compiler on Lattice 'C' took 4-5 months, delaying start of project until resolved.
		Screen cueing never correctly resolved with audio cue. Visual appears after audio.	Many hours were spent working with Sony to get the audio description and visual cue to occur at the same time.
		CMI would not link with the programs.	The problem with CMI link was caused by the transfer of control from CMI to the course and back to CMI. There was a change of connection with the software. This was not a big problem, but caused a small programming nuisance each time. This occurred often and required an undetermined amount of time and labor to resolve.
		Reverses and fades were very hard to do and took a lot of programming.	Programming reverses in a lesson were very costly because they usually started in a fade, and stopping a reverse in black usually caused people to think the system went out - exact timing and programming to get the reverse timed correctly was very costly. There were many reverses and each took a lot of time. Cost undetermined.
		Received wrong version of DOS for Sony View System.	One system had the wrong version of DOS installed which caused several days of downtime discovering the probable cause of problems and conversing with Sony and eventually installing the correct version.
		Changed version of Lattice C and found it was incompatible with drivers for compiler.	They changed from one version of Lattice 'C' to a newer version to take advantage of some new features. This version turned out to be incompatible with the drivers in the 'C' tool kit. This caused two days of lost time.
		Had problems compiling code because a bad version of driver was installed.	The problems caused by the drivers in compiling took many hours to resolve over several days. Total time was not available.

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TABLE 9. (cont'd)

CASE	SOFTWARE TYPE	PROBLEMS	EFFECT OF THE PROBLEMS
Case 3 continued		Tests were restricted to 25 questions and no two part answers were allowed because of the CMI design.	Most tests had to be rewritten to meet the CMI restrictions. No estimate was given of time. Overtime was not charged, first disc took twice as long as remain-two, some due to test rewrites.
		Time and software restrictions eliminated use of graphics already produced.	Writer produced a lot of graphic enhancements and writing was done on own time to develop a high quality product. Never used it because they ran out of time and money. Time spent on products not used was not documented.
		Had to change to Lumena from PC paint for control of graphics because PC paint was not compatible with CMI. Had to redo all graphics done in PC paint.	The change from PC paint to Lumena caused several days of production time beyond that planned, plus an extra day of time to learn how to use Lumena.
		Sony touch area on screen was larger than they advertised. Interactive programs were designed for 1/4" square touch areas. Actual sensing was more than 1/2" and erroneous results were recorded when these overlapped on the visual.	Redoing the touch areas to eliminate overlays caused many overtime hours neither billed nor recorded.

problems caused by lack of space or programming problems unique to each software were the source of a major portion of the additional expenses.

In Case 1, the authoring language had to be discarded and replaced by a low level programming language. The reason for the change was twofold. First, the initially selected authoring language was too large to fit the available computer memory and leave enough work space for programming the course content. Second, individual alphanumerics had to be sensed from the keyboard during instructional lessons. The authoring system could only sense words, not individual key strokes.

Case 2 also had to change languages, not once but twice. As can be seen in Table 9, Pilot Plus, Pascal MT+, and MS Pascal were all used during the contractual effort. In addition, a change of equipment during the project changed the operating systems from CPM to MS-DOS, necessitating yet another reprogramming effort and a switch to a second version of Pascal MT+ which was still under development. It can easily be seen that an additional five months to a year of programming time was added to the project simply because of changes in software. An additional effect in Case 2 was the need to reprogram months of work done by an inefficient programmer to make the code fit on the storage disc. Further, a programmer able to write code in an assembler language was needed to program functions required by the client into the program. This took additional time, up to six months, because MS Pascal did not perform as required. The total effect of software problems on Case 2 was at least 12-18 months of additional project time and corresponding labor of two programmers and an instructional designer/editor.

Although Case 3 problems were more numerous, the total impact was not as great as on the other projects. Incompatibility of software with compilers and drivers caused significant down time. The need for more storage space for graphics than was available required time to find an alternative media method. The solution was to produce an overlay on the video track of the disc. In addition, there were timing problems with cues and audio tracks, lengths of audio tracks did not match video sequences, and the touch areas on the screen were much larger than expected. These were time consuming problems, but not of the same magnitude of those experienced in Case 2. The most significant problem in Case 3 occurred when Lattice C was not compatible with the Sony View compiler and delayed the start of the project by several months. This caused a time schedule problem, but did not affect overall cost. However, the frequency and number of problems did add up to additional costs which contributed significantly to the cost overrun.

From these data, it appeared that software problems were easily the most significant factor affecting cost or time on an IVD project. Lack of planning or experience led to selection of an inadequate language for the effort which was frequently only discovered well into the project. This usually required a language switch and conversion effort leading to a major cost overrun in reprogramming. Also, as seen in Case 2, software suddenly lost manufacturer support or was no longer viable because of equipment or other external changes. However, as was seen in Case 3, the same language throughout a project did not necessarily predict a problem free project.

Research Question 10: To what extent do unintended events and unplanned events create a time and cost overrun in an IVD project?

To answer this question, it was necessary to first define unintended and unplanned events. Two criteria were established. First, such an event was not part of the normal instructional design process. This criterion separated "unintended and unplanned" events from those in the process which should have been foreseen but which were not due to lack of foresight or experience. An example of an event which should have been expected was the necessity to reformat graphics which were not in a video format.

The second criterion for defining unintended and unplanned events was that such events were caused by something out of the control of the project team. For example, a misapplication of software would be something which should have been controlled by the team, but malfunctions of the computer would be an unplanned event.

To identify these events, the data from all cases were reviewed for time and cost overruns. The associated activities which appeared to have caused the overruns were examined and entered into Table 10 if they met either of the two criteria.

Table 10 describes these events and their effect on both cost and time on the project. Review of the table reveals that, with few exceptions, the major effects were technical in nature. These involved either the IVD machine, the software, or the manufacturing of the video discs. The only exceptions were improper shipping and client escorting requirements during visits (Case 1) which took away from time actively spent producing the product. Case 1 also had a unique problem. The videodiscs are composed of layers. Four discs began to separate which made them thicker and caused problems in the

TABLE 10. Creation of Cost Overruns by Unintended and Unplanned Events

CASE	EVENT DESCRIPTION	EFFECT ON TIME OF PROJECT	EFFECT ON COST OF PROJECT
Case 1	Client sent boxes of video discs to an office in the wrong state. Discs had to be shipped by an Express service to the correct location.	2 days waiting for discs.	Several hundred dollars for reshipment of discs.
	IVD systems malfunctioned and had to be replaced by the manufacturer.	Took up to 5 days to replace the machine each time it happened.	Minimal cost - labor hours to diagnose and ship.
	Video discs came unglued and the layers separated, making the disc thicker, exceeding the physical clearance in the machine. Discs were scratched and became unreadable. Dust and shavings got mixed in the machine and caused player problems.	Project was delayed while the machines were repaired and modified to run the discs.	Discs had to be redone; cost was borne by the disc producer. Labor to work on the machines.
	Disc manufacturer had to debug their machines while producing the video discs.	Several days of delay while the problem was being resolved.	None.
	Client required escorting on every visit.	No work could be done by lead programmer during one to two day visits.	Overtime hours were expended, but contractor did not charge the client for them.
Case 2	Client dropped their support for Pascal MT+, and the language producer stopped supporting it. Project software had to be reprogrammed to MS Pascal.	3-4 days were spent developing a conversion program to go from Pascal MT plus to MS. Several days were necessary to debug converted software.	Programmer time for conversion and debugging.
	Client changed equipment from Sony SMC-70 to Sony View System. This resulted in reprogramming since the new operating language was MS-DOS.	6-8 months of reprogramming and rewrite of courseware. 5 months of content data re-entry.	Several thousand dollars for labor and travel costs, plus cost of new machines. ($150,000 to $200,000)
	Client agreed to obtain the Sony View Systems and help with programming and editing of the courseware. The budget reflected their assistance. Clients equipment did not arrive until near the end of the contract.	The project took several months longer due to lack of client participation.	Costs of the extra time was for labor of programmers and editors to do what the client was to have done.
Case 3	Capacity of the computer on the IVD system was not large enough to accommodate all the graphics required in the project. The contractor had to develop them, put them on master tape and hence to the disc, rather than use graphic overlay.	Additional days for mastering tape and editing.	Studio time for editing and mastering. Several hundred dollars.
	There were a limited number of IVD systems. The contractor had to wait for them before they could produce the courseware.	Project took 2 years instead of planned 12 months. Some was due to this wait.	Minimal.
	Coding of the SFA on the master discs was not correctly done. It could not be replayed on the IVD system. The discs had to be redone.	Several days wait for new discs, and several days to diagnose the problem.	Cost to manufacturer to redo the discs.
	Size of screen touch areas, used for interactivity, was much larger than indicated in the manufacturer specifications. This caused rewriting and reprogramming to select new touch items on the visuals so the touch screen could be used as planned.	Several hundred hours of delay to diagnose the problem and several days to redo programming and courseware.	Several thousand dollars for programmer's and editors' time.

laser player machines. The increased thickness created disc wear. Shavings from the discs jammed the players and the wear made the discs opaque. The programmers had to "guess" at visuals until the new discs were produced and received. Project delay and reprogramming were the results of this problem.

Machine malfunctions were a general rule across all three cases. In Cases 1 and 3, a shortage of manufactured machines caused repair or replacement to be delayed. This in turn, resulted in project delays of several days.

Other unplanned events related to the video discs themselves. This occurred in Cases 1 and 3. Either equipment malfunction (Case 1) or procedures in mastering still frame audio (Case 3) caused the problems, and the discs had to be redone by the manufacturer.

Case 3 experienced two other unexpected problems. Both problems related to machine capabilities. In one situation, the computer of the IVD system did not have the capacity to handle both the authoring language and the required graphics. This resulted in production of graphics and their transfer as visuals to the master tape rather than digitized for storage in the computer. Secondly, Case 3 experienced problems when the touch areas on the screen were larger than specified by the manufacturer and more than one intended touch point on the visuals lay in the same area sensed by the light pen. This problem required redesign and reprogramming to ensure touch points had more separation on the screen. Graphics were redone to enlarge diagrams on the screen, and test answers were reformatted by resequencing answers when more than one response was correct to avoid an overlay of the touch points.

The unintended/unplanned event problems in Case 2 were almost totally related to the changes in hardware and software initiated by either the client or the manufacturer of the system. Software changes were two-fold. The dropping of support by the manufacturer for Pascal MT+ caused several days to change to Pascal MS. The change in hardware caused a change in operational language and resulted in several months of reprogramming. This hardware change from the SMC-70 to the Sony View 2000 was significant in cost ($150,000 - $200,000) because of a need to totally reprogram to use the new operating system and then to reenter project data. The final problem in Case 2 was related to machines, but resulted from the client's lack of responsiveness to help solve the problem. The client had agreed to provide part of the programming and editing team, as well as equipment. However, the computers and players did not arrive until late in the project and were improperly configured when they did arrive. The contractor had to do the work, causing cost overruns, and had to delay delivery of the courseware, commensurately adding several months to the contract performance time.

In summary, the unexpected and unintended events which most often occurred were related to machine delivery or failures and disc manufacturing problems. These problems can be extremely costly and delay projects by several months, as seen in both Cases 2 and 3.

Research Question 11: When and under what circumstances do unexpected costs occur in an IVD project?

To answer this research question required an examination of the data with respect to those costs which were either overlooked in budgeting for a project or for which cost was underestimated in the budget. The data were examined for cost overruns and the probable cause of the overrun was identified. The results of this examination are described in Table 11. Two types of cost overruns were identified: direct costs (machine purchase or shipping) and labor costs for unexpected hours beyond those budgeted.

Most of the problems described in Table 11 concerned the production phase of the effort. Closer examination showed the greatest percentage of the problems were related to hardware and software. In all three cases, many of the hardware problems resulted from new equipment malfunctions or unexpected limitations. Beyond this, there did not seem to be a pattern across all three cases except for a language change. All cases changed programming languages, though the Case 3 language change occurred prior to the point where this study began examination of the case. However, the effects of the change were still felt by two of the primary contractors in Case 3.

The unexpected costs in Case 1 resulted from higher than anticipated travel costs, audio recording, production to provide higher quality sound effects and a change in authoring languages. Travel costs were for a variety of activities, mainly to attend more project review meetings than anticipated and to work with the recording studios to produce the audio tracks. The change from authoring system to language resulted in a 50% increase in programmer wages. The audio production costs were high because the sound effects were very poor in the original media sound track. Further, there was background music which had to be diminished in the videodisc sound track because of the segmentation of the learning sequences which used only portions of the sound track. Case 1 also experienced high

TABLE 11. Circumstances Under Which Unexpected Costs Occur

CASE	CIRCUMSTANCES OF UNEXPECTED COSTS	COST EFFECT ON THE PROJECT
Case 1	Original sound tracks which were to be used for the project were lost. The contractor was forced to use audio with background music. This loss caused special editing to diminish the music in the video disc sound track.	Cost of editing studio and labor to do the work.
	The original authoring system could not react to keystrokes, only complete words. It was necessary to change to Pilot Plus authoring language.	Many more programmer hours were required, nearly doubling the programming costs.
	Shipping was double that expected. The high use of Federal Express was not expected.	Shipping by rapid delivery was not budgeted. Cost was several hundred dollars.
	Production studios needed careful guidance and meetings were held out of state. Both required travel from the contractors site.	Higher than budgeted travel costs.
	Many sound effects were poor and needed to be redone.	Added 1/3 to cost overrun.
Case 2	The new Sony system had many problems when first introduced, and resolution required many hours on the phone with their technicians. In some cases, problem was not resolvable or had to be done by contractor.	40-80 hours of programmer time.
	Several groups of subject matter experts were supplied by the client. The final validation by one group found inaccuracies which had been in the content for months. These all had to be corrected before final production.	Several days of editor and programmer time to work around the inaccurate visuals for reprogram sequences.
	Client SMEs were not available for all of design and production.	Time estimate unavailable.
	Change of equipment during project was initiated by the client and hardware manufacturer. This change caused a major reprogramming effort because of a change in operating systems.	6-8 months of programming for 2 programs (100 to 150K). Cost of the new systems was about $10,000. Contractor has to buy 3 of them.
	Changed from Pascal MT+ to MS Pascal when manufacturer refused to support the MT+ any longer.	3-4 days programmer time to write a conversion program.
Case 3	SFA caused several problems in coding onto the video disc. The production technicians had to be supervised by the contractor and the process redone a second time.	Caused several hours of production time, studio costs and travel.
	Needed to change to a programming language, Lattice C, because the authoring language could not perform many of the required functions. Lattice C took longer than expected to use for the IVD.	Programmers time and more production work.
	SFA had to be developed in total. There was more on the Level II which could be used on the Level III discs. Scripts were not the same as the disc and none of the verbal tracks could be used.	Cost overrun due to all the documentation correcting, reprogramming and SFA problems. $15,000 - $20,000 over budget.
	Computer managed instruction (CMI) module was developed by one subcontractor for use by all others on the project. The CMI would not always link with the instructional programs.	Several weeks of programmer time were required to resolve the problem.
	The program required interactivity between the student and visuals. This could not be done within linear video sequences because of machine processing problems. Still frames had to be developed and placed at the end of each linear sequence to provide for the interactive requirement, and for SFA needed.	Caused large percentage of the $20,000 overrun per disc due to labor costs.
	Graphics were not compatible with the CMI software. Had to change graphics package near the end of the project.	Purchase of software and 2-3 days of programmer time.

shipping costs because an express service had to be used as a mode of shipping.

The unexpected costs in Case 2 stemmed mainly from the newness of the IVD System and changes in systems and software. As has been mentioned before, the change of software was necessitated by an equipment change and by the withdrawl of support by the software manufacturer. The equipment change was initiated by the client and resulted in several months of reprogramming. Because of a change in the operating language, the new IVD System had many hardware and software malfunctions to be resolved. The issue of subject matter experts affecting cost is not clear until it is recognized that they were also to be part of the design and production team. Their absence forced the contractor to provide more labor hours to complete the job.

Almost all of the unexpected costs in Case 3 were caused by software problems or changes. A change from an authoring system to Lattice C caused more programming time and additional costs for labor than anticipated by the primary contractor. SFA was a big cost impact due to improper production techniques at the studios, audio on the original Level II discs and the need to develop SF at the end of every linear sequence to provide interactivity. The inaccurate discs were caused by the production engineer's lack of precision in laying down the tracks. Because the aim of the project was to convert Level II to Level III IVD, it was assumed the Level II tracks were sufficient. They were not and audio had to be redone. The lack of ability of the IVD system to accommodate interactivity with linear sequences caused a need to intersperse still frames between linear sequences to be used for interactive courseware. This need caused several days of production and programming.

The CMI developed for Case 3 caused two problems. First, the CMI would not interact with the instructional program without some software design. The CMI restricted the programming. As an example, tests had been designed with a large number of test questions and with more than one answer to several questions. The CMI program was structured to only accept 25 questions per test and one correct answer per question. This structure cost several thousand dollars for programmers to redo the software and courseware. In the second problem, the graphics package had to be switched because of incompatibility with CMI. The Lumena graphics package was used for linkage with the CMI. This change resulted in several hours of extra programming and about 25 hours of overtime to reprogram the existing graphics.

In summary, a review of Table 11 showed that all three cases experienced unexpected costs due to a software change. However, the remaining unexpected costs across the three cases were not very consistent except that the majority were related to hardware and software problems or malfunctions.

Question 12: When and under what circumstances do unexpected time delays occur in an IVD project?

To determine the answer to this question data from the three cases were examined to identify when time delays occurred and the circumstances which caused the delays, and then the effect of the circumstances was quantified in time. The results of this analysis are presented in Table 12.

A review of Table 12 showed that the production phase was when

TABLE 12. Circumstances Creating Unexpected Time Delays

CASE	WHEN	CIRCUMSTANCES	EFFECT
Case 1	During production of master tape	The client decided that they needed a special demo tape and asked to have one made up according to some specifications which were not part of the initial contract.	Delayed production by 2-3 days.
	During production of the courseware	The equipment would stop working and had to be sent back to the manufacturer for replacement.	Up to 5 days delay for each circumstance.
	During production of the courseware	The programming language was changed from authoring system to Pilot Plus. The student programmers were 50% slower with Pilot Plus than expected.	Several days for training and many overtime hours to correct errors.
	Production of the courseware	There were limited numbers of IVD systems and that allowed only a few programmers to work at a time.	Caused longer than expected programming time.
	Production of disc/ master tape	Blizzard at production site kept people home from work.	Two days.
Case 2	During development and production	New equipment had erroneous documentation. The problems were not always obvious and many phone calls with manufacturer were required to resolve it.	2-5 days per problem.
	Product validation	Subject matter experts called in to validate instruction. Found several procedural errors which had to be corrected, and which were not found during design.	2-3 weeks of delay.
	During production	Client had agreed to help with various parts of the production and programming. Their equipment arrived 20 months late, and contractor had to work longer to make up for the loss of time, forcing project to take longer.	4-5 months of programmer time.
	Production and validation	Client was overdue on validation of the media and courseware.	2 months delay.
Case 3	During production	The Computer Management Instruction (CMI) software was developed by one of the several team member companies. It was not always compatible and it would only handle tests of 25 questions (or less).	Had to redo software and redesign tests. Several days per module were lost. Overall 8-10 weeks of programmer time.
	Design and production	The new Sony machines had unexpected "bugs." The phone calls to convince the manufacturer there was a problem, track down the correct person to solve it, and then resolve the problem, were very time consuming.	Lost several days to several weeks for each problem.
	Production of the courseware	SFA was incorrectly put down on the master tape. Not enough precision was used to put the SFA on the correct frame.	2-3 days.
	Development of the courseware	Client requested many changes to script format and wording.	Several days to make changes.

most time delays occured for all three cases. Case 1 experienced delays with master tape and disc production and programming of courseware. Case 2 experienced production delays because of equipment malfunction or late delivery of client equipment. Case 3's production delays were due to three separate issues: (a) limited capability of a CMI package which prevented implementation of several courseware features, (b) malfunctions in new machinery, and (c) a lack of editing precision where audio was not always begun on the exact frame number necessary to match the visual to which it referred.

There were only two other instances where time delays were experienced due to unexpected circumstances. The first was during courseware validation or formative evaluation to check the correct sequence of course steps when the subject matter experts discovered errors in the content of the program (Case 2). Time had to be taken to correct these errors. The second significant delay was due to the unexpected emphasis by the client on script format and appearance (Case 3), when the script appearance had not been considered a significant issue by the contractor.

Table 12 also displays a series of circumstances under which time delays were experienced. Each case seemed to have its own set of issues. A review of these circumstances revealed that each case had equipment problems. Other significant issues which have not been mentioned above were: a change from an authoring system to an authoring language which slowed down inexperienced programmers (Case 1), overdue responses from client on product reviews (Case 2), and weather caused delays (Case 1).

The three cases demonstrated that unexpected problems with hardware, programming software and client-instigated changes in the courseware or documentation are the most often experienced causes of unexpected delays.

Summary of Findings

There are several areas which appear to have created the largest negative effect on the cost of design, development and production of IVD courseware. These areas are:

- Software
- Hardware
- Client knowledge
- Contractor experience and qualifications
- Design
- Team functioning

Overall the data showed that time delays ranged from about 2 months in Case 1, to 4 months in Case 3 and one and one half years in Case 2. The total cost effects ranged from about 20% in Case 1 to about 45% in Case 2 and about 40% in Case 3. One area, organization size and capability, did not appear to adversely affect the time and cost of the project.

Software

The largest cost effect in all three cases stemmed from software problems. Cases 1 and 2 had selected or been given software which did not support the courseware design. Changing to software which did support the design caused significant changes in cost due to the need to reprogram the courseware. Case 2 experienced two additional changes, once to accommodate the changing equipment which had incompatible operating languages and a final change due to the sudden non-support of the software by the manufacturer. The switch in operating languages was more extensive (5-6 months) than the final conversion effort.

Graphics software packages proved incompatible in both Cases 2 and 3. Case 3 experienced the most extensive reprogramming of graphics in order to match the courseware to the CMI developed.

Hardware

Hardware problems appeared to be directly related to the fact the equipment was newly released from the prototype state. As with any new technology, there were reliability problems. In all three cases, the project manager and/or programmers spent many hours and lost from days to weeks attempting to resolve the problems by telephone. This did not always prove successful. On several occasions the equipment or parts of the equipment such as the XEBEC hard disc, light pens and disc player had to be shipped back to the manufacturer. In other situations, the programmers received little or no help from the manufacturer and had to work around the problem such as in the redesign of the instruction to avoid the overlap of touch areas, reconfiguring the equipment to use a faster compiler, or contacting other users for advice based on experience.

Equipment acquisition costs (Cases 2 & 3) and delays in receiving equipment by the client (Case 2) caused large overruns in material costs and added labor to accomplish the work.

Defective discs or incorrectly mastered discs also affected the cost through delays, travel and remastering costs.

Client Knowledge

The level of client knowledge appeared to play a key role in the escalation of costs during the project. Client specification of equipment, software, design features and use of existing materials often proved unworkable or costly to the contractor. In some instances equipment and/or software had to be changed to support the design features specified by the client. In addition, in all cases where the client directed the contractor to use pre-existing materials such as audio tapes and video, a cost increase resulted and the quality of the final product was often limited.

There was evidence to show the client's knowledge grew throughout the project, causing a change in their expectations of what they wanted the product to do. The changing expectations led to the changing of the design and the addition of special features which in turn caused a need to reprogram the courseware and/or created a need for additional programming to meet the new requirements.

Finally, the client's lack of knowledge and understanding of the complexity of the medium and requirements to accomplish the task surfaced in unrealistic timelines. Extensive overtime was required by contractor professional staff to meet the unrealistic delivery dates.

Contractor Experience and Qualifications

Contractor experience and qualifications had a varied effect on the cost of the project. It appears that the contractor's desire to acquire experience in IVD often led them to bid lower than they might have had they had extensive IVD experience. Further, the contractors prepared bids based on general information and did not always recognize the need to investigate details, such as evaluation of the audio tapes to determine what would be required to make use of them.

Contractor inexperience and lack of training in Level 3 IVD manifested itself in extra costs in two major areas: design and programming. In each case, design of courseware was too complex for the software, and programmers had to spend extra time in redesign meetings with designers or change to different languages to meet the design requirement. Inexperience also caused problems in programming. In Case 2, an inexperienced programmer worked for several months creating code which was very inefficient and exceeded the available computer memory. This code had to be reprogrammed over a period of weeks. Case 1 had to develop short software templates and routines for less experienced programmers to use as tools. Further, the switch from a relatively simple authoring system to an authoring language increased the programming time since the programmers were not skilled programmers by profession in Case 1.

Another area which showed evidence of contractor inexperience was the undue desire to please the client, agreeing to make changes and willingness to incorporate new requirements without assessing the cost effects of the requests.

Poorly designed communication methodology also had a negative effect on each project. Exact costs could not be discerned. However, all three cases had to reprogram courseware because of slow communications, miscommunications, and management decisions which were not transmitted in a timely manner to the team workers. Case 3 tried to solve communications problems by using group meetings. However, with the number of companies involved, large amounts of time were consumed making simple decisions, and frequent changes were made in courseware design to make each product look similar to the other products.

Design Phase

The data show that the activities of the Design Phase have the greatest effect on all other activities and phases. The Design Phase establishes the instructional flow, instructional treatment, level of interactivity, visual conventions and the management structure. In this study, the level of complexity put into the design often outstripped the abilities of hardware and software selected. This adversely affected the programming aspect and caused software changes. In addition, equipment frequently had to be reconfigured to provide the added memory space required for the code to achieve the complex design.

Methods selected for storyboarding and scripting were often inadequate and did not provide the detail required by the programmers. In Cases 2 and 3, the instructional designer had to simplify the design during the programming stage either to save time so the delivery dates could be met or because the software couldn't support the feature. Again, in both Cases 2 and 3, the instructional designer had to spend many unplanned hours with the editor in the video production and with the programmer to ensure an accurate product was achieved as well as to facilitate efficient production work.

Team Member Roles and Functions

Personnel assigned to the team typically performed multiple roles. Some team members had a broad range of experience and could adequately fill the requirements of project manager, instructional designer, producer and director; others, however, performed these multiple functions because of the pressure of schedules. Performance of multiple roles and functions by team members affected the projects both positively and negatively. In a positive sense, it fostered communication between team members and helped ensure that members were operating with the same understanding of what was to be achieved. In a negative sense, mistakes were made because of inexperience in performing the task which required time to redo, such as in the case of some of the writers, instructional designers and programmers.

The management role was often performed by the instructional designer, video producer/director, or a programmer. There did not appear to be evidence to show one type was better than another. What did affect a project budget was the retention of staff members for the duration of the project and the communication flow between team members. The changing of staff, either management or team members, appears to have had an adverse effect. This was especially evident in Case 2. Adequate documentation was unavailable and each of the four managers had a different perspective on the design, purpose and requirements of the program. This created undue changes, delays and labor costs.

Overall, the way in which the team members communicated and transmitted critical information and decisions appeared to be as much of a factor as the role they performed. The data showed that team members did not perform an isolated task in a single phase and then leave the project. Designers and programmers in particular were required throughout all phases of the effort.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This concluding chapter has two major sections: (1) a summary of the study, and (2) findings, conclusions and recommendations for future research.

Summary of the Study

Purpose

The purpose of this study was to investigate and develop a baseline knowledge of problem variables which appear to cause time and cost overruns in the development of Level 3 interactive videodiscs. Twelve specific research questions were used to explore the effects of problems associated with such variables as contractor knowledge, client knowledge, contractor agency size and capability, team member functions, project team organization, personnel IVD training and experience, IVD phase activities, hardware, software, unintended and unplanned events, unexpected costs, and unexpected time delays on final cost and time to produce the product.

Methodology

The case method approach was used in the study to derive the key problem variables which affect time and cost in Level 3 IVD projects. From a potential list of 8 cases, three cases were selected for inclusion in the study. Each case was a Level 3 IVD project to develop training for government or private industry which was either completed or near completion and which had incurred a cost overrun.

The cases were projects produced by a large educational institution, a private firm doing only training analysis and development work for the Department of Defense, and a composite of firms doing training and development work for a single manufacturer. The size of the projects varied greatly. Only Case 2 performed all phases from analysis through production. Case 1 was predominantly development and production, while Case 3 covered design through production.

The time delays extended from about two months on one project to one and one half years on another. The cost overruns incurred varied from about 20% in Case 1 to about 40% in Case 3 and about 45% in Case 2.

Data from the three Level 3 IVD projects for industry and government were collected and analyzed. The data collection included in-person guided interviews with project managers, instructional designers, information programmers, and video producers. Script writers or graphics programmers were included in the interview process where required. Data were also collected by examination of project documentation and products for each case.

Findings, Conclusions and Recommendations

The conclusions of the study are presented in Table 13 with the related research questions, findings and recommendations for future research. The remainder of this section discusses the conclusions and recommendations for each research question.

TABLE 13. Findings, Conclusions and Recommendations

Research Questions	Findings	Conclusions	Recommendations For Future Research
1. What type of knowledge is needed and when does it have to be available to make time or cost estimates for an IVD project?	Cost estimates were based on very general information about the content, software, hardware, staff available and existing materials to be used. Cost overruns were incurred.	The type of information available appears to be correct. The depth and accuracy of the information was not sufficient for accurate costing.	The development of a model or procedure for extracting required information from the client prior to contracting and costing a project or project phase.
2. To what extent does client IVD knowledge, as reported by the contractor, have an effect on time and cost of an IVD project?	Client knowledge grew during the project. This changed client expectations which led to the request for program changes. Client specified software and/or hardware prior to or during early stages of the contract did not support the desired design.	Client change requests occurred as their knowledge increased and caused extensive redesign and reprogramming. Client delineated specifications may be unrealistic because of inadequate knowledge about IVD.	Study of how to educate the client before contracting so that realistic contractual agreements can be made.
3. What effects, if any, do contractor agency size and capability have on time and cost of an IVD project?	Contractor agency size and capabilities varied from large to small. Most contractors had to subcontract some portions of the effort to provide capabilities they lacked or required to supplement a small staff.	Agency size and capability do not appear to have an effect on direct costs and time.	Study the size and capability factor across a large enough sample to be statistically relevant. Conduct a study on the effects of subcontracting by the contractor on the overall cost of the product to the client.
4. What functions does each team member perform in the process of carrying out an IVD project?	The project manager usually is skilled in one of the other functions such as programming, video production or instructional design. Most team members performed more than one function. Some producers and software programmers worked in the capacity of instructional designers, some instructional designers were also the software programmers. Writers became involved in several phases of each project.	The role of each team member is not clearly delineated. Each team member is required to perform functions outside the general team position given.	Study the various activities and skill requirements for IVD development to determine the composite skills required by each team member to make an effective IVD team.
5. What effects, if any, does project team organization, and personnel IVD training and experience have on time and cost of an IVD project?	Lack of experience and training, especially of programmers, caused added time and cost to redo programs. Project team organization was important because it affected communication patterns. Poor communications resulted in improperly done work and added hours in redesign and reprogramming.	Organization of an IVD development team must concentrate on the multiple roles of team members, identify clear lines of communication, and provide for frequent reviews to prevent unnecessary effort.	Conduct studies to establish the minimum competencies required by instructional designers, programmers, producers and managers in all instructional development phases for Level 3 IVD. Study the skill requirements for IVD development to derive cost efficient and time effective IVD team organization and communication models.

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TABLE 13. (Cont'd)

Research Questions	Findings	Conclusions	Recommendations For Future Research
6. What activities in a phase have a time and cost effect on subsequent phases of an IVD project?	Programmers found that some of the interactive courseware design could not be programmed within schedule or budget. In several instances the design could not be accomplished by the software chosen for the project. Too much interactivity became distracting to the student and the program had to be redesigned during production.	The design activities of the project are the most influential on the cost and time required in subsequent phases.	Develop models which would establish the interactive requirements for the range of instruction from highly cognitive to highly psychomotor. Conduct time and cost studies on the application of the different models of interactivity.
7. Is one phase more likely than any other to affect time and cost of an IVD project?	Specifications made in the instructional design, during the design phase, often could not be met or had to be modified during the production phases to meet time schedules. The complexity of the design done during the design phase affected the amount of time and cost required for programming in the production phase.	The design phase appears to have the greatest affect on time and cost since it is in the design that the complexity of the program and features are defined. The program complexity and features directly relate to programming time required. However, the production phase is the most costly phase of a project in terms of labor, since both the video production and programming are completed during production.	That models of interactivity be developed and studied for time and cost. That programming design models be studied. That instructional design features be studied to determine cost and time effects.
8. What effects, if any, does IVD hardware have on time and cost of an IVD project?	New machines were delivered in all cases studied with problems which were not fully resolved. Close interactions with manufacturers were required, and in some cases took several days to resolve problems. Machine memory was too small in each project to accommodate all required program code. Machine changes were experienced in Case 2 during the project and in Case 3 just prior to the project.	There were numerous problems with hardware. If newly developed machines are used in a project, the manufacturer will be the only source of help to resolve the problem.	Examine the emergence of new technology and develop a prediction algorithm showing the effect on future IVD development work. Identify the most important design features for IVD hardware for purposes of making recommendations to hardware manufacturers.
9. What effects, if any, does IVD software have on time and cost of an IVD project?	In each case, the software was changed once or twice during the project causing almost complete reprogramming. Causes for change included: • Machinery changes caused need for new software • Non support of the software by the software vendor • Software would not allow programming of features the client requested • The software was too cumbersome and required more memory than was available on the equipment • Graphics packages were incompatible with machine software	The software does not create a time and cost overrun; the time and cost overruns are incurred for programming when the software has to be changed to accommodate program design.	Determine the most appropriate design features of software for IVD. Identify effective software (hardware) configurations as they relate to a range of IVD instructional design requirements. Using a statistically appropriate sample, study the time and cost required for executing given IVD instructional design models with given software.

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TABLE 13. (Cont'd)

Research Questions	Findings	Conclusions	Recommendations For Future Research
10. To what extent do unintended events and unplanned events create a time and cost overrun in an IVD project?	Systems malfunctioned and had to be replaced. Videodisc layers separated and were damaged in the machine, and had to be replaced. Software support was dropped by the manufacturer and caused a change in software. Change in equipment by client caused reprogramming to accommodate change in operating language. Late delivery of client's systems caused contractor to do more work in lieu of client's expected help. There were a limited number of IVD systems. Still frame audio was not correctly mastered, had to be redone.	There are a number of unintended and unplanned events related to hardware and software which have a negative effect on time and cost. Budgets and schedules should be planned to accommodate these instances.	Using a statistically appropriate sample, study the percentage of cost incurred due to unintended and unplanned events to derive a realistic costing value which can be included in a costing algorithm. Using a statistically appropriate sample, study the percentage of time increase due to unintended and unplanned events which can establish a standard to be included in timeline algorithms.
11. When and under what circumstances do unexpected costs occur in an IVD project?	Software changes were incurred which raised cost of the project. Different groups of subject matter experts caused redo of content just prior to final programming. New systems caused delays and costs to get problems resolved. New software took more programming hours than budgeted. Higher than expected shipping costs. Close supervision at audio and video studios took more travel than budgeted.	Unexpected costs occur when newly developed hardware and software systems are introduced. Budgets should be built to accommodate relatively small unexpected costs.	Same as Recommendations for Research Questions 8, 9, and 10.
12. When and under what circumstances do unexpected time delays occur in an IVD project?	Hardware malfunctions caused project delays Software programming difficulties caused delays when reprogramming was required. Client instigated changes to software or hardware Client changed courseware and design.	Unexpected delays will be experienced in a complex Level 3 IVD project. Project schedules should be constructed to accommodate a reasonable delay factor.	Same as Recommendations for Research Questions 8, 9, and 10.

Research Questions

Research Question 1: What type of knowledge is needed and when does it have to be available to make time or cost estimates for an IVD project?

As stated in Table 13, the data in all three cases clearly showed that information about the instructional content, software, hardware, staff and existing materials was generally made available before contracting and was used by contractors in the development of project cost estimates. However, once the contract was underway, added information about these same aspects became apparent and could be tied directly to time delays and added costs. From the data one can conclude that the type of information being made available was appropriate. However, the depth and accuracy of the information was insufficient to make accurate cost estimates at the time of contracting. Further, as shown in Research Question 2, the client knowledge about IVD was often insufficient for the client to know when they were providing incomplete and inaccurate information. Therefore, it is recommended that research be conducted to develop models or procedures for extracting required information from the client prior to contracting and costing a project or project phase. To develop a model would require the identification of initial elements in each of the aspects of instructional content, software, hardware, staff and existing materials to be used, which have a time and cost affect on the project.

Research Question 2: To what extent does client IVD knowledge, as reported by the contractor, have an effect on time and cost of an IVD project?

Essentially, there were two effects of client knowledge as observed by contractors. First, the clients knowledge about IVD tended to increase during the project and their expectations of how the product should look and operate changed accordingly in all three cases. Each client added or changed previously accepted design features during the project. Secondly, each client specified hardware, software and/or design features which did not support the desired design. The software was either too inflexible or required too much time to achieve the effect. The hardware lacked required features, critical memory space, or operated too slowly to be efficient instruction. The design features specified proved unworkable or became distracting to the instructional process.

The client change requests occurred as knowledge increased which in turn caused extensive redesign and reprogramming efforts on each contract. Further, the client-delineated specifications may have been unrealistic because of the client's lack of critical knowledge about the capabilities of Level 3 IVD and the processes and procedures required to develop the product. These findings are similar to the findings by Klotz (1983) in a survey of problems related to IVD.

To ensure that expectations remain realistic and that client specifications are executable, studies on how to educate the client before contracting so that realistic contractual agreements can be made appears critical. Focusing on present client self-education methods which changed expectations and on modes of discerning the client's knowledge level about IVD would provide valuable information toward establishing how to educate and the amount of education to provide to the client before contracting. Ultimately, client education would minimize false assumptions and provide the client with information to use in specifying their requirements to contractors. Until such studies are completed, some contractual contingencies are required to minimize the impact of these client changes on contractors.

Research Question 3: What effects, if any does contractor agency size and capability have on time and cost of an IVD project?

As stated in Table 13, contractor agency size and capabilities varied from large to small. Contractors appeared to use subcontractors, consultants and specialized free lance personnel, such as writers, to secure the necessary capabilities to complete the job. Regardless of the approach used, contractors had identified the requirements at the time of contracting and often had made the necessary agreements prior to completing the timeline and cost estimate for the project. From the data, one can conclude that agency size and capability did not have an effect on time and cost estimates of a Level 3 IVD project.

It is recommended that this conclusion regarding the effect of agency size and capabilities on IVD development time and cost be verified by conducting a study across a large enough sample to be statistically relevant. An added study could be conducted to discern whether IVD projects cost more or less in relationship to the amount of subcontracting activity. This information would assist clients in selecting the most cost effective and efficient contractor.

Research Question 4: What functions does each team member perform in the process of carrying out an IVD project?

The data collected showed team members performing in more than one role. In each case studied, the project manager performed in one or more of the team positions of instructional designer, programmer and video producer. Personnel with instructional design training most often serve as the project manager. Other team members also performed multiple duties or activities typically defined for another position, e.g. programmer. It was not unusual to have instructional designers and writers doing programming. A few programmers did do some instructional design. Thus, it can be concluded that the individual roles of team members were not clearly delineated. Each team member could very likely be required to perform functions which they are not necessarily skilled or trained to perform. This undefined role may be a direct factor of the complexity and interrelationship of the medium requiring individuals to possess a composite of skills.

Research is required that focuses on the various activities and skill requirements for IVD development which would determine the composite skills required by each team member to make an effective IVD team. This research is necessary to bridge the gap between the highly specialized person and the more broadly skilled person whose knowledge and expertise can be wedded to other critical areas involved in IVD development.

Research Question 5: What effects, if any, do project team organization and personnel IVD training and experience have on time and cost of an IVD project?

As stated in Table 13, each case showed effects traceable to the inadequate experience and/or training in IVD development. The seriousness of the problem was most evident among programmers. While all programmers had formal training, many did not have enough experience programming with the selected language and developing efficient program code. This experience was critical in helping programmers to stay within the boundaries of the machine memory and maximize the operational speed of the final program. The overall team organization affected the communication patterns and modes of communication. Absentee and unavailable key personnel, communication by phone and/or written notices tended to result in missed information, misinterpreted information and poorly executed work which had to be redone. This problem is similar to the findings by Klotz (1983). It can be concluded that the organization of an IVD development team must focus on the multiple as well as diverse roles of team members, establish clear lines of communication, and provide for frequent product reviews to prevent unnecessary effort.

Research is required that would establish the minimum competencies required by instructional designers, programmers, producers and managers in all instructional development phases of a Level 3 IVD project. The establishment of minimum skill requirements would help minimize the effects of inexperienced or untrained team personnel. Further, a study of the skill requirements for IVD development would help derive cost efficient and time effective IVD team organization and communication models. Such models are required to facilitate the interaction of diverse staff, such as instructional designers and programmers, and ensure the transmission of accurate and complete information.

Research Question 6: What activities in a phase have a time and cost effect on subsequent phases of an IVD project?

As reported in Table 13, the case data indicated that the single activity which generated subsequent time and cost problems is related to the design phase. Programmers had to request that designs be modified in order to accomplish them within schedule and/or budget. In some instances, the design could not be executed with the available software. Finally, some designs proved ineffective and counter to good instruction when executed. Either the content had to be redesigned, or software had to be changed to support the design. In any event, delays occurred and added costs were incurred to rectify the deficiencies. Klotz (1983) also found that the more sophisticated the level of design the more likely problems would occur during programming. Thus, it can be concluded that the design developed for the IVD appears to control the time and cost in the development, and production phases.

Further research is required to develop models which would establish the interactivity requirements for the range of instruction from highly cognitive to highly psychomotor. The theoretic literature to date has not focused on specific design models for IVD. Typically, models applied are drawn for print, linear mediums or CBI which do not adequately address the capabilities and features of IVD. Time and cost studies on the application of the different models of interactivity are essential once models are developed. Such studies would yield more precise costing parameters and would prove useful in establishing budgets.

Research Question 7: Is one phase more likely than any other to affect time and cost of an IVD project?

As discussed in the previous research question, the activities in the design phase appeared to have had the greatest effect on subsequent activities. Essentially, the instructional design either had to be redone or modified to fit within existing time schedules. It also was evident that the more complex the design, the more time and cost increased during production. The speed of executing a complex design was also related to the flexibility and ease of using the selected software. Clearly, from the data one can conclude that the design phase has the greatest effect on time and cost. However, the costs are incurred in executing the design. This makes the production phase the most costly phase of a project. The programming aspect of the production phase was the most difficult time and cost to discern and/or estimate.

The resulting recommendations are somewhat like those stated for Question 6. Research is required to develop and study models of interactivity for time and cost. Related to this research is the study of design features to determine cost and time effects. Many of the treatments, such as light pen, touch points, and instructional strategy, require extensive time to program. It would be useful when costing to have some clear estimates of programming costs for these and similar features. Further, this study showed that the efficiency of the programmer code affected time and cost. Studies need to be made of programmer design models to identify efficient models for programming IVD. These studies could extend to identifying links between the instructional design and the computer program design.

Research Question 8: What effects, if any, does IVD hardware have on time and cost of an IVD project?

Table 13 summarizes the problems linked to hardware. These problems emanated from three separate issues. First, newly developed machines contained problems which could only be resolved in consultation with or by the manufacturer. Secondly, machine memory space was too small to accommodate the required program code in each case. Finally, some cases experienced equipment changes during the project which caused extensive reprogramming and extensive time delays. It is common for any type of technology to have problems. Further, it is common to expect newly released hardware to require a debugging phase. With the technology changing rapidly, one can conclude that there will continue to be numerous problems with hardware and that resolution of the problems will require interaction with the manufacturer. Therefore, it is important that research be conducted which will examine the emerging new technology and develop a prediction algorithm showing the effect on future IVD development. In addition, research studies conducted which would identify the most important design features for IVD hardware for purposes of making recommendations to hardware manufacturers would be useful. To date the technology is an eclectic gathering of diverse pieces forced into service to produce and play instructional IVDs. While some manufacturers have begun to treat the technology as a single unit, input is required which would make the medium more usable and perhaps more cost efficient for instruction and training requirements.

Research Question 9: What effects, if any, does IVD software have on time and cost of an IVD project?

Significant time delays and cost increases were evident in each project during the programming stage. The time and cost increases directly relate to the changes made in the software packages used for the project. Each case changed languages at least once. One case changed languages three times. Graphics packages were changed in all cases. As reported in Table 13, the reasons for the software changes were external to the programmer or the software itself. The difficulties occurred when the software was incompatible with the design, too cumbersome for accommodation in the available memory, incompatible with the machine operating language, and lacked manufacturer support. The actual functioning of the software did not create time and cost overruns. Rather, time and cost overruns were incurred for programming when a complete software had to be changed or when the software selected was inappropriate for the job. Existing programmed material could not be converted in most cases and had to be reprogrammed.

Clearly, research is required to help identify the most appropriate design features of software for IVD development. To date, most of the software being used for IVD was created for some other purpose. As a result, critical features for programming instruction on IVD are either lacking or are too cumbersome to be used. Additional research to identify effective software (hardware) configurations as they relate to a range of instructional design features would be useful to those selecting software. Finally, once IVD design models are developed, time studies using a variety of the software would provide valuable data for people in a position to select efficient, as well as effective software.

Research Question 10: To what extent do unintended events and unplanned events create a time and cost overrun on an IVD project?

Unintended and unplanned events were occurrences outside of the normal instructional design process which had a time and cost effect. These time and cost items were out of the control of the project manager or personnel. It is significant that each project experienced some unplanned/unintended events. Problems common to all projects were system malfunctioning and the limited availability of systems for the project. Other problems related to disc separations, changes in equipment by the client, manufacturer non-support of software and delayed delivery of production equipment. Manufacturer delays in equipment delivery was also identified by Klotz (1983). These unplanned/unintended events occurred frequently enough and caused large enough time delays and cost effects to be significant. Unplanned/unintended events related to hardware and software will continue to occur. Budgets and schedules should be planned to accommodate these events. The difficulty lies in predicting a time and cost percentage since the problems vary and so will the effects on time and cost vary.

Studies of the percentage of time and percentage of cost created on projects by unplanned/unintended events would be useful data for establishing realistic values to insert into time and cost algorithms used for time and cost budgeting. By using a statistically appropriate sample, one could also establish some prediction levels of the likelihood of certain types of problems occurring with corresponding time and cost percentages.

Research Question 11: When and under what circumstances do unexpected costs occur on an IVD project?

A series of unrelated, unexpected costs were encountered on each project. These costs were due to software changes, redo of invalid content, new systems replacing old systems, unexpectedly long programming times, shipping costs and added travel. Like unplanned events, unexpected costs will always occur on a project. Again, the type of problem and the effect on time and dollars is unpredictable. Data are required to provide percentages of costs which occur due to unexpected problems. Similar studies as outlined in Research Questions 8, 9, and 10 would provide the required data to develop more predictive cost percentages.

Research Question 12: When and under what circumstances do unexpected time delays occur in IVD projects?

Time delays occurred across all projects. Many of the delays were attributable to the client's change of hardware, courseware design and/or software. Time was consistently affected by changing of graphics packages which generated a need to reprogram. Further, each project experienced time delays because of equipment malfunctioning. Delay varied from one day to several weeks. The more scarce the equipment, the greater the project delays. Technology, particularly new and emerging technology, will continue to increase time on Level 3 IVD projects. It is important to conduct research which would help delineate the percentage of time. Such data would be valuable for establishing realistic timelines. The conduct of research similar to that listed in Research Questions 8, 9, and 10 would provide the data necessary to establish time guidelines.

General Recommendations

After carefully reviewing the data and results of this study it appears valuable data could be obtained by conducting another study, using the case methodology, of Level 3 IVD projects with a fixed price contract which did not incur a time or cost overrun. A comparison with the data of this study would help to identify differences between projects incurring cost overruns and those completing work within budget. Further, if similar problems do occur, valuable data could be collected on how the problem was handled to avoid the negative time and/or cost effects.

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APPENDICES

APPENDIX A

PRODUCT DESCRIPTION/COST DECISION WORKSHEETS

PRODUCT DESCRIPTION/COST DECISION WORKSHEETS

I. CBT Approach

Characteristics	Costs*	Total
Drill & Practice	$3,000	________
Tutorial	4,000	________
Simulation	7,000	________
Game	8,000	________
	CBT APPROACH TOTAL =	________
	(MAXIMUM = $22,000)	

II. Instructional Design

Characteristics	Costs	Total
1. Interactivity: (learner interacts with CBT e.g. through questions, responses or other activities)		
highly interactive	$20,000	________
moderately interactive	14,000	________
minimally interactive	8,000	________
2. Prompts:		
every question	3,000	________
key questions only	1,000	________
3. Help Function:		
extensive	1,000	________
moderate	500	________

*n.b. Cost figures not based on actual dollar value, meant to indicate relative value only.

II. Instructional Design (con't)

Characteristics	Costs*	Total
4. Summaries:		
frequent	$2,000	____
occasional	1,000	____
5. Learner able to make comments	10,000	____
6. Learner able to skip ahead without answering	4,000	____
7. Feedback:		
Feedback presented for wrong answer responses	1,000	____
Feedback presented for correct answer responses	1,000	____
Answer judging	3,000	____
Records kept on student performance	1,000	____
8. Learner Control		
1. Learner able to move around within course	3,000	____
2. Learner to answer correctly before moving on	500	____
3. Learner allowed out of question after 3 tries	500	____
4. A main menu describing options to learner	500	____
5. Help menu	500	____
9. Learner adaptation (learners name incorporated into feedback)	1,000	____

INSTRUCTIONAL DESIGN TOTAL = ____

(MAXIMUM = $76,500)

III. Graphics/Screen Design

Characteristics	Costs*	Total
1. Split screen: (horizontal or vertical)	1,000	________
2. Sound:		
- frequent	3,000	________
- occasional	1,000	________
3. Animation:		
- frequent	8,000	________
- occasional	4,000	________
4. Pace:		
- fast	5,000	________
- medium	3,000	________
- slow	1,000	________
5. Color:		
2 colors	3,000	________
ea. additional color	1,000	________

GRAPHICS/SCREEN DESIGN TOTAL = ________

(MAXIMUM = $29,000 with 2 colors)

IV. Technical Issues

Characteristics	Costs*	Total
One disc course (approximately 1 hour of instruction)	$10,000	______
Self-booting (program automatically loads from operating system)	15,000	______
booting-up instructions in documentation	3,000	______

Compatible with (will run on):

IBM PC (or compatible)	5,000	______
DEC Professional	5,000	______
Apple IIE	3,000	______
Wang PC	3,000	______

TECHNICAL ISSUES TOTAL = ______

(MAXIMUM = $44,000)

SUMMARY WORKSHEET

COST DECISIONS	TOTAL
I. CBT Approach	$________
II. Instructional Design	________
III. Graphics/Screen Design	________
IV. Technical Issues	________
TOTAL FOR ONE-HOUR COURSE (MAXIMUM=$171,500)	$________
FOR EACH ADDITIONAL DISC ADD 40% OF TOTAL (HOUR OF INSTRUCTION)	$________
GRAND TOTAL	$________

APPENDIX B

STUDY INTRODUCTION TO CLIENT

LEVEL 3 INTERACTIVE VIDEODISC STUDY

This study is being undertaken in an effort to generate baseline knowledge of the problem variables, processes and interactions in the analysis, design, development and production of Level 3 Interactive Videodisc programs for training in industry and government which affect the final cost and time to produce the product. Below you will find further information which will outline your role as a participant in this study.

OBJECTIVE: To collect empirical facts about Level 3 IVD development and production time and cost factors which create cost overruns.

PARTICIPANTS: Companies who have produced Level 3 IVD programs for training in industry and/or government on a contract basis.

PROCESS: This study is built around the in-depth analysis of projects (cases) which have been completed and which have incurred a time and/or dollar loss. To collect the information necessary for the analysis, the following steps need to be performed:

- In-person interviews will be conducted with staff who planned, analyzed, designed, developed and produced the disc. The roles performed may include project director, instructional designer, programmer and video producer.

  Each interview will take from one to two hours depending on the complexity of the project and the activities which generated problems in the process. The source of all information will be kept confidential.

- The initial interviews may be followed by telephone interviews to clarify and expand information which may either not have been clear from the initial interviews or overlooked during the interviews.

I wish to thank all participants in advance for your time and cooperation. I will be happy to share the final findings with all participants in this study. If you are interested in the findings, please don't hesitate to contact me at:

Clara Steier
1041 Shaffer Trail
Oviedo, FL 32765
305/365-2603

APPENDIX C

INTERVIEW GUIDE

APPENDIX C

INTERVIEW GUIDE

IVD COST AND TIME FACTOR STUDY

The following interview guide was adhered to only as a checklist, since the recommended procedure for collecting data for the case study method was to permit the interviewee to control the conversation. Thus, logical sequence was not necessarily followed. It was the responsibility of the interviewer to make sure that all areas of interest were covered. Accuracy was checked through reviewing audio tapes of the session. The areas listed below did not occur in all projects. The study focused on the problem areas in each project. Provisions were made for follow-up phone calls to clarify data and collect missed data.

A. INTERVIEW RECORD IDENTIFICATION DATA (These data will be recorded verbally and in writing on a label on each tape)

Date: ____________________

Company: ____________________

Interviewee: ____________________

Position on Team: ____________________

Telephone: (   ) ____________________

Address: ____________________

____

B. INTRODUCTION OF MYSELF AND THE STUDY TO INCLUDE (Project Director or company contact)

1. Elicit cooperation.

2. Provide confidentiality guarantee by presenting of copy of the introductory letter to the study (This letter may have preceded in-person interview in many cases).

3. Ask permission to see products and documentation where appropriate.

C. ELICIT A DESCRIPTION OF THE PROJECT TO SET INTERVIEWEE AT EASE (All participants)

4. Description of client to include type of organization and client knowledge and experience in interactive video.

5. Size of project.

6. Content type.

7. Equipment type and amount.

8. Degree of project completeness (up to implementation)

9. Obtain an overall view of the interviewee's assessment of the problematic areas (e.g., design, scripting, or programming).

10. Determine interviewee terminology and definitions.

D. GENERAL INFORMATION (Project Manager)

11. Descriptive information about the contracting company for the development of interactive videodiscs:

    a. Company Name: ______________________________

    b. Company Size (number of people and skill types)

    ____

    ____

    c. Company Description: ______________________________

    d. Organization (Generalists or specialists in Departments

    ____

    e. Experience in interactive videodisc:

        (1) Number of projects __________
        (2) Levels (1, 2, 3 or 4) __________
        (3) Client(s) (same or different) __________

    f. If previous disc experience:

        (1) How similar are completed projects?
        (2) What is the team composition for the projects (same or different)?

g. Staffing:

(1) What type of credentials do you require?

(2) How much individual experience do team members have in interactive video? or in related areas as CAI? linear video?

h. Staff Training:

(1) What kind of training was provided to staff working on the project?

(2) How and by whom was the training conducted? When?

- Professional meetings and workshops
- In-house by an employee or an outside firm

12. How often did you meet with the client and for what purposes?

13. What kind, if any, decisions were made by phone with:

a. the client
b. production houses
c. other

E. ANALYSIS PHASE (All subjects)

14. How would you define analysis?

15. Describe your role in the analysis phase?

a. How did you begin the work on this project?

(1) Determine needs
(2) Set goals
(3) Collect and analyze tasks
(4) Select hardware or software or both

16. What type and number of client meetings were held during and after completion of the analysis?

17. Can you describe how you conducted your task analysis?

18. Who did the analysis? How many people were required to complete the analysis?

19. What prior experience did you have doing analysis for interactive video?

20. When and how did you select the hardware? software?

21. What criteria did you use to select the hardware?

22. When did you contact the mastering facility and for what?

a. Input devices
   - joysticks
   - mouse
   - touch screen
   - tablet or bit pad
   - voice actuation
   - graphic overlays
   - movement recognition
   - light pen
   - bar code reader
   - keyboard

b. User controls
   - scan
   - stop
   - fast
   - slow
   - freeze

c. Ease of Use
   - language
   - controls

d. Visual clarity
   - resolution
   - other

e. Added features
   - range of color
   - operation
   - cost
   - availability

f. Predetermined by client

g. Maintenance or repair

23. Staffing:

a. What people did you have to interact with during this phase?

   (1) Skills and knowledge (designers, developers, producers, programmers, other)

b. Can you describe the interactions between team members?

   (1) Kind
   (2) Amount

F. DESIGN PHASE (All subjects)

24. How would you define the design phase?

25. Describe your role during the design phase?

    a. How did you begin your work in this phase?

        (1) Select re-usable film, audio, graphics
        (2) Establish objectives
        (3) Establish performance measures
        (4) Develop management plan
        (5) Develop formats

26. What type and number of client meetings were held during and after completion of the design work?

27. How many people were involved in doing the design work?

28. What prior experience did you have in design for interactive videodisc?

29. Staffing:

    a. What people did you have to interact with during this phase?

        (1) Skills and knowledge (designers, developers, producers, programmers, other)

    b. Can you describe the interactions between team members?

        (1) Kind
        (2) Amount

30. Describe the processes and procedures you used to:

    a. Select re-usable film, audio, graphics
    b. Establish objectives
    c. Establish performance measures
    d. Develop management plan
    e. Develop formats

31. How was the design affected by the analysis work?

32. What decisions made in analysis affected the instructional features used in this design phase?

    a. Hardware
    b. Software
    c. Content

G. DEVELOPMENT PHASE (All subjects)

33. How do you define the development phase?

34. Describe your role during the development phase?

35. How did you conduct the work of the development phase?

    a. Outline the content, interactivity and use of still frames

    b. Draft script and storyboard

    c. Develop display formats

    d. Reviews of scripts, storyboards for content, style, feasibility

    e. Design and develop the computer program

    f. Conduct formative try-outs

    g. Plan effects, animation

    h. Other

36. What type and number of client meetings were held during and after completion of the development work?

37. What prior experience did you have for doing development work in interactive videodisc?

38. How was the development work affected by the:

    a. Analysis phase?
    b. Design phase?

39. Staffing:

    a. What people did you have to interact with during this phase?

        (1) Skills and knowledge

    b. Can you describe the interactions between team members?

        (1) Kind
        (2) Amount

40. How was the development work affected by:

    a. Hardware
    b. Software
    c. Content

41. Can you describe the procedures you follow which were different from any other instructional medium development work?

    a. Flowcharting
    b. Scripting
    c. Storyboarding
    d. Other

H. PRODUCTION PHASE (All subjects)

42. Can you give me your definition of production?

43. Can you describe your role in the production phase?

44. How would you describe your procedures and activities during production? Typical production activities include:

    a. Preparation of production list, final script

    b. Coding

    c. Obtaining masters of existing materials used (audio, motion, stills, etc.)

    d. Contracting talent and music if needed

    e. Layout of disc

    f. Planning production

    g. Produce, review/approve video text, frames, animation

    h. Produce and review/approve art, photos, print materials

    i. Shoot location video

    j. Shoot studio video, record, edit

    k. Review and approve audio and video

    l. Preliminary edit

    m. Make edit master tape (with effects)

    n. Review/approve master tape, print materials

    o. Have master tape made into disc

    p. Review and approve disc-coded tape

q. Review returned Check Disc

r. Write computer program

s. Test and debug program

t. Calculate frame numbers from master tape, enter program

u. Enter final frame numbers in program

v. Debug and refine program

45. What parts of the production were done:

    a. In-house?
    b. With external sources?

46. What prior experience did you have in doing interactive videodisc production? other related experience?

47. Staffing:

    (a) What people did you have to interact with during this phase?

        (1) Skills and knowledge (designers, developers, programmers, producers, other)

    b. Can you describe the interactions between team members?

        (1) Kind
        (2) Amount

48. How was the production phase affected by decisions and activities of the:

    a. Analysis phase
    b. Design phase
    c. Development phase

49. How was the production work affected by:

    a. Hardware
    b. Software
    c. Content
    d. Other

50. What type and number of client meetings were held during and after completion of the production work?

51. Can you describe the product revision process which you used, if any?

52. How did you control the quality and performance of the mastering house?

53. Describe the processes which are unique to interactive videodisc in the production phase?

I. BUDGETING (Project Director, ID, Programmer, Video Producer)

54. What was the original cost bid without overhead and profit dollars? (If willing to reveal).

55. What was the final (actual) cost? (If willing to reveal).

56. If subject is unwilling to reveal actual figures:

    a. Can you tell me how much over and under you were in cost by percentage (i.e., 5%, 10%, etc.)?

    b. Can you tell me how much over or under you were in cost by percentage in each phase?

57. What data were provided by the client contracting for the interactive videodisc?

    a. Can you describe the type of information provided?

    b. Sufficient level of information?

    c. What interaction was there between contractor and client before the proposed bid?

    d. What parameters and restrictions were placed by the client in:

        (a) Hardware
        (b) Content
        (c) Time
        (d) Instructional features
        (e) Software
        (f) Other

58. Who established the project cost? and how did you go about the process?

    a. Entire interactive videodisc team
    b. Individual
    c. Contracts department
    d. Other

59. What IVD software and equipment did you have in-house when you decided to bid on the project?

60. How were in-house materials used?

61. What, if any, types of information (equipment/hardware/ software) were investigated before the bidding or contracting?

62. How did you select and contract staff for the project?

63. What types of individual skills and resources were allocated for acquisition after award of the contract? In what amounts or numbers?

    a. Staff
    b. Equipment
    c. Software
    d. Facilities

64. What kind of assumptions did you make, if any, when you bid the project?

65. Can you describe the modifications you would make to your costing of future contracts for Level 3 interactive videodisc?

END OF INTERVIEW GUIDE