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CONTRIBUTIONS TO ADULT LEARNING BY COMBINING EXPERT SYSTEMS AND OPTICAL DATA STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED INSTRUCTION

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Timothy McLaughlin

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CONTRIBUTIONS TO ADULT LEARNING BY COMBINING EXPERT SYSTEMS AND OPTICAL DATA STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED INSTRUCTION

By

Timothy McLaughlin

A DISSERTATION

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ABSTRACT

CONTRIBUTIONS TO ADULT LEARNING BY COMBINING EXPERT SYSTEMS AND OPTICAL DATA STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED INSTRUCTION

By

Timothy McLaughlin

The purpose of this research was to determine expert judgements about possible technological combinations of expert systems and optical data storage systems that might occur within the next five years (1991 - 1996) and to determine the impact such combinations could have on adult learners if applied in the education and the training fields. This research sought to raise the awareness of hardware and software developers, trainers and educators as to the opportunities that exist for adult learners if instructional systems based on an expert system and an optical data storage medium were introduced into adult education settings.

Three rounds of the Delphi technique were conducted with 74, 68 and 67 participants in each respective round with 49%, 49% and 60% return rates. The participants were composed of instructional technology professionals, trainers, expert system researchers and developers, and optical data storage system developers.

The major findings from this research were as follows: Participants predicted that it will be possible to combine an expert system with an optical data storage technology (eg. CD-ROM, interactive video, CD-I) in CAI within the next five years. Such an instructional system could benefit adult learners by:

1. providing instruction that is individualized for each learner,
2. creating performance support systems at the work site,
3. increasing the portability of computer assisted instruction systems to the degree that learning would not have to occur in the formal computer laboratory setting.

However, it was also noted that the effective application of these combined technologies in an instructional system for adult learners may be hindered by:

1. production costs,
2. the technical and production difficulties of creating such systems,
3. the technical and production difficulties of updating such systems,
4. the lack of cost/benefit analyses which demonstrate the value of these instructional systems.

Also noted in this research was the broad understanding across the professional areas of the contributions that could be made to adult learners though combining these technologies. Of the 64 statements generated from the 153 initial ideas in Round One, only three statements were unique to any one professional area.

Dedicated to My Mother, Eileen McLaughlin

and

My son Wesley McLaughlin, as he looks to the future.

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CHAPTER I

Introduction

When Dustin Heuston was the CEO of WICAT Systems, a major software company, he commented that if a process could improve the productivity of the 25 students in a classroom rather than being focused on the improvement of one teacher, it would be making an extraordinary contribution (Van Horn, 1991). The implication of this statement is that, for too long, the focus of change in educational and training has been on teaching rather than learning. Van Horn (1991) echoed this thought by saying:

> ...we must concentrate our reform efforts on learners and not on teachers. ... When we invest in new technology, we must invest in new learning systems, not in new teaching systems.

The purpose of this research was to determine expert judgements about possible technological combinations of expert systems and optical data storage systems that might occur within the next five years (1991 - 1996) and to determine the impact such combinations could have on adult learners if applied in the education and the training fields. In addition, it was hoped that the participants in the study, a number being software developers, as well as public educators and corporate training personnel, would be encouraged to develop and/or utilize software products containing the linkages identified by the study.

This chapter addresses the problem under consideration and the rationale for this study. The theoretical base for this study is developed and limitations of the study are discussed. In addition, definitions of key terms are given. The chapter concludes with an examination of how the study was organized.

The Problem

Education and training systems have always faced the problem of matching the instruction to the student. Most obvious, in this match, is identifying what a student knows upon entering instruction and then customizing the learning experience to focus on what needs to be learned. Less obvious is the matching of the instruction to the learning style of the student. Skipper (1985) points out that the most effective instruction matches the learner's style. Ast (1988) supports this by stating:

> It is reasonable to assume that the learning of all students would be enhanced if they were taught in a manner conducive to their individual learning style(s).

While the earlier research of Scerba (1979) and MacNeil (1980) indicated that there was no significant increase in learning when learning style and teaching style were matched, the more recent research of Dunn and Griggs (1988), Garlinger and Frank (1986), Shelby (1985) and a paper presented by Ast (1988) support the matching of learning and teaching styles in order to increase learning. However, learning style is composed of elements from cognitive, affective, and physiological aspects, that can combine in infinite patterns. Thus, it follows that an individual's learning style is unique (Ast, 1988). How, then, can even an aware teacher match instruction to each of the students in the classroom?

Another issue plaguing education and training is identifying the pace at which the learning is to occur. Too rapid a pace can cause unreasonable pressure and frustration for the learner. Excessive amounts of remediation can destroy the motivational effects of a steady challenge (Daniel & Cox, 1989).

Computer-Assisted Instruction (CAI) has, for years, offered the promise of greater capabilities in being able to analyze the learner's instructional needs, learning styles, and pacing in an attempt to match the instruction to the learner. Some stand alone computer programs have addressed these areas of analyzing the learner's instructional needs, learning styles, and pacing. Two Computer Managed Instruction (CMI) programs that have been developed to assist with the assessment of students needs are The Computerized Test of Reading Comprehension and the Computerized Test of Spelling Errors (Chadwick and Watson, 1986).

Other software programs, such as the Learning Styles Inventory and HILI (How I Learn Inventory), are designed to identify a student's preferred learning style. Cosky (1980) points out that once a student's learning style is identified, instructional strategies, activities, media, and assessment used in computer-assisted instruction should match that style. However, a study by Clariana and Smith (1988) indicates that there is a shift in student learning style preference in CAI environments. Consequently, a computer-based program designed for students originally assessed with a particular learning style may not provide evaluation materials that match the student's learning style by the end of the program.

Pacing was studied at the Yeoman "A" School at the Naval Technical Training Center, Meridian, Mississippi. The data from this study indicated that computer assisted self-paced instruction produced significantly higher achievement than did non-computer assisted self-paced instruction, which was being used at the time (Enochs et. al., 1984).

As illustrated above, the current application of computers to address the instructional issues of needs analysis, learning styles and pacing is through separate software programs. The combining of these into a single instructional package is still on the horizon but the combination of these applications is not the only issue. Can the needs of the learner, the learning style and the pace of the instruction be monitored throughout the instruction and modified to match the changes in the learner in order to maintain motivation?

The answer to this question may be in a specialized area of Artificial Intelligence (AI) called expert systems.

Adams and Hamm (1987) describe an expert system as a computer program consisting mainly of a set of rules and knowledge contained in a database also referred to as a knowledge/rule base. Unlike most computer programs which follow a predetermined sequence, expert systems use sets of these rules in an unordered fashion to evaluate information against their knowledge base and then report the best match between the input information and the knowledge base. Ruyle (1989) describes this operation of an expert system as one of gathering evidence using an heuristic approach (an exploratory approach using successive evaluations of trial and error) to solve a problem.

An expert system monitoring the learner's input and comparing it to a knowledge/rule base using sets of unordered rules for needs analysis, learning styles, and pacing may prove to be the tool that draws these areas together. Such a system interacting with the student may make it possible to continuously adapt the learning environment to each individual student.

The database necessary for such an expert system would, undoubtedly, need to be very extensive and require a medium of mass storage. One acceptable medium may be in optical storage. The basic optical storage technology for a 12cm (4.72 inch) compact disc-read only memory (CD-ROM) provides for a capacity of approximately 550 megabytes (MB) of data and advancements may increase this by a factor of four (Magel, 1990). Optical storage media have other advantages

as well. At present, 72 minutes of audio (Gery, 1989) and varying amounts of still and motion video, depending on the display resolution (Magel, 1990), can be supported. In a learning situation, the data for the expert system, as well as the data (program controls, text, numbers, etc.) for the material to be learned, the audio and the video could all be combined on the same optical disc. If one disc proved to be insufficient, technological solutions such as Jukeboxes, which automatically change 6 discs, and daisy chaining up to seven CD-ROM drives together can greatly increase storage capacity (Magel, 1990).

The video component of optical discs may be an, as yet, untapped technology in learning. Gery (1989) believes that the vast majority of optical disc applications are strictly for information storage and a survey of companies with 100 or more employees, conducted in 1990 by Training Magazine, found that 88.7% of the companies were using videotape as an instructional method but only 15% used some form of interactive video (Gordon, 1990). Donohue and Donohue (1977) suggest the importance of video in learning as it imparts a "live look" when compared to the same content on film and is considered by the viewer to be more esthetically pleasing. Since television is our most common means of visual communication this finding is not surprising. With the introduction, several years ago, of constant angular velocity (CAV) video discs and other optical storage technologies, CAI can now include high quality images and 30 minutes of full motion video in the visual format that most viewers relate closely with reality.

Finally, instruction should be both valid and reliable, actually delivering what it promises, and delivered with consistency. One of the most problematic issues for instruction and training is that of validating the instruction and then providing consistent delivery for what was validated. Presently, once the instruction is validated, CAI has the ability to provide reliable delivery to the targeted population.

The larger problem that all of this is driving toward is found in adult education. Adult learners, those who have left the formal education system either as drop-outs or graduates, re-enter formal education with very diverse backgrounds. Brookfield (1986) summarizes this as:

> ...a collection of experiences, skills, and knowledge, that are going to influence how new ideas are received, how new skills are acquired and how the experiences of others are interpreted.

With regard to the impact this has on instruction Brookfield continues:

> Hence, as educators we can never predict with total certainty how one adult (let alone a group) will respond to being presented with new ideas, interpretations, skill sets, experiences, or materials.

In this adult setting, the educator's role becomes one of a facilitator whose function spans a broad spectrum.

For the self-directed learner with a high degree of self-knowledge and critical awareness the facilitator's function may be solely that of a guide (Knowles, 1984). But for those learners who require direction in order to progress through the instructional materials, a more structured approach may be in order to challenge them to consider alternatives and expand their paradigms (Brookfield, 1986).

In summary, the apparent advantages of identifying what a student needs to learn, the student's learning style, appropriate pacing, and accommodation of diverse backgrounds raised the initial questions which prompted this study. First, does the technology exist today, or will it exist in the near future, that will allow adults to benefit from computer-assisted instruction which utilizes a combination of expert system and optical data storage technologies? Second, could combining these technologies in computer-assisted instruction result in an improved ability of the computer system to match the instruction to the learner by identifying the student's learning needs, learning style, adjusting the pace and utilizing the learner's background of experiences? And, third, what additional benefits may result for adult learners from a combining of these technologies?

The Purpose of the Research

The purpose of this research was to determine expert judgements about possible technological combinations of expert systems and optical data storage systems that might occur within the next five years (1991 - 1996) and to determine the impact such combinations could have on adult learners if applied in the education and the training fields. It was the researcher's expectation that the insights offered by the expert participants making up the subjects of this study would suggest a greater degree of interaction between the learner and the computer, with the role of the computer being to continually monitor, assess and adjust to the learner's needs and changes in learning style. The computer program would also adjust to the learner's pace, producing a constant challenge, while presenting material at a level of sophistication that would neither patronize nor belittle the adult learner.

The researcher was also optimistic that the results of this study would stimulate the participants, a number being software developers, as well as public educators and corporate training personnel, to develop and/or utilize software products containing the linkages identified in this study.

Definition of Terms

In this section, major terms that were used in this study are defined.

Andragogy is the "art and science of helping adults learn" (Knowles, 1984).

Adult education is based on the andragogical model of education which emphasizes "that the purpose of education is the development of learning skills and the continued practice of those skills throughout the lifetime (Peterson, 1987)."

Adult learner is a term that is not definable by age (Krupp, 1982). Knowles (1973) states that an adult learner is one who shows self-direction and autonomy. Levine (1981) defined adult learners as those individual who are self-directed, rich in experience, concerned with their development, problem focused, and desiring immediate application of what they have learned to the problem at hand.

Computer-assisted instruction (CAI) "involves the use of the computer for direct contact with the learner. In this capacity the computer can be used for practicing recently acquired skills. It can also be used to teach new skills (Hofmeister, 1984)."

Computer-facilitated learning (CFL) involves the use of the computer for direct contact with the learner, with the learner and computer interacting to create a learning

environment appropriate for the individual student along the pedagogy/andragogy continuum. This learning environment may range from instruction directed entirely by the computer to self-directed learning on the part of the student. The computer is concerned with the diagnosis of pupils' strengths and weaknesses, adjusting to changes in the learning style and modifying the pace of the instruction to maintain student motivation.

Computer-managed instruction (CMI) "is concerned with the diagnosis of pupils' strengths and weaknesses, the prescription of learning activities based on this diagnosis, and the monitoring of these learning activities. When the computer is being used for computer-managed instruction, it is not necessary for the [student] to come into direct contact with the computer" (Hofmeister, 1984).

Constant angular velocity (CAV) video disc "A CAV disc revolves continuously at 1800 rpm, one revolution per frame, making each frame of the disc addressable. This feature is a basic requirement for interactive videodiscs" (Daynes, 1982), enabling the random selection of information on the disc.

Constant linear velocity (CLV) video disc "A CLV or 'extended play' disc maintains a consistent length [of space on the disc] for each frame, thus enabling longer playing time per side, but sacrificing individual frame addressability" (Daynes, 1982). The rotation rate of the

disc varies to maintain a constant speed for each frame as it is read by the laser.

Delphi technique is a process of soliciting and deriving consensus from a group of individuals through written responses to questions without bringing the individuals together. The data from the first question provide the direction for writing a question to be used in the next round, and so on until the desired number of rounds is completed.

Expert systems are software programs that emulate the way people solve problems. These programs "contain both declarative knowledge (facts about objects, events, and situations) and procedural knowledge (information about courses of action) to emulate the reasoning processes of human experts in a particular domain" (Mishkoff, 1985). Like a human expert, they request information about the problem under consideration and then draw upon their own store of knowledge to give advice (Moose & Shafer, 1987) or to perform some task (Carr, 1989).

Functional Literacy is the possession of the essential knowledge and skills that enable an individual to function effectively in his or her home, community or the workplace. It is literacy defined by stressing it's functional aspects (Worthington, 1984). Brocklehurst (1980) quotes Sheila K. Hollander, Adelphi University as saying:

> Functional literacy is defined on the basis of specific tasks. In other words, you are asking, 'literacy for what?' Do you want to check your bank statement, or do you want to write a letter of

> complaint to a business or firm? ... We are all illiterates at certain tasks, but if we define functional illiteracy specifically, then we have a better chance of attacking it, because we can take tasks that adults have to deal with, and using reality, help people learn to do the things that they have to do.

Heuristic Approach is an exploratory approach to a problem using successive evaluations of trial and error to arrive at a final result (AECT Task Force, 1979).

Information society describes the shift to a new economic era in the United States when, in 1956, white-collar workers in technical, managerial and clerical positions outnumbered blue-collar workers in the workforce. Today, our economy is based not on industry, but on the production and distribution of information (Naisbitt, 1982).

Instructional Technology Professionals are those individuals involved with designing, planning and managing training programs and who work to promote maximum utilization of educational techniques and media that are effective in practical use (AECT Membership Directory, 1990).

Learning Styles "are characteristic cognitive, affective, and physiological traits that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment (Keefe, 1987)." An earlier work by Cornett (1983) elaborates on these traits suggesting that the cognitive aspects of this definition includes the ways learners decode, encode, process and retrieve new information. The affective aspects comprise emotional and personality characteristics including such areas as motivation, attention, interests, willingness to take risks, persistence, responsibility and sociability. Sensory perception (auditory, physical manipulation, smell, taste, visual), environmental conditions (noise level, type of lighting, arrangement and temperature of the room) and the times of day for optimum learning compose the physiological component of the definition.

Needs Analysis is the identification of gaps between an individual's current skill level and the expected skill level, assessing the suitability of training or education to close the identified gap, and prioritizing the sequence of closing these gaps (Sullivan et al., 1990, Sredl and Rothwell, 1987, Mehrens and Lehmann, 1984).

Pace is the rate at which new instructional material is presented to the learner.

Pedagogy/Andragogy Continuum - The range of learning styles, appropriate with all age groups, from directed learning along a spectrum to self-directed learning.

Pedagogy is the "art and science of teaching children" (Knowles, 1984).

Self-directed learning "describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes" (Knowles et al., 1984).

Importance of this Research

Functional literacy in this country received national attention in 1983 when the nationally commissioned study, A Nation At Risk: The Imperative for Educational Reform, reported that 23 million American adults, 13 percent of all 17-year olds and as high as 40 percent of minority youth were functionally illiterate (Gardner, 1983). More recently both David T. Kearns, Chairman and CEO of Xerox Corporation, and Adam Smith, of Adam Smith's Money World, pointed out that American public high schools are currently graduating 700,000 functionally illiterate students every year ("Experience For Hire", 1990). In addition, the Literacy 2000 Task Force in Wisconsin (1988) reported that the state had 492,720 adult residents who were at or below the level of functional literacy, with another 412,720 considered to be "at-risk." The Literacy 2000 report continued, indicating that, nationally, over 54 million adults are functionally illiterate and at-risk literate ("Report of the Literacy 2000 Task Force", 1988). These functionally illiterate adults, including the high school graduates, need to learn additional skills in areas such as reading, writing, speaking and computing to be able to perform in our increasingly complex information society.

Brookfield (1986) suggests that the best method for these adults to use in learning their new skills exists somewhere on the continuum between directed learning and self-directed learning, depending on the time and the purpose of the learning. The facilitator's role, in this learning, is to identify the juncture where the learner falls on the continuum so as to provide the most effective and efficient learning environment for the individual student.

Functional illiteracy is not only the result of inadequate preparation to enter the work force, but also the result of a fast-changing workplace, a workplace in a market where, as Geber (1990) points out, the company that doesn't get it's products and services to the market faster than the competition, loses. As such, keeping the work force, be it blue collar or white collar, current with changes in the workplace must be done with as little disruption to productivity as possible. Taking large numbers of employees through instructor-led classroom training is rapidly becoming impractical for businesses. Why should an employee be taken out of the production process to spend a day or more in instructor-led training designed to cover the needs of many when the individual needs only a portion of the material to upgrade his/her skills? Again, the assumption is that a facilitator could provide an appropriate learning environment.

Another example, from the workplace, is the new employee who needs to acquire skills or understand company procedures to carry out his/her duties effectively. Large companies may hire new middle managers, on average, once every two months. How should these individuals be trained in company procedures? If classroom training is delayed until there are six new middle managers, the first hired is already twelve months into the job. Much of what was needed, initially, to perform the job has already been learned on-the-job, possibly through trial and error. This individual's needs, therefore, may be very different from the person last hired. Again, the need is for a facilitator to identify the appropriate learning environment.

The need for adults to acquire and maintain functional literacy is evident when looking at the resources invested in training in this country. According to Training Magazine's Industry Report 1990 survey of 2,645 U.S. companies (a 22 percent return rate) with 100 or more employees, 45.5 billion dollars were budgeted for formal training in 1990. This money would provide 39.5 million individuals with 1.2 billion hours of training. The area where most of this training would be focused was on new employee orientation. However, 15 percent of the organizations responding indicated that they provide remedial education in basic skills (Lee, 1990).

Forty one percent of the companies responding to Training Magazine's 1990 survey indicated they used computer-assisted instruction (CAI). Of these CAI users, 84 percent used the CAI to teach computer related skills. Twenty-six percent indicated that the computer-assisted instruction delivered training in technical skills not related to operating a computer and only 17 percent use the computer for non-technical training (Gordon, 1990). This 17 percent of those companies using CAI translates to just under 7 percent of all those organizations responding to the survey. With 15 percent of the organizations offering remedial education in the basic skills, these figures indicate that less than half the organizations offering basic skills education may be using CAI as a delivery method.

As the 1990's begin, training budgets appear to have flattened. Training departments are going to be expected to do more with less (Gerber, 1990). In examining the cost, the single most expensive component of virtually all training is the time the trainees are away from the job (Carr, 1989). An expert system acting as a facilitator, or in Gerber's (1990) term a "performance support system," could reduce training time. This could be done by teaching individuals how to use the performance support system instead of teaching all the material contained within the performance support system (Carr, 1989). Training time would be reduced to the amount needed to operate the performance support system. As questions arise, on the job, the employee would not have to take the time to attend special training sessions because the question could be answered at the job-site using the performance support system. It is also noted that through the 1980's computer-based and interactive video discs training delivery systems have been studied extensively and:

> Overwhelming evidence shows that under the right circumstances these forms of delivery are considerably more cost-effective than classroom training and produce learning that is at least equal to what can be achieved in a classroom (Geber, 1990).

The importance of this research is in attempting to identify linkages between the technologies of expert systems and optical data storage for the purpose of developing computer-facilitated learning at the adult level. The researcher hopes that once these linkages are identified, public education, corporate training departments and software developers will apply them to new products aimed at increasing and maintaining functional literacy in this country in a cost efficient manner.

Value of this Research to Educational Technology

The researcher believes that the results of this research could stimulate the development of new models for adult instruction, involving a greater amount of interaction between the student and computer, possibly to the degree that the computer takes on more of a role as "facilitator" than an "instructor" in the learning process.

In assuming this facilitator role the computer might engage the learner in more of a dialogue, offering suggestions on a course of action for the learner to take and being more responsive as to what the learner wishes to accomplish.

Hardware and software developers and users might become more sensitive to the possible contributions of systems allowing for increased self-direction of learning combined with real-time video, possible obstacles to developing such systems, and the possible solutions to the problems forecast in this research. This, in turn, could stimulate hardware and software developers to begin more pilot projects combining these two technologies.

Another result of this research might be to encourage the consumers of CAI to look for materials that were developed based on the results of this research. Utilizing just the capabilities of the expert systems discussed here, educators and trainers would have the ability to identify a student's or trainee's learning style and instructional needs. This information could guide the instructor in selecting instructional modes (variables) that best suit the student.

From the perspective of research, data could be kept on how students and trainees progress through the materials they are learning. This information might provide greater insight into how adults learn, how particular subjects are best learned, or how instruction may be improved.

Theoretical Base for the Study

The primary theoretical foundation of this research is based on the adult learning theories and models proposed by: Knowles (1984) - andragogy, Cross (1981) - Characteristics of Adults As Learners (CAL), McClusky (1963) - Theory of Margin, Knox (1980) - Proficiency Theory, Mezirow (1981) - Perspective Transformation, Freire (1970) - Theory of Conscientization, and Brookfield (1986) - transactional encounter. Each of these theories or models examine aspects of adult life that can have an impact on the ability to learn. Andragogy characterizes the adult learner as: 1) being self-directed, 2) having a large experience base, 3) being ready to learn as a result of some need to acquire new knowledge or skills, 4) having a problem-centered orientation to the learning, and 5) being intrinsically motivated (Knowles, 1984). The CAL model examines the personal characteristics of: 1) physiological aging, 2) sociocultural phases, and 3) psychological stages; and the situational characteristics of full-time versus part-time learning and compulsory versus voluntary learning (Cross, 1981). The Theory of Margin focuses on an adult's life situations, the demands placed on the adult and the resources available to deal with those demands (McClusky, 1963). In a similar manner Proficiency Theory is also concerned with the adult's life situation. In Proficiency Theory the adult recognizes that there is a discrepancy between the current level of some performance in their life and the desired level of performance (Knox, 1980). Perspective Transformation focuses on adults critically reflecting on how and why past experiences have created and shaped their life. Such a self evaluation may reveal distorted, inauthentic or otherwise invalid assumptions governing the adult's life (Mezirow, 1981). Conscientization also places the adult learner as one involved with critically looking at their life situation and then having the capacity to change that situation (Freire, 1970). Finally, transactional encounter characterizes the adult learning process as being a dialogue between the learner and the facilitator to establish the content of the curricula, instructional methods, and evaluation of the learning (Brookfield, 1986).

Merriam (1987) points out that most of these theories and models are unified by four components of adult learning. In some way, each theory or model is concerned with the adult learner: a) being autonomous and self-directed in the learning process, b) having a store of experiences with which to relate new learning, c) reflecting upon, or self-evaluating, the learning that has occurred and d) being able to immediately apply the learning to some life-centered situation.

Based on this foundation, a survey of databases, including ERIC, Dissertation Abstracts, Magazine Index, Popular Magazines Review On-Line, and Newspapers, as well as personal readings of hardcopy books, journals, and documents, reveals that the combining of expert system and optical data storage technologies to either deliver instruction or facilitate learning in adults has not been researched in any depth.

The descriptors that were considered for searching each database mentioned above were focused on: the technologies under consideration, individualized instruction, learning theory, and visual response. The area of visual response was confined to how viewers are affected by visual images. The descriptors, by category, are:

Technologies:

Artificial Intelligence
Expert Systems Cybernetics
Compact Discs
Interactive Video

Individualized Instruction:

Programmed Instruction
Independent Study
Teaching Methods
Teaching Styles

Learning Theory:

Pacing
Cognitive Style
Comprehension
Learning Modalities
Learning

Visual Response:

Viewer Response
Visual Aids
Visual Learning
Motivation

Several authors did suggest rationales for the use of these individual technologies for improving instruction. Kirrane and Kirrane (1989) state that expert systems may assess learner characteristics and create a model of the student's learning style, identify gaps in knowledge and then "mimic the way a human instructor customizes and personalizes pacing and use of examples when working with an individual ... rather than a group." Siegel (1989) characterizes expert systems not as tools for teaching but as tools for learning, because of the environment that they create. In the case of expert systems that perform tutoring, this environment allows the student at the computer to take the initiative by asking the tutor questions and, therefore, direct the lesson based on natural inquisitiveness (Adams & Hamm, 1987). This is in sharp contrast to most computer assisted instruction in use today which guides the student through a predetermined sequence. Lippert (1988) sees this learning environment as combining the roles of the computer as tutor, programming object (instructing it to perform some task through a programming language) and tool (such as a word processor) in the classroom to improve students' higher level thinking skills and problem solving abilities as well as more traditional subject matter specific knowledge.

With regard to one optical data storage technology, interactive video (IVD), Gerber (1990) indicated that IVD training produces results that are at least equal to what can be achieved through traditional classroom techniques. In support of this, McNeil (1989) performed a meta analysis of interactive video instruction over a ten year period which showed that, generally :

> [interactive video] instruction could be expected to move the typical person from the 50th to the 69.2nd percentile of achievement.

Research Questions

This study has attempted to answer five research questions:

1. Which combinations of the expert system and optical data storage technologies are most likely to be achieved in the next five years?
2. What contribution(s) to adult learning could the combinations of these technologies be expected to produce?
3. Which insights were unique and originated solely from those participants involved in human resource development (HRD), as a group, and those participants involved in the development of the hardware and software technologies (DEV), as another group?
4. Is there a significant difference between the group judgements of the HRD and DEV participants for any of the statements?
5. What are the factors that may negatively impact the effective application of these combined technologies as an instructional system for adult learners?

Limitations of this Research

This research relied on two sources of data, from the professional literature and from experts in the field. Expert opinions, collected through the Delphi technique, were drawn from prominent individuals developing and using interactive video disc for instruction/training and individuals involved with expert systems. This latter part of the research, based on data derived through the Delphi Technique, dealt with expert judgements rather than objectively derived facts. Mitroff and Turoff (1975) point out that the conclusions drawn from such judgements are, by the very nature of the Delphi process, compromise positions and may lack the significance that extreme or conflicting positions may suggest.

Another factor which may effect the conclusions of the Delphi process is the technique used to rank the judgements. Possible techniques include the total weighted average, medial ranking, frequency ranking, unweighted frequency, and rank orders. An individual item may shift up or down in the ranking depending on the technique used (Orlich, 1978).

Biases may also be introduced into the Delphi process by the researcher, through the use of value-laden terms or the inclusion or omission of terms when constructing the question(s) and/or statement(s). Such actions on the part of the researcher may affect the priority ranking in each round of the Delphi process and result in a biased set of responses (Orlich, 1978).

Finally, the mechanics of how these technologies will interface was not the intent of this research. Rather, the intent was to determine what benefits might occur if these two technologies, optical data storage and expert systems, could be interfaced to develop valid, reliable computer-facilitated instructional/training systems that are more individualized and audiovisually more realistic to the adult learner than could be offered by other available technologies.

Summary and Overview of this Study

Chapter I focused on the need for the study and its purpose. The first section focused on the problem of matching instruction to the student; identifying what the student needs to learn, the student's learning style, and the appropriate pacing of the instruction. The possibility of combining expert systems and optical data storage technologies with CAI to facilitate this matching was then discussed. This section closed with a brief discussion of the unique problem in adult learning based on the learner's personal experience.

In the next section, the terms that required clarification for this study were defined. This was followed by a statement of the purpose of this research: To identify potential linkages between optical data storage and expert systems technologies which may provide advancements in CAI for adult learners and to rank the feasibility of achieving each of the linkages and associated advantages within the next five years (1991-1996).

The importance and value of conducting this research was then considered and lies in the large numbers of functionally illiterate adults currently in this country and those adults who will become functionally illiterate as a result of their fast-changing workplace. Effective and efficient means to correct this situation are needed. These means may require the development of new models for adult CAI, and greater consumer awareness on the part of educators and trainers when choosing instructional materials for adult education programs.

The theoretical foundation for the study was then presented based on the adult learning theories and models of Knowles, Cross, McClusky, Knox, Mezirow, Freire and Brookfield. And, finally, the limitations of the study were discussed.

Chapter II is a selected review of the literature pertinent to this study. The areas reviewed include: Adult Learning, Expert Systems, Optical Data Storage, Computer Assisted Instruction, and the Delphi process of forecasting future trends.

Chapter III covers the design and methodology of the study. This chapter includes the criteria for selecting the participants, the description of the participant sample, the development of the Delphi exercise, the data collection schedule, and how the data will be analyzed.

Chapter IV reports on the ideas collected in the Delphi exercise. And, in Chapter V the findings of the study are summarized, implications of these findings for computer-facilitated adult learning are be stated, and recommendations for further research are given.

Chapter II

REVIEW OF THE LITERATURE

Introduction

This chapter reviews the literature from five major areas pertinent to this study. These areas are: 1) adult learning theory, 2) nature of expert systems, 3) the technological state of optical data storage, 4) applications of computer assisted instruction (CAI) in adult education and 5) the Delphi research method.

Adult Learning Theory

The first area reviewed examines the work of seven theorists Knowles, Cross, McClusky, Knox, Mezirow, Freire and Bloomfield, whose research and writings have widely influenced the field of adult learning. In discussing each theorist's work the researcher endeavors to illustrate how each contains the components of adult learning dealing with: a) self-direction, b) the relationship of life experiences to learning, c) self-evaluation of what one has learned, and d) immediate application of the learning that has occurred as mentioned by Merriam (1987) in Chapter One. The relevance of these components to this research lies in recognizing the unique characteristics of adult learners, as compared to the characteristics of children, when considering the possible impact on adult learners by combining expert systems and optical data storage technologies in computer assisted instruction for adults.

Malcolm Knowles began using the term "andragogy" in his writings in 1968. He defined it as the "art and science of helping adults learn" (Knowles, 1984, p. 6). Knowles andragogical model of adult learning focuses on five assumptions about adult learners.

First, the learner is self directed. As the individual matures his/her self-concept moves from being dependent on others for making decisions regarding his/her life, toward being capable of taking responsibility for one's self. If others do not recognize this desire to take responsibility in the individual, that individual may feel that someone else's will is being imposed on them and feelings of resentment and resistance may result (p. 9).

Second, the individual adult learner comes to the educational situation with a great volume of life experiences that differs in quality from that of anyone else. The volume and quality of experiences in life lead to an individual's self-identity. If an adult's experience is ignored, not valued, or not made use of, it is not just the experience that is rejected but the person (p. 11).

Third, adults become ready to learn when they have a need to know or acquire a skill to carry out some aspect of their lives more effectively (Knowles, 1984, p. 11) or recognize what the consequences will be if they do not learn (Knowles, 1986, p. 41). This readiness to learn may stem from personal, social, or career life roles (Varah & Clemens, 1989).

Fourth, as a result of their need to know or acquire a skill to carry out some aspect of their lives more effectively, most adults come into the learning situation with the desire to solve a problem, acquire a skill or in some other way gain the ability to affect some aspect of their life. This orientation is in contrast to subject-centered learning where the individual learns for the sake of learning (Knowles, 1984, p. 12). Finally, the motivation for adults to learn, though it may be partially extrinsic (increased wages, job promotion) in nature, is primarily derived from intrinsic factors such as increases in self-esteem, responsibility, creativity and self-fulfillment (Knowles, 1986, p. 42).

In summary, Knowles bases the andragogical model on the assumptions that the adult: 1) is self-directed, 2) has a large background of experience, 3) has a need to learn, 4) has a need to learn that is problem centered and 5) is intrinsically motivated. Merriam's four components are self evident in Knowles' model. The components of self-direction and the relationship of life experiences to learning relates directly to Knowles concepts of self-direction and background of experience. The component of the immediate application of the learning is directly related to Andragogy's recognition of the need to learn in order to carry out some aspect of life that is problem- or life-centered. And, self-evaluation of what has been learned relates, in Andragogy, to the recognition by the learner that there is no longer a need for learning in a particular area because the skills are now available to deal with life.

Based on research about learning processes, practices, and preferences of adults and about developmental stages and phases, K. Patricia Cross (1981) offered the Characteristics of Adults as Learners (CAL) model as a way to merge all these streams of research with the definitive purpose of elucidating the differences between children and adults as learners. Cross hoped that this would ultimately lead to the basic position of andragogy in suggesting how teaching adults should differ from teaching children (p. 234). The CAL model places five variables into two classes; personal characteristics and situational characteristics, Figure 1.

Figure 1.
Cross' Characteristics of Adults as Learners (CAL)

Personal Characteristics

————————> Physiological/Aging ————————>
——————> Sociocultural/Life Phases ——————>
————> Psychological/Developmental Stages ————>

Situational Characteristics

Full-Time Learning Versus Part-Time Learning
Compulsory Learning Versus Voluntary Learning

Cross describes her model as follows. Personal characteristics are the variables which describe the learner. The Physiological/Aging continuum describes factors related to age. Along this continuum Piaget's theory of cognitive development might be placed, as well as the decline in vision usually associated with middle age. The Sociocultural/Life Phases continuum is characterized by transitions, such as graduation and moving into the workforce, marriage, and parenting. The Psychological/Developmental Stages continuum is characterized by transitions in the formation of the concept of "I" or "me". This continuum begins with the infant exploring the surrounding environment and establishing what is "me" and "not me" and continues through life as the organization of perceptions defining the "self" (Combs, et al., 1980, p. 8).

Cross continues with the situational characteristics, the conditions under which the learning takes place.

> (These variables) are usually treated as dichotomous because they differentiate adult education from education for children more sharply than other variables, and they provide much of the flavor and distinction of adult education (p. 241).

Cross elaborates on this statement by recognizing that neither of the variables under the situational characteristics are true dichotomies. Cross justifies discussing the variable of part-time versus full-time learners as a dichotomy based on the assumption that children and adolescents have a major "full time" responsibility of "going to school" whereas adults have primary commitments to a job and family and schooling is often a secondary commitment. In a similar manner compulsory versus voluntary learning is justified. School is compulsory for children and voluntary for adults. In situations where the adult is a full time learner and/or is under much compulsion to learn, Cross indicates that the situational variable(s) no longer distinguish the uniqueness of adults as learners and should be disregarded in the model. The personal characteristics, in such cases, should still be given full consideration in determining how to treat the adult learner. Thus, the adult learner would always be treated differently from the schoolchild (p. 242).

Merriam's components of adult learning can be incorporated into the CAL model continua. First, the components of the adult coming to the learning situation with a bank of experience can be incorporated into the physiological/aging continuum. Cattell (1963) postulated the existence of two intelligences in the individual that illustrate this continuum, fluid and crystallized (Shouksmith, 1970 p. 68). Fluid intelligence is characterized as the ability for new conceptual learning and problem solving, while crystallized intelligence represents acquired knowledge and developed intellectual skills (Eysenck, 1971 p. 54, Knox, 1977, p. 421). As the individual ages, the fluid intelligence of one year contributes to the crystallized intelligence of the next year (Shouksmith, 1970 p. 69). Goleman (1984) supports this idea of an accumulation of crystallized intelligence by stating that research shows a decline in fluid intelligence with age, while crystallized intelligence continues to rise over the life span.

Merriam's component of the immediate application of the learning is contained in the transition points along the sociocultural/life phases continuum. The arrival of a baby for new parents might illustrate this point. With this transition to parenthood comes the need to adjust many aspects of the individual's life. Self evaluation determines when the needs no longer exist.

Finally, the development of the self-concept in the psychological/developmental stages continuum accounts for the self-directedness of the learner as suggested by Merriam.

In 1959 Howard McClusky introduced his theory of Power Load Margin (PLM), also known as the Theory of Margin, with the intention that it would be used for studying adults in order to develop realistic educational programs for adults (Weiman, 1984, p. 1). The basic concept of this model is that in order for adults to participate in education they must possess a margin of resources that can be devoted to the educational process. This margin is determined as the ratio between an individual's total "load" or obligations and the "power" or resources that the individual has to deal with the load. An individual's load is both external and internal. The external factors of the load are the factors imposed on the individual by civic and social obligations, family and work, as examples. The internal factors are the expectations and demands set by one's self, based on values, attitudes, needs and goals. Power is composed of the strengths available to bear the load. As with the load, an individual's power is both external and internal. External power may be composed of positions, allies, financial situation, social standing and other tangible factors. Internal power consists of physical ability, mental ability and the life skills accumulated as one matures (Day & James, 1984, p. 5, MacLean, 1985, p. 46-47, Weiman, 1984, p. 2). Therefore, the greater the power or the lesser the load the greater the margin of resources which the individual can devote to learning.

The life-span studies of Buhler, Henry, and Peck (McClusky, 1963, p. 10), which lead McClusky to develop the theory of Power Load Margin, were concerned with the identification of stages in human development as related to life-span. In identifying these stages it was observed that they marked major changes in life direction for the individual. These major changes in life provide the natural occurrences, for the need to know, the motivation to learn, and the immediate application of the learning. Having the basis for the theory of Power Load Margin (PLM) in life-span studies also relates to Cross' (1981) Physiological/ Aging continuum and Goleman's (1984) concept of crystallized intelligence and, consequently, the acquisition of experience in adults.

Finally, McClusky (1963) contends that a person has margin who has the autonomy to choose relevant resources from a broad range of resources in dealing with their personal loads (p. 17). This autonomy and the ability to choose implies that the theory of PLM recognizes the adult as a self-directed individual, given the necessary resources. In choosing resources the individual would also be evaluating the effectiveness of what is learned from these resources and if others are needed in order to deal with the personal loads.

Alan B. Knox introduced his Proficiency Theory in 1980 as another model of understanding adult learners. At the core of this theory is the notion that the individual notices a discrepancy between the current level of some performance and the desired level of that performance, or the level of proficiency (Knox, 1980). In his 1980 article, Knox defined "proficiency" as the capacity of an individual to perform satisfactorily if given the opportunity (p. 378). In 1986 he elaborated on this definition, stating that proficiency emphasizes optimal standards of performance as related to adult life roles. Knox believes this is the distinguishing feature of proficiency-oriented education when compared to competency-based education, which emphasizes only the minimum standards of performance in a task (Knox, 1986, p. 16).

Knox recognized that in progressing toward optimal proficiencies, the adult will be building on the current proficiencies (Knox, 1986, p. 16). He also identified several factors that may affect a person's striving to enhance proficiency. These include the individual's physical ability, educational background, values, interests, and self-concept (Knox, 1986, p. 17).

Once again, the reader will find that the components of adult learning as mentioned by Merriam are contained within the Proficiency Theory. The basic premise of the theory, that there is a discrepancy recognized by the individual between what is and what is desired, indicates the recognition for a need to learn that is intrinsically motivated and is problem-/life-centered, hence, there is a need for immediate application of the learning. The existence of the experience which an adult brings to an educational setting is acknowledged in the theory as new proficiencies being built upon current ones. And self-concept, which impacts self-directedness and the ability to conduct self-evaluation, is recognized as a factor that can directly affect the success of the individual attaining new proficiencies.

When developing the Perspective Transformation theory for adult learning, Mezirow drew on the works of the German philosopher Jurgen Habermas who stated the conditions for free and full participation in reflective discourse. Mezirow believed these conditions were also ideal conditions for adult learning (Mezirow, 1991). As a result, the Perspective Transformation theory for adult learning postulates that learning is a process of, first, critical inward reflection on how and why past experiences have created the assumptions and premises by which a person derives meaning in life (Mezirow, 1981, pp. 6-7). These past experiences may have created limited, distorted and arbitrarily selective modes of perception with regard to 1) the development of the adult self-concept, 2) relationships to others and 3) the way new experiences are given meaning for the individual. This reflection on the assumptions and premises becomes transformative, changing the assumptions and premises, whenever the assumptions or premises are found to be distorting, inauthentic, or otherwise invalid (Mezirow, 1991, p. 6). As a result of the transformation of the assumption or premises, the final step in the Transformation Theory is some action on the part of the individual based on the new perspective (Mezirow, 1981, pp. 6-7).

Merriam (1987) describes how the perspective transformation process might typically come about:

> The process of perspective transformation begins with a "disorienting dilemma" to which one's old patterns of response are ineffective. This situation precipitates a self-examination and assessment of assumption and beliefs. A movement begins whereby one revises specific assumptions about oneself and others until the very structure of [the] assumptions becomes transformed...and results in a new agenda for action (p. 194).

The adult learner who is the product of this process should be one who is aware of the assumptions and premises which dictate the way personal meaning is assigned to new experiences, capable of evaluating these assumptions and premises as a result of new experiences and willing to modify these assumptions and premises, when necessary, based on new experiences.

In relating Perspective Transformation theory to the four components of adult learning, it is noted that the process is initiated by a personal "disorienting dilemma," which in itself, creates an immediate application for the learning. As it is a process of critical inward reflection on past experiences the components concerning self-evaluation of the learning and the relationship to life experiences are accounted for. And, though Nowak (1981) suggests that the perspective transformation process can be facilitated, it remains largely self-directed, being primarily a mental exercise on the part of the individual.

Paulo Freire's commitment to adult learning rests on his conviction that any individual, however ignorant, is capable of critically looking at their life situation (Mashayekh, 1974). The embodiment of this commitment is in the concept of conscientization which refers to the process as one "in which [individuals], not as recipients, but as knowing subjects, achieve a deepening awareness both of the socio-cultural reality which shapes their lives and of their capacity to transform that reality (Freire, 1970, p. 27)." Fundamental to the concept of conscientization is the assumption that humans exist "in" and "with" the world.

That humans have the ability to objectify and act upon their world to cause change, not just react to it. That they have the ability to stand apart and analyze not only the present but the past, which has led to the present, and project into the future (Freire, 1970, pp. 28-32). Being able to critically reflect upon the experiences that have shaped one's existence leads to a recognition of the obstacles that have prevented a clear perception of reality (Freire, 1970, p. 51) and allows individuals to understand and change their situation in life. This increased awareness of one's situation results in the individual moving from a level of consciousness where there is no understanding of how forces shape one's life to a level of critical consciousness (Merriam, 1987).

Lloyd (1972) stated that Freire's conscientization method had been widely used in a number of Latin American countries. The most notable success being observed in Chile where the illiteracy rate dropped from 15-30% of the population in 1968 to just 5% in six years (p. 4).

In looking critically at one's life, which is the mark of conscientization, discrepancies between what is and what is desired will manifest themselves. As with the discussion of Mezirow, above, this type of self examination ultimately leads to learning which incorporates self-directedness and life experiences, has immediate application and is self-evaluated.

Brookfield's own research (1980, 1981), supported by that of Thiel (1984) and Pratt (1984) (Brookfield, 1986, pp. 42-43), has resulted in his view of adult learning as a transactional encounter or transactional dialogue "in which learners and teachers are engaged in a continual process of negotiation of priorities, methods, and evaluative criteria" (Brookfield, 1986 p. 20). In this context the responsibility for determining the content of the curricula, instructional methods and how to evaluate achievement is a process shared by both the instructor and the adult learner.

Brookfield believes that dialogue must occur to prevent the educational process from becoming entirely instructor or learner driven. In a totally instructor driven setting learners merely regurgitate what has been delivered from the instructor's academic repository. In a purely self-directed setting the instructor is reduced to a role of administrator, publicist and budget specialist. The instructor's insights, views, experience and knowledge are lost in the educational process (Bloomfield, 1986, p. 21).

A learning process that is totally self-directed also has the disadvantage of not challenging the learner's paradigms. Bloomfield (1986) suggests that often the most significant learning adults experience is as the result of some anxiety-producing event which causes an uncomfortable reassessment of some aspect of the personal, occupational or social life. Through transactional dialog the function of the instructor can become one of a facilitator who will challenge learners with alternative ways of interpreting their experience and to present to them ideas and behaviors that cause them to critically examine their values, ways of acting, and the assumptions by which they live (pp. 22-23).

In relating the four components of adult learning to transactional dialogue it is noted that the adult learner has only partial control or self-direction over the content of the learning. As a result, this may influence the degree to which the learning has an immediate application in the learner's life. The transactional dialogue also affects the self-evaluation of the learning. The adult's perception of the effectiveness of the learning may be moderated by the input from the facilitator. Even though transactional dialogue does not directly address previous life experiences, these life experiences cannot be discounted in the learning process. As discussed in the preceding theories and models, previous life experiences will always act as foundations and filters for new material that is learned. So too, with transactional dialog.

<u>Research Supporting the Common Components of Adult Learning</u>

The common ground for these adult learning theorists lies in the areas of self-directed learning, incorporation of life experiences into the learning process, self-evaluation and immediate application of the learning. The first of these, self-directed learning, is considered by Merriam and Caffarella (1991) to be "where the learners have the primary responsibility for planning, carrying out, and evaluating their own learning experiences (p. 41)." The importance of self-directed learning in adult education has been noted in several studies.

In 1970 Allen Tough conducted a survey to determine how common and important the undertaking of new learning was to adults. Of the 66 individuals interviewed, 98% had taken on at least one learning project within the last year. The survey results indicated that the typical person undertakes about eight learning projects in one year investing between 700 and 800 hours in the learning. Of particular interest was the degree of control that the interviewees exerted in deciding and planning for the learning. A full two-thirds of the learning projects were self-planned (self-directed), with 95% of the interviewees self-planning at least one learning project within the last year.

Merriam and Caffarella (1991) note that Tough's 1970 study became the basis for other studies which also verified the existence of self-directed learning among adults. These studies were conducted by Coolican (1973), Bayha (1983), Brookfield (1984), Richards (1986), and Caffarella and O'Donnell (1987, 1988) on a wide variety of populations ranging from mothers with small children to farmers and physicians. Leean's study (1981) could also be added to this list. Cross' observation, made in 1981, that even though the percentage of the adults may vary between studies, the participation of adults in self-directed learning is almost universal (p. 63), still appears valid.

Further support for self-directed learning came in a 1989 study conducted by The Personal Adult Learning Lab, part of the Georgia Center for Continuing Education, at the University of Georgia's residential conference center. Data were collected from their clients over a two year period about the nature of the educational interaction between the individual and the computer assisted instructional materials available at the lab. These data were from both staff observations of the clients' interactions with the CAI and survey results from the clients. Analysis revealed that the adult learners regularly wanted to pick and choose their subject from a larger content of materials available. Furthermore, within their subject the learners wanted to be able to adjust the speed and sequence of the presentation, and skip around within the material as their interests dictated. "When the instructional technology did not permit these learning strategies, adult learners became frustrated with the interaction, and the quality of the experience was diminished (DeJoy and Mills, 1989)."

Studies such as these have indicated that many, though not all, adults are capable of and prefer self-directed learning experiences. Instructional designers need to keep this variability and preference in mind as new adult education programs are developed.

The impact that life experience has on the learning situation is the second common thread linking these theorists together. The importance of combining life (practical) experience with academic studies has been voiced numerous times in the literature (Faure, 1972, Smith and McCormick, 1992, Dewey, 1916, Davies, 1981, Lindeman, 1926. Lawler, 1991). Dewey (1940) stated:

> We are familiar only with things which specifically enter into our lives and with which we steadily reckon and deal. All concepts, theories, general ideas are thin, meager and ineffectual in the degree in which they are not reflective expressions of acts and events already embodied, achieved in experience (p. 151).

Three studies conducted in the 1980's examining the role of previous life experiences in learning, stand out in the literature. Gibbons, et al. (1980) identified several findings with regard to life experience and how it affected the lives of nineteen acknowledged experts without formal training beyond high school and one with only one year of college. Initially, some primary life experience focused these individuals' attention and interest on the particular field of their expertise. Thereafter, all other random experiences were related to this field. Formal education either played an insignificant or negative role in these individuals' lives. Consequently, they developed their expertise through self-directed, experiential, situational and often challenging means. Generalizing the effect of life experience on self-directed learners, Gibbons, et al. (1980) concluded that practical experience is an important factor in self-directed learning from the perspectives of: 1) choosing what is to be learned, 2) implementing a personal learning style, and 3) gaining additional knowledge from the practical application of what was learned.

Taylor (1981) was able to identify a common pattern of integrating new learning with previous experience among adult learners. The model developed was cyclic in nature and identified four phases in this process; detachment, divergence, engagement and convergence. Detachment represents a new experience which fits within an existing pattern of experiences or frame of reference. Divergence represents the point at which new learning begins. It is at this phase when an experience does not fit, or diverges from, the existing frame of reference resulting in cognitive dissonance (Festinger, 1964) and discomfort with the new experience. During the engagement phase the learner accepts that the new experience does not fit an existing frame of reference and begins to examine the new experience in greater detail. Gradual insights lead to the convergence phase which is characterized by a major insight or a new understanding to be incorporated into the individual's frame of reference. In summary, experience, as a frame of reference, interacts with new learning to create varying degrees of discomfort in the adult learner. The adult will then progress through a series of phases in order to resolve this discomfort and bring the new learning into their frame of reference.

Jarvis' research (1987) on meaningful and meaningless experience acknowledges previous life experiences as part of the individual's biographical history. As new experiences are confirmed within this biographical history the individual's growth is in the form of reinforcing knowledge and beliefs. New experiences which cannot be confirmed within the biographical history cause the individual to reflect on the new experiences and engage in active experimentation with regard to the new experience. Provided the biographical history is adequate, the individual makes an evaluation on the new experience (assigns meaning to it), internalizes it into the biographical history and becomes a more experienced person. The failure to associate the new experience with an adequate biographical history results in the experience being meaningless and results in a failure to learn.

Each of these researchers has identified previous life experience as the foundation for new learning. Developing learning strategies which recognize the importance of experience in adult education programs may lead to a more effective use of the personal body of knowledge which adults bring to the learning situation.

The third common thread linking these theorists together is the importance of establishing self directed approaches to the evaluation of learner outcomes. As Knowles (1970) explains, there is no greater incongruity in self-directed learning than having an instructor grade a student. Such an act reduces the adult to the level of a child and for the adult it is the ultimate sign of disrespect and dependency.

Agee's research (1991) indicates that lifelong adult education programs have been successfully relying on self-assessment for years. These programs have discovered that honoring the experience and maturity of their students also meant being partners in the evaluation process. The resulting dialog between the student and the teacher in establishing the assessment criteria compromised neither the academic standards nor learner identity. It was also noted that during such exchanges teachers often observe how the content and process of learning provides students with the raw materials they need to construct meaning through their individual identities and that students became more aware of how the content and processes of learning extends their experience and helps them explore their identities in different contexts.

Kopp (1987) points out that "evaluation strategies for adults are most effective when traditional authority roles are de-emphasized, and the learner's role as an autonomous, responsible adult is emphasized" (p. 50). These roles are established through collaboration, or a dialog, between the instructor and adult learner to identify objectives, evaluation techniques and criteria. Kopp reports that the results of constructing evaluation in this fashion benefit adult learners by: 1) identifying current skills and knowledge, which is necessary in order to determine the learning objectives and evaluation techniques, and 2) providing adult learners with a valuable understanding of how they learn.

The similar findings of Agee and Kopp stress that during the process of developing self-evaluation learners benefit first by gaining insight into the act of learning. This insight involves the clarification of the difference between their entry level and the desired exit level with regard to what is learned. Second, learners gain insight into their own personal preferences in such areas as learning style or biases in different situations. Strategies in adult learning which recognize the importance of developing self-evaluation may promote the acquisition of these benefits in learners.

Finally, each of these theorists believe that the ability to apply new learning to practical life situations is a major factor in adult learning. Several studies, mostly conducted in the 1960's and 1970's, support this position. One of the most recent, a survey conducted by Selz (1979), revealed that being able to apply learning is of prime importance to adult learners.

In an earlier study involving 35 adults to determine the major reasons for beginning and continuing a self-learning project, Tough (1968) concluded that, "The single most common and important reason for adult learning is the desire to use or apply the knowledge or skill (p. 52)." In the same report Tough sites the work of Johnstone and Rivera (1965) in a national survey of adult learners in the United States. This survey concluded that a major emphasis in adult learning was placed on subject matter that was practical, applied and directly useful in performing everyday tasks and obligations. Also cited, was a study conducted by Robinson (1965) which concluded that the majority of interest for learning in adults comes from the personal, practical needs of everyday life rather than curiosity about an academic body of knowledge.

One additional study worth note was conducted in France by Dumnazedier (1967) and was aimed at "discovering the attitudes of the self-educated (p. 204)." This study reported that the adult learner's attitude toward topics was utilitarian in nature. The preferred subject matter for these adult learners dealt with matters concerning everyday life.

These studies indicate a preference among adults engaged in self-directed study for learning which has a practical application in real life situations. Recognition of this preference in adults may influence how adult learning programs are designed to interact with the learner.

Expert Systems

As this research is concerned with combining the technologies of expert systems with optical data storage, this section will review the literature which broadly describes the nature of expert systems in order to give the reader a general feeling for their potential abilities.

In most fields, human experts could be used much more frequently than they currently are to solve problems and offer advice. But due to the great demand for their services human experts are usually in short supply (Mishkoff, 1985, p. 53, Frenzel, 1987, p. 1) or may be too expensive to engage in solving a problem (Parsaye and Chignell, 1988, p. 1). Forsyth (1986) points out yet another problem with human experts: when they die they take their expertise with them (p. 186). One potential solution to these problems is the expert system, an artificial intelligence computer program specially designed to represent human expertise in a particular subject area or domain (Mishkoff, 1985, p. 54).

Storrie-Lombardi (1986) trace the historical roots of expert systems back to the 1940's and 50's with McCulloch, Pitts, and Weiner's work on cybernetics, the use of opposing mechanisms to achieve a range of stability within a system (Parsaye and Chignell, 1988). Cybernetics, in turn, sparked attempts at trying to develop computer systems which would simulate the way the real human neural net works, the beginnings of the research and work on Artificial Intelligence (AI). These AI neural nets would not process data step by step as most computers handled data, but in parallel streams. Developers of these systems foresaw computers capable of dealing with the unforeseen and of synthesizing knowledge from random data with little or no human assistance (Galagan, 1987, p. 76). The complexities of this effort gave way in the 1960's to attempts at building computer systems around symbol-manipulation. In this arena Newell and Simon at Carnegie-Mellon developed a program called the General Problem Solver (GPL) which functioned well within the limits of a set paradigm, but had trouble in expanding beyond those boundaries. Some ten years later Feigenbaum's team at Stanford turned this apparent weakness of GPL into a strength by focusing programming efforts on very specific areas of expertise (Storrie-Lombardi, 1986).

Parsaye and Chignell (1988) characterize this developmental sequence as one of the main lessons to be learned from the history of artificial intelligence. That is, general purpose problem solving strategies often failed to achieve an acceptable level of performance. However, by narrowing the scope of the problem, successful "intelligent" systems could be developed (p. 4). These successful "intelligent" systems became known as expert systems.

Shoval (1985) defines an expert system as a computer system that:

> ...performs the job of an expert or consultant in some area, and supports making decisions in unstructured problem situations.

A more rigorous definition was offered by Parsaye and Chignell (1988):

> An expert system is a program that relies on a body of knowledge to perform a somewhat difficult task usually performed only by a human expert. The principal power of an expert system is derived from the knowledge the system embodies rather than from search algorithms and specific reasoning methods. An expert system successfully deals with problems for which clear algorithmic solutions do not exist (p. 1)

To accomplish its task, an expert system must be equipped with the same resources as the human expert, and it must be able to follow the same method of reasoning as the human would to reach its conclusion (Hawkins, 1987, p. 95). While the human expert's resources are the accumulated facts, structure and rules in the expert's domain, the expert system's resources are stored in its knowledge/rule base (Frenzel, 1987). Two types of knowledge comprise the knowledge/rule base. The first is factual knowledge or information that can be documented. The second is heuristic knowledge which captures the rule-of-thumb experiences of the human expert (Hofmeister and Lubke, 1986). The items within the knowledge/rule base are related to each other in a definite logical and structured way. However, there may be many different paths through the knowledge/rule base (Hawkins, 1987, p. 95).

For the human expert to be able to solve a problem, a method of reasoning must be employed that can extract relevant information from the domain-specific resources. In the same manner, the part of the expert system that conducts a method of reasoning to extract relevant information from the knowledge base is called the inference engine (Parsaye and Chignell, 1988, p. 32). The inference engine is the program that drives an expert system. It establishes the connections among the rules stored in the knowledge/rule base in order to develop a recommendation or conclusion (Hawkins, 1987, p. 95 and Frenzel, 1987, p. 101).

To briefly summarize the relationship between the knowledge/rule base and the inference engine in the expert system; the knowledge base contains domain specific content, the inference engine contains the general problem solving knowledge that is applied to the knowledge/rule base in the expert system. As the inference engine is general in nature, it is possible to use the same inference engine with different knowledge/rule bases in constructing expert systems (Parsaye and Chignell, 1988, p. 33).

Just as human experts need a way of communicating with their sources of information and their clients so, too, do expert systems need communication channels between their knowledge/rules base and their users. This communication channel is referred to as the user interface. The user interface typically gathers input data from the computer keyboard as the user responds to questions displayed on the monitor by choosing from a list of options or responding in full sentences (Frenzel, 1987, p. 101). Another means of human-machine communication can be through a graphic user interface (Parsaye and Chignell, 1988, p. 33) , where the user inputs data by chosing from icons available on the monitor. It is also possible that the user interface does not link directly to a human at all. The expert system may be embedded within larger application programs. In these configurations the expert system may be invoked as a component of the larger system when a binary request is passed across the interface to the expert system, which in turn produces a binary response that is passed back across the interface to the larger system (Walters and Nielsen, 1988, p. 6, Parsaye and Chignell, 1988, p. 33) .

Mishkoff (1985) states that there is no such thing as a "standard" expert system. The problem the expert system is designed to solve and how the knowledge engineer approaches the problem impact the design of the final product. However, most authors recognize the three components discussed above as common to all expert systems: knowledge/rule base, inference engine and user interface (Mishkoff, 1985, Frenzel, 1987, Parsaye & Chignell, 1988, Hawkins, 1987). The researcher believes that one additional component should be included in the discussion of expert systems, as Forsyth (1986) calls it, the explanatory interface.

Just as human experts may need to explain their recommendation or decisions to a client, expert systems need to be able to justify their actions if requested to do so by the user. Having the ability to demonstrate to the user how it arrived at the recommendations or decisions made on a problem can have the effect of reassuring the user as to the appropriateness of the expert system's performance (Parsaye and Chignell, 1988, pp. 33-34).

The explanatory interface may also function as an instructional tool. As users study the expert system's rules for arriving at solutions in the knowledge domain, they may begin to understand the human expert's reasoning process that was used in developing the expert system. With enough explanations and practice, users may become experts (Frenzel, 1987).

Another way this explanatory interface can be used is for the expert system developer to check on the rule construction and sequence in the knowledge/rule base (Frenzel, 1987) and evaluate the effectiveness of an expert system by following through its operations (Parsaye and Chignell, 1988, p. 34).

Though similar to a database program in its ability to retrieve information, the above discussion differentiates an expert system from a database on one significant point. A database contains only declarative knowledge and so users are expected to draw their own conclusions, based on the information retrieved from the database. An expert system contains not only declarative knowledge but also procedural knowledge and, therefore, is capable of drawing its own conclusions and presenting them to the user (Mishkoff, 1985, p. 54).

Expert Systems in Education

Little research has been conducted on the advantages of applying CAI with an expert system to adult learning. Specifically, what is missing are the benefits adult learners would gain from such systems in the areas of self direction, incorporating personal experiences into the learning, self evaluation and being able to apply the learning immediately to real-life situations.

Oravec (1988) contends that one of the great advantages for adult learners using CAI with expert systems is the ability to receive interactive advice which is tailored to a specific problem (p. 109). This advice may take the form of suggestions on the curriculum content the learner should cover, or when additional review or skipping material may be appropriate. Oravec continues by stating a second advantage of many expert systems is their ability to explain why the advice was given (p. 109). For an adult learner who questions a CAI/expert system recommendation, this capability may be able to provide the rationale necessary to alleviate the learner's concerns.

In a broader examination of the research on CAI combined with expert systems in education, Hartschuh (1990) sees expert systems having their most dramatic effect as intelligent tutoring systems. These systems have the capability to guide students through instruction based on the student's strengths and weaknesses (Hartschuh, 1990, "Power On!", 1988). Such a system, also known as intelligent computer-assisted instruction (ICAI), is capable of making decisions during the instructional sequence about which instructional methods to select on the basis of rules provided by the knowledge engineer.

Winn (1987) reminds his readers that an instructional system capable of making decisions during the instructional sequence is not a new development. Programmed text and interactive video, for example, depend on a student's response to determine what happens next in the instructional sequence. In effect, once delivery systems were developed that could branch on the basis of student performance, they became capable of making primitive instructional decisions. What distinguishes ICAI from these forerunner systems is the ability of the ICAI to adapt to relevant contingencies within the realm of the instruction and its ability to present information to the student in a variety of formats; text, graphics, and audio. This ability to adapt indicates that ICAI systems must have the capability to monitor instructional situations. Several examples of ICAI systems which demonstrate this ability to adapt, follow.

The first is the Minnesota Adaptive Instructional System (MAIS) which was designed to monitor student performance in order to determine how many items a student needs to practice during instruction. The algorithm that guides this decision making process also takes into consideration the relative disadvantages of not letting a student progress even though the subject matter has been mastered, and of letting a student continue without learning the subject matter (Tennyson, Christensen & Park, 1984).

The Geometry Tutor monitors how students apply geometric rules in developing proofs. The system's knowledge base contains "ideal" geometric proofs and the various errors that students are most likely to make in developing a proof. By comparing the student's work to its knowledge base the system can determine if a student has applied an inappropriate rule. If an inappropriate rule has been applied, the tutor then takes remedial action (Anderson, Boyle & Yost, 1985, "Power On!", 1988).

Kimball (1982) developed the self-improving tutor for symbolic integration which provides another example of the ability to adapt to contingencies. This ICAI system monitors a student's progress in solving a problem by comparison to a model procedure. However, if the student solves the problem effectively in fewer steps than the model procedure the system retains the student's solution for future use.

O'Shea's (1982) self-improving tutor for quadratic equations relates different strategies to the achievement of four goals: 1) increasing the number of successful students, 2) increasing the average post-test score, 3) decreasing student time on task and 4) decreasing the amount of time the computer is used. In working with the student the system uses a deductive procedure to determine which strategies are likely to result in achieving one or more of the goals. These strategies are then implemented and the impact on the four goals is statistically monitored. If there is a significant improvement the new combination of strategies is incorporated into the system's production rules.

SOPHIE (SOPHisticated Instructional Environment) monitors students in a simulated electronics laboratory as they examine faulted circuits and attempt to problem solve the situation. The system is capable of providing detailed feedback as to the logical validity of a student's proposed solution and can generate counter examples and critiques when the student's hypothesis has flaws in its logic (Barr & Feigenbaum, 1982).

GUIDON is an ICAI program for teaching diagnostic problem-solving for infectious diseases. A unique feature of this system is its ability to initiate "opportunistic tutoring." That is, the adaptation and presentation of material, when needed, into the diagnostic dialogue. GUIDON is sensitive to how a tutorial dialog fits together, and what kinds of interruptions and probing are reasonable and expected for the diagnosis under study (Barr & Feigenbaum, 1982, p. 275)

As a last example, SCHOLAR is an ICAI system designed to tutor students about simple facts in South American geography. Barr & Feigenbaum (1982) describe SCHOLAR as a mixed-initiative tutoring system, capable of responding to questions as well as initiating a conversation with the student. Such a dialogue allows the tutor to identify the relevant material to be learned, based on the student's previous knowledge, and to identify any misconceptions that the student might have.

Winn (1987) points out that ICAI systems, such as these, simulate aspects of the instructional designer's and teacher's expertise which have to do with the selection of appropriate instruction, based on the close monitoring of student interactions. Systems such as those, above, demonstrate that it is possible to have ICAI systems monitor instructional situations in order to prescribe effective instructional methods. This ability to monitor the interaction of the adult learner with the computer assisted instruction will be necessary in systems that are going to be able to adapt to the unique characteristics of adult learners. Adaptations that will need to consider the degree of self-directedness and self-evaluation which produces an optimum level of learning in the adult learner, the personal experiences of the adult learner which could be incorporated into the instructional situation and real-life situations to which the instruction could be immediately applied.

The Technological State of Optical Data Storage

As this research is concerned with combining the technologies of expert systems with optical data storage, this section will review the literature which broadly describes the technology differentiating one type of optical data storage from another.

LaserVision videodiscs introduced in 1980 and compact disks introduced in 1982 were the first commercially available optical disks that appeared on the market (Ullmer, 1989). Since that time other optical formats have appeared and still others are under development. Schamber (1988) observed that these optical disk formats go by many names, e.g. Optical Disk (OD), laser disk and just simply disc, all of which are acceptable. Though most optical disks cannot be erased and lack the access speed of hard disks, these disadvantages are offset by their huge storage capacity, higher level of accuracy and greater durability (Schamber, 1988; Blanchard, Frisbie, and Tullis, 1988).

The optical disk is usually either 4.72 or 12 inches in diameter. Some Write Once, Read Many (WORM) optical disks are 5.25 or 8 inches in diameter. A 14 inch diameter disk is offered by some manufacturers and a smaller 3.5 inch disk has been introduced to the market (Dykeman, 1988). Ullmer (1989) characterized the capabilities for optical disks as read only; write once, read many; and write many, read many. Ullmer (1989) also separated optical disks by their method of storing information; analog and digital. Table 1 is a brief classification of optical disk technologies based on Ullmer's classification.

Table 1.
Classification of Optical Disk Technologies

Disk Capabilities	Analog	Attributes	Digital	Attributes
Permanent Storage ------- Read Only	LaserVision (Reflective)	CAV 54,000 frames 30 min motion 30 MG	CD-V	20 min audio 5 min motion
			ICVD	10 min motion
		CLV 108,000 frames 1 hr motion	CD-ROM	550-650 MG Storage life 50 yrs Capacity for: audio still frame text graphics programming information
	LaserFilm (Transmissive)	32,400 frames 18 min motion		
			CD-I	Capacity for: audio still frame text graphics programming information
			DVI	1 hr motion Capacity for; audio still frame text graphics programming information
Permanent Storage ------- Write Once, Read Many	DRAW	1 GB per side	CD-WORM	500 MG
Erasable Storage ------- Write Many, Read Many	(None Available)		CD-EMO	.6 - 1 GB Storage life 25 years More than 1,000,000 rewrite cycles
			Phase Change	.44 - 1 GB Approximately 100,000 rewrite cycles

Ullmer (1989) discusses three types of analog disc formats; reflective, transmissive, and Direct Read And Write (DRAW). The first two systems discussed are read only technologies, reflective and transmissive. Both technologies use a laser beam to read the encoded data on the disc. The reflective technology reflects the laser light off the surface of the disc. Information is encoded on the disc surface in a series of irregular pits. The laser light is weaker when reflecting off from a pit than it is when reflecting off the disc's normal surface. A photodiode senses these strong and weak reflections and converts them into a standard television signal.

The transmissive technology differs from the reflective technology in that it uses a transparent film containing a sequence of dots which encode the information rather than a reflective surface with pits. The varying intensity of the laser light as it passes through the disc is picked up by a photodiode and converted into a standard television signal.

These two videodisc formats differ in storage capacities. The reflective technology in a constant angular velocity mode (CAV) can hold 54,000 still images or 30 minutes of real-time motion video, about 30 megabytes of data (Ullmer, 1989, Bradley, 1989). In the constant linear velocity (CLV) mode reflective technology can hold one hour of real-time motion video and 108,000 still images (Helsel, 1990). The transmissive technology has a capacity of 32,400 still frames or 18 minutes of motion.

The third videodisc technology Ullmer discusses, known as Direct Read And Write (DRAW), allows a user to record a playable videodisc without going through the expense of creating a "master disc" from which replicas can be made. This technology allows up to 1 Gigabyte of information to be written on each side of the videodisc only once (Schwartz, 1986). The disc cannot be altered once the information is encoded on the surface. Recorded data on the disc may be read immediately after writing.

All digital disc formats share three common technical elements. First, all use a reflective laser for reading the information on the disc. Second, the audio and video information is encoded on the disc in a digital format. Third, the discs rotate with a constant angular velocity (CAV). Beyond these commonalties, the technologies vary greatly to provide for different utility in the systems. Ullmer (1989) briefly describes each of the optical disc technologies as follows.

Compact Disc-Video (CD-V) offers 20 minutes of digital audio and 5 minutes of full motion analog video on a 4.72 inch disc (Ullmer, 1989). Even though the time available on this format is limited, it may prove useful in the same arena as the single concept filmloop of the 1970's and 1980's.

Interactive Compact Video Disc (ICVD) combines interactivity with digital audio and analog video. This format provides up to 10 minutes of video in the CAV mode and 20 minutes in the CLV mode.

Three other formats may prove more useful for education and training. The first of these is Compact Disc-Read Only Memory (CD-ROM). A CD-ROM drive is a computer peripheral that functions as a mass data storage device, similar to a hard disk, but capable of storing upwards of 550-650 megabytes (Bradley, 1989, Arnold, 1991). With this amount of storage capacity and an estimated storage life of 50 years (Arnold, 1991), CD-ROM has great potential in business applications, education and libraries.

Compact Disc Interactive (CD-I) is another of the CD formats that Ullmer forecasts as having potential applications for education (especially continuing education) and training. The international standards established for CD-I specify that the medium must be capable of carrying not only the information for audio, still video, text, graphics and data on the disc but programming information as well. This will give CD-I players the capability to operate as stand alone machines (Ullmer, 1989, "Power On!", 1988). This stand alone capability will remove the need for an external computer interface with the CD player, allowing it to function in a manner similar to Level II interactive video systems.

The third CD format that Ullmer forecasts as having potential applications for education and training is Digital Video Interactive (DVI). By using sophisticated data compression/regeneration techniques, DVI can provide more than an hour of full motion, full screen digital video from a standard CD-ROM configured disc. The DVI format also supports still video, audio, text, graphics and data. Until recently the inability of these systems to produce high quality still and real time motion video was their greatest draw back. However, the development of the Edit Level Video technology has greatly improved the real time motion and by using compression ratios of 2 and 3:1 still images are now suitable for medical training. While analog videodisc still provides the sharpest still images and the smoothest real time motion, DVI is rapidly closing the gap.

Write Once, Read Many (WORM) offers the user the ability to record 500 megabytes (Arnold, 1991) of information onto an optical disc. These optical disc files can be edited or copied from a personal computer, but they cannot be erased. All versions of edited materials are saved with the most recent appearing when the user recalls the file. Previous versions of edited files are "archived" and can only be accessed through a read-only mode. (Modern Office Technology, 1989)

Schamber (1988) describes the Compact Disk-Erasable Magneto Optic (CD-EMO) format as a combination of optic and magnetic technologies. Like WORM, CD-EMO requires separate read and write lasers. In writing to the disc, Roth (1991) describes the process as one where an infrared laser rapidly heats selected data storage spots on a 20 nanometer thick magnetic material pressed between two polycarbonate layers. Before these spots can cool, a magnetic coil aligns their magnetic field either with the north pole up (digital 1) or the north pole down (digital 0). When light from the read laser strikes these spots it is polarized either clockwise or counter clockwise depending on which way the spot is magnetized. This polarized light is then received by a photodetector and interpreted as binary data by the disk drive. CD-EMO disks have a storage capacity between 600 MB up to 1 Gigabyte (GB) with an expected life of the storage media that may approach twenty-five years and over one million rewrite cycles (Davis, 1991, Stone, 1991).

The technology of phase change involves the changing of a reflective metal film between a highly reflective crystalline state and an amorphous state of lower reflectivity. To create an amorphous spot in the metal film a highly focused laser melts a very small area. The heat is rapidly conducted to the surrounding material and a reflective crystalline structure does not have time to form. By defocusing the laser a larger spot on the disk is heated. The center of this spot cools more slowly because of the surrounding heated material and allows a reflective crystalline surface to form (Bradley, 1989). A photodiode senses the strength of the laser reflected off these spots and converts them into an electronic signal. The storage capacity for phase change technology ranges from 44 Megabytes to 1 Gigabyte (Davis, 1991).

Optical Data Storage Systems in Education

Optical technology has the ability to "change the way information is stored and delivered in content area disciplines (Blanchard, Frisbie and Tullis, 1988, p. 698)." Rowe and McLeod (1988) believe that only the surface potential of this powerful laser disc medium has been explored especially when optical disc technologies, such as CD-ROM and video discs, are linked together. These linked optical disc technologies in conjunction with hypertext software, which allows linkages between different but related ideas (Halsey, 1989), could allow students to identify materials and develop an easily searchable computerized package that best meets their needs. In effect, students could literally develop their own "books" on a subject.

Of the optical technologies that are available to education and training, videodisc and interactive videodisc (IVD) have been available to educators and trainers since the late seventies (Blanchard, et al., 1987), a longer period of time than have the CD-ROM formats. Lookatch (1989) cites that throughout the past decade IVD has been compared to traditional classroom methods of instruction, such as lecture and demonstration, and the results have consistently favored IVD. These results have shown that instruction using interactive video produces achievement in knowledge and skills equal to or greater than that achieved by traditional training methods. These results have also shown that the time needed to acquire new skills and knowledge is reduced when using interactive videodisc instruction. Longitudinal studies indicate a greater retention of the material learned from IVD when compared to traditional training methods. And, the individuals who use IVD system have shown an enthusiastic acceptance of and preference for IVD training over traditional training methods.

One interactive videodisc program which has a user base of over 700 sites across the country (Rabe, 1990) is the Principle of the Alphabet Literacy System (PALS). Developed by International Business Machines (IBM), this program is designed to improve the reading and writing skills of illiterate and functionally illiterate adolescents and adults. Recent studies of this system have been conducted by the Bidwell Training Center, Inc. (Njie, 1989), Office of Educational Research and Improvement (Mann, 1989) and the Center for the Study for Adult Literacy, Georgia State University, Atlanta (Nurss, 1989). All have concluded that PALS can be an effective tool in teaching adults to read and write. Njie and Mann reported reading and writing improvements of 2-3 grade levels in only 20 weeks.

Bosco and Wagner (1988) conducted a study of the effectiveness of IVD training compared to classroom format using instructional videotapes. The study involved the development of two parallel programs to deliver training to UAW-GM employees on the handling of hazardous materials and was administered to 209 employees from 15 Mid-West GM plants. The results of this study showed that the subjects in the IVD group had a significantly higher achievement than those in the videotape group. With regard to the attitude of the subjects to their training, 22% more of the IVD group felt that their training would help them make safe users of the solvents while 14% more of the IVD group felt the training was interesting. The IVD group took advantage of the ability to set their own pace in moving through the instruction. Times ranged from 20 - 74 minutes with the mean being 33.87 minutes. Finally, 80% of the employees that experienced both types of instruction indicated a preference for the IVD.

RAND Corporation conducted research into the effectiveness of IVD used in the advanced individual training of 764 communications electrons specialists at the U.S. Army Signal Center, Fort Gordon, Georgia (Winkler and Polich, 1990). Two studies examined two common applications of IVD in training communications electrons specialists: 1) supplementing hand-on training with IVD and

2) simulating hand-on training with IVD. The results concluded that supplementing hand-on training with IVD caused improvements in measures of subsequent task proficiency, specifically, radio installation time was reduced by 15 percent. Replacing hands-on equipment training with IVD training did not diminish students' ability to perform the relevant tasks. Alignment of communications systems was performed as well by the IVD trainees as those trainees who actually practiced with equipment.

Compact Disks, as an optical data technology, were introduced for computer applications in 1985 by Sony and Phillips Corporations (Blanchard, et al., 1987). Their application to education and training, in their various forms, is just starting to emerge and be studied. Blanchard, et al. (1988) indicate that most of the databases used by teachers and students are now available in CD-ROM formats. These include *Grolier's Encyclopedia, Dissertation Abstracts, Educational Resources Information Centers (ERIC), Books in Print, Ulrich's International Periodical Directory, Reader's Guide to Periodic Literature*, dictionaries, thesauri, almanacs, writing style manuals, and spelling checkers. However, the research of Gary Marchionini (1989) indicates that novices using CD-ROM databases are severely limited in their use, choosing only the features that have been made explicit to them as defaults or preset options and, consequently, bypass more powerful features.

In 1988, Discis Knowledge Research, Inc. began creating Discis Books, interactive computer books on CD-ROM for children. Each Discis Book contains the complete text and graphics of the original book with the enhancements of in-context information for every word and picture element. Music and sound effects are also added for the student's enjoyment. The Discis Books have an audio channel to assist with pronunciation, second language translations, and oral presentation of sentences. Initial research indicates that students who were previously considered nonreaders became more independent readers because they did not have to depend on the teacher for explanations of unknown elements in the story. An increase in story writing and reading of other books was also observed ("Discis Books", 1990).

Computer Assisted Instruction and Adult Learners

Because this research is concerned with combining expert system and optical data storage technologies in computer assisted instruction for adult learners, a brief review of the research relating the effectiveness of computer assisted instruction to adult learners will be undertaken.

Bostock and Seifert (1986) state that from their own research, and that of colleagues, they have been able to conclude that the use of computer assisted instruction with adult learners can improve the quality of adult learning in courses across the whole spectrum of subject areas (p. i). Weller (1988) echoes this belief by stating that computer-based instruction has been demonstrated to be a very powerful technology (p. 23). And, in support of these general comments, Ebner, et al., (1984) indicate that many researchers of computer-assisted instruction have established, through their work, that there is an improvement in learning efficiency that occurs relative to standard instructional methods. That is, the same level of proficiency can be achieved in less time.

Galagan (1987) states that James J. L'Allier's research on CAI in training programs has led him to comment that:

> If you were to compare a traditional form of instruction and that same instruction on a computer, you would find no real difference in the outcome. But the amount of time spent learning on the computer would be half that spent with the traditional method (p. 73).

The significance of L'Allier's statement lies in the rapidity with which knowledge becomes obsolete and the frequency of career changes. For example, an engineer's knowledge is out of date three years after graduation and individuals entering the work force today are expected to make at least four career changes, each requiring training (Galagan, 1987. p. 73) .

Kamm (1983) compared 50 tutorial physics units that were developed to parallel a traditional lecture style physics course based on a mastery model, where students could retake exams until mastery was achieved. For the computer assisted instruction, the results showed a decrease in the number of students who left the course without finishing the 50 units. Also, for those students involved in the computer assisted instruction, the number of retakes necessary to achieve mastery on the units decreased.

In a study involving nursing students, Boettcher, Alderson and Saccucci (1981) compared the outcomes of computer assisted instruction against the outcomes of more traditional programmed instruction techniques. They found that in posttest scores and longitudinal follow ups designed to measure retention of knowledge, skills and interest that there were no statistically significant differences between the effectiveness of the two methods. Their conclusion; that computer assisted instruction can be as effective as more traditional programmed instruction techniques for teaching factual knowledge and skills.

Deignan and Duncan (1978) compared computer assisted instruction with programmed instructional text in a medical radiology course and to the traditional lecture method in a medical laboratory course. The results indicated a greater knowledge gain for the students participating in the computer assisted instruction than those in the lecture or using the programmed text. It was also reported that time savings on completing the assigned material ranged from twelve to fourteen percent.

As Hamilton (1984) suggests, studies such as these do not conclusively indicate that computer assisted instruction is superior to any other instructional methodology (p. 68). Supporting this, a conclusion drawn by Jamison, Suppes and Wells (1974), after an comprehensive study of instructional media, was that there was an overabundance of statistically no significant difference studies with regard to computer-assisted instruction. They continued by stating the belief that computer-assisted instruction had not reached its envisioned role. Perhaps the incorporation of expert system and optical data storage technologies into computer-assisted instruction will fulfill this vision.

The Delphi Research Method

The RAND Corporation developed and introduced the Delphi technique as a method of data collection in the early 1950's to systematically solicit the views of experts in controversial sociopolitical areas of discourse. However, it was not until the mid-1960's that it came to the attention of individuals outside the defense industry and was applied to technological forecasting (Linstone &

Turnoff, 1979, Spinelli, 1983). Broadly, the Delphi technique is a questionnaire method for organizing and shaping the opinion of a number of experts in a field through group feedback. The individuals participating in a Delphi response group are anonymous to one another, with a Delphi administrator collecting and compiling the participants' responses for each round. After each round the administrator returns the compiled responses to the participants along with a new question for a new round.

The Delphi usually engages the participants in conjecturing about the likelihood of an event occurring at a particular time in the future (Weaver, 1972). The objective is to allow the group to achieve consensus about a given topic (Spinelli, 1983). The experts participate in three or more rounds of questionnaires. Each questionnaire, after the first, provides the participants with compiled data for the entire group. This use of multiple questionnaires with feedback is what distinguishes the Delphi from an ordinary polling procedure. It gives the participants the opportunity to modify or refine their judgments based upon their reaction to the collective views of the group (Mitroff & Turoff, 1975).

The Delphi process is terminated after the participants have achieved consensus or stability on the topics. Consensus on a topic may be determined by having a certain percentage of the votes falling within a prescribed range (Scheibe, et al., 1975). The observation that people tend to shift their estimates toward a group norm under conditions of iteration is a consistent and solid observation (Weaver, 1972). However, groups of strong-minded individuals may produce a bimodal or flat distribution indicating no strong convergence of opinion. This type of information in a Delphi is no less valuable then that which arrives at a consensus and should be viewed with special interest. Identifying these variations in the Delphi involves a measure not of consensus but of the stability in the participant's vote distribution curve over successive rounds (Scheibe, et al., 1975).

As a data collection tool, the Delphi technique has a number of unique advantages. It can be used to forecast when events might occur as the experts arrive at consensus through the use of the repeated questionnaires (Weaver, 1972). Face-to-face contact among the participants is not required. This anonymity prevents professional status and high position from forcing judgements in certain directions --as frequently occurs when panels of experts meet (Weaver, 1972). It also avoids the possibility that personality conflicts and interpersonal politics might affect judgements (Orlich, 1978).

Another advantage is that the Delphi technique allows experts to be assembled for a group decision making process that may otherwise be impossible to achieve due to personal schedules or costs if the individuals had to meet at a common venue.

Delbecq, et al., (1986) discuss a further benefit of the Delphi technique. Since the time frame for the rounds can allow participants several days, or even weeks, to respond, they have the flexibility to respond at times that are most convenient for them. This also gives the participants adequate time to think and reflect upon their responses.

The Delphi technique, as with any other research methodology, also has some caveats. First, the manner in which the question(s) and/or statement(s) in each round are written may affect the priority ranking. Value-laden terms cause shifting in the rank upward or downward and result in a biased set of responses (Orlich, 1978). If value-laden terms are used, the researcher must be aware of their purpose in the research.

The Delphi technique involves a great deal of data handling between rounds. This may involve the compiling of statements from an open ended question in the first round and editing supporting comments in successive rounds. In performing these tasks the researcher must be aware of the subjectivity that may enter into the editing (Orlich, 1978).

Mitroff and Turoff (1975) point out that the judgements which typically survive a Delphi may not be the "best" judgements but, rather, the compromise position. As a result, the surviving judgements may lack the significance that extreme or conflicting positions may possess.

Finally, in cases where there is a lack of consensus on the Delphi items, the method used in making the rankings might shift the priorities. Several techniques may be used to determine rankings, such as, 1) total weighted average, 2) medial ranking, 3) frequency ranking, 4) unweighted frequency, or rank orders. Depending on the technique used an individual item might shift upward or downward in priority (Orlich, 1978).

Summary

Implementation of adult education programs can benefit from the awareness that many adult learners are deeply imbued with the characteristics of being self-directed, desiring an immediate application for the learning, wanting to self-evaluate the learning and having a large reservoir of experiences which form a context for the learning. As a result, adult learning may take a form more along the lines of a dialogue between the learner and the information provider in determining the approach to the learning situation.

As this research involves the integration of expert systems and optical data storage technologies into computer assisted instruction, a discussion of each of these areas was undertaken. First, expert systems are an area of Artificial Intelligence (AI) which focus on solving problems or providing advice within highly defined knowledge boundaries. They are designed to perform the same functions as a human expert would in the same subject area. Several expert systems have demonstrated the ability to monitor the learner and adapt the instruction during CAI. This ability will be necessary if ICAI systems are going to be developed to meet the needs of adult learners.

Second, optical data storage systems exist in a variety of formats with their main advantage being the mass storage of data. The main impact that optical data storage has had on education to date has been in the areas of videodiscs, interactive videodiscs and CD-ROM. The effectiveness of interactive videodiscs as an instructional method has proven itself over the last decade. While CD-ROM is still fairly new on the educational scene, it is primarily finding its way into education as large databases of information containing text, graphics, audio, photographs and motion video. Some interactive applications are now being developed.

Third, computer assisted instruction applied to adult learning has demonstrated that it is as effective as more traditional instructional methods, such as lecturing or programmed instruction, but may be able to reduce the time needed for instruction significantly.

In the last section of this chapter the Delphi research method was discussed. As a means of soliciting ideas from a group of participants about a specified future event and then bringing that group to a consensus on the ranking of those ideas, the Delphi method is a powerful tool.

CHAPTER III

RESEARCH METHODOLOGY

Introduction

The purpose of this research was to determine expert judgements about possible technological combinations of expert systems and optical data storage systems that might occur within the next five years (1991 - 1996) and to determine the impact such combinations could have on adult learners if applied in the education and the training fields. The Delphi technique of arriving at consensus on this forecast was chosen since the experts most qualified to address the topic were widely separated geographically and/or employed in separate companies. Being so widely separated it was not economically nor temporally practical for this reseacher to bring these individuals together for a face-to-face group process.

Research Questions

This study attempted to answer five research questions that evolved through three rounds of the Delphi Process. The research questions were:

1. Which combinations of the expert system and optical data storage technologies are most likely to be achieved in the next five years?
2. What contribution(s) to adult learning could the combinations of these technologies be expected to produce?

3. Which insights were unique and originated solely from those participants involved in human resource development (HRD), as a group, and those participants involved in the development of the hardware and software technologies (DEV), as another group?

4. Is there a significant difference between the group judgements on the HRD and DEV participants for any of the statements?

5. What are the factors that may negatively impact the effective application of these combined technologies as an instructional system for adult learners?

To begin the Delphi process (described later in this chapter) an initial question was put to the participants as follows:

> "Over the next five years, what specific contributions to adult learning can be expected by the combining of expert system and optical data storage technologies in computer-assisted instruction?"

Participants were asked to answer this question in two parts (Appendix C). First, by indicating which of the optical data storage technologies will be combined with an expert system; for example, an expert system combined with CD-ROM. Second, the impact that this combination will have on adult learning.

Responses to this question formed the basis for the design of the second round questionnaire which asked participants to offer a judgement for each statement on the questionnaire (Appendix I). Participants were asked to:

1. Judge if the statement described or implied some advantageous impact on the adult learner.

2. Judge if the combination of technologies described would be combined in the next five years.

3. Offer supporting comments for their judgements.

Based on the results of the second round, a third round asked participants to re-evaluate their judgements for each statement after considering each of the following:

1. Whether the statement described or implied some advantageous impact on the adult learner.

2. The possibilities that the technologies described in the statement would be combined in the next five years?

3. Their own original judgement of the statement.

4. The group judgement value for the statement.

5. The supporting comments offered by the group for the statement.

Population of the Study

The population for this study was composed of computer scientists researching artificial intelligence/expert systems, optical data storage developers, expert systems developers, industrial training professionals, and instructional technology professionals. Only individuals who had at least one year's experience with expert systems, optical data storage systems, and adult learners were included as participants. This limit was imposed as it was assumed that only participants with a year's experience in each of these areas would have the understanding of the systems and concepts necessary to respond to the survey.

Criteria for Selection of the Sample

A research sample of 74 subjects was selected. The total sample, though heterogeneous, was made up of five homogeneous groups: Expert Systems developers; optical data storage developers; professionals involved with the designing, planning and managing of training programs; instructional technology professionals; and researchers in the field of artificial intelligence/expert systems. Delbecq, Van deVen and Gustafson (1986) suggest that if participants within these homogeneous groups are well-chosen, 10 - 15 participants would be enough to generate a full range of ideas, with few new ideas being added once the group size exceeds thirty.

The computer scientists were selected from the Expert Systems membership list of the American Association for Artificial Intelligence (AAAI). The optical data storage and expert system developers were selected from companies identified using the Training Marketplace Directory. This included companies such as Allen Communication, BCD Associates, Paperback Software, WICAT Systems, Inc., and National Educational Consulting, Inc. The industrial training professionals were drawn from the Industrial Training and Education Division (ITED) of the 1990 membership list of the Association for Educational Communications & Technology (AECT). The instructional technology professionals were identified through the Instructional Technology Professional Practice Area of the

1990 membership list of the American Society for Training and Development (ASTD). The only two criteria imposed on the sample subjects, as a whole, were that the individuals were currently involved in their field of work, as identified for this Delphi, and that they had dealt with expert systems, optical data storage systems, and adult learners for at least one year. The researcher felt that these requirements were necessary to ensure that participants had adequate exposure to their fields.

To ensure diversity in the responses, only one participant was selected from the same company or institution except for the companies involved in developing expert systems, where the maximum was two participants. (The rationale for this is explained below.)

Samples from each group were selected using the following techniques. The ITED membership list contained 261 individuals. Each seventeenth member was selected to ensure one complete pass through the list. If an individual declined to participate in the Delphi or did not meet the one year criterion the second pass through the list began on the eighteenth member and then proceeded with each seventeenth member. This process was repeated until the requirement of 10 - 15 individuals had agreed to participate in the Delphi. The Instructional Technology Professional Practice Area of the ASTD membership directory contained 3,104 individuals. The procedure for selecting participants from this list was the same as for the ITED membership list, only an interval of 207 was used. The AAAI Expert Systems membership list contained 11,000 individuals. Each 740th member was selected to ensure one complete pass through the list.

As the list of companies involved in expert systems development contained only 12 firms it was decided to ask these 12 firms for referrals to other companies developing expert systems in an attempt to find participants from different companies. A roll of a die determined the interval for selecting from the original 12 Expert System companies to be three. The second pass through the list would start on the fourth company with the same interval, and so on.

Four of the Expert Systems companies were also involved in optical data storage technology. These four companies were not included in the selection list for optical data storage to avoid biasing the opinions collected. As such, 44 firms were on the optical data storage list. Again, one individual was sought from each company. A roll of two dice determined the interval to be nine.

Description of the Sample

Three hundred forty nine phone calls were placed to secure the 74 participants. 16 were Expert Systems developers; 12 optical data storage developers; 16 professionals involved with the designing, planning and managing of training programs; 19 instructional technology professionals; and 11 researchers in the field of artificial intelligence/expert systems.

Table 2 shows the average number of years experience each of the participant groups possessed with expert systems, optical data storage technologies, and adult learning.

Table 2.
Participants Average Years of Experience by Field

Group	Expert Systems	Optical Data Storage	Adult Learning
Expert System Developers	7	4	10
Expert System Researchers	6	3	4
Instructional Technologists	6	8	11
Optical Data Storage System Developers	7	9	16
Trainers	4	5	16
Collectively	6	5.8	11.4

Collectively, the group averaged 6 years experience with expert systems, 5.8 years experience with optical data storage system technologies, and 11.4 years experience in working with adult learners.

Development of the Delphi Exercise

The Delphi Exercise for data collection can be characterized as a method for structuring communication within a group (Linstone & Turoff, 1979) for the purpose of allowing the group to develop a clearly defined and convergent pattern of major points while maintaining the minority opinion in a well-outlined form (Orlich, 1978). The participants in a Delphi are usually anonymous to each other and do not meet face-to-face. The Delphi administrator serves as their mutual contact. This structured communication may begin with the participants, independently, expanding on or exploring in greater detail the subject under discussion. This is followed by the members of the group expressing their degrees of agreement or disagreement and their supporting rationale for the views developed while exploring the subject. The communication is concluded when all previously gathered information has been analyzed by the group and a consensus of opinion is indicated.

This study was an attempt at forecasting some possible effects on instructional technology for adult learners over the next five years as the result of combining expert systems and optical data storage technologies in computer-assisted instruction. The Delphi technique was chosen as the tool to gather this information because, as Weaver (1972) points out, the purpose of the Delphi is to engage experts in conjecturing about the likelihood of an event occurring in the future. Other considerations were also taken into account when choosing the Delphi for use with this group. Three of the five participant groups (trainers, instructional technologists, optical data storage developers) in this study might have been adversely affected by the necessity of a face-to-face group meeting. Using the Delphi, avoided the possibility that recognized leaders in the field of Artificial Intelligence would dominate other group members during the idea generating process. The anonymity afforded by the Delphi process prevents certain individuals from dominating the process in this manner. The participation of the expert systems developers and the optical data storage developers may also have been affected by a face-to-face meeting. As these individuals were involved in commercial product development, knowledge that a competitor is part of the group could have made them more reticent to share ideas. Again, the anonymity of the Delphi process would alleviate this problem. Finally, it was not economically nor temporally practical for this researcher to bring all of these individuals together for a face-to-face group process.

The data collection effort for this research involved three questionnaires that comprised the Delphi Exercise. In the first questionnaire (Appendix C), the researcher stated the initial question for the participants to explore and expand upon. In the second questionnaire (Appendices H

& I), the researcher asked participants to offer a judgement and supportive reasoning on a collated list of responses from question one. These judgements were to be based on the possibility that the technologies described in the response will be combined in the next five years and will provide an advantageous impact on adult learners. Judgements were offered on a six-point Likert scale offering the following choices:

6 = Advantage for adult learners, Will be achieved technologically
5 = Advantage for adult learners, Possible to achieve technologically
4 = Advantage for adult learners, Impossible to achieve technologically
3 = No advantage for adult learners, Will be achieved technologically
2 = No advantage for adult learners, Possible to achieve technologically
1 = No advantage for adult learners, Impossible to achieve technologically

Five responses to the first questionnaire suggested that combining expert system and optical data storage technologies would have negligible or no impact on adult learners. This area required a separate five-point Likert scale in order to establish group agreement or disagreement with these suggestions. This second Likert scale offered the following choices:

5 = Strongly Agree
4 = Agree
3 = No Opinion
2 = Disagree
1 = Strongly Disagree

In the final questionnaire (Appendices M & N) a ranked list was compiled for the group and returned to the participants. They were, once again, asked to offer a judgement on the same six-point and five-point Likert scales as in the second questionnaire for each item and to provide arguments supporting their judgements. Participants' judgements this time should be based on: 1) the possibility that the technologies described in the response will be combined in the next five years, 2) the combination of technologies will provide an advantageous impact on adult learners, 3) the individual's original judgement and reasons, 4) the group judgement value, and 5) supporting comments offered by the group for each item. An account of the development process for each questionnaire is detailed on the following pages.

Round One Question: The purpose of this round was to identify how expert systems and optical data storage systems might be combined in the next five years and what impact these combinations might have on adult learners.

This question also involved the development of a telephone script (Appendix A) to guide the researcher in the initial contact with a potential participant, and a cover letter (Appendix B) to accompany the first question (Appendix C). These materials were pilot tested by 5 individuals, 1 from each of the five respondent groups. Each reviewer was approached as the actual participant would be, with the initial telephone script. The exception being that they were aware of the pilot test nature of their participation. The reviewers were sent the Question 1 Cover Letter, Question 1 with instructions, and a Pilot Test Cover Letter (Appendix D) soliciting the following feedback:

a) Does the initial telephone conversation prepare the individual for this Delphi exercise?

b) Does the cover letter provide enough detail as to the structure of the study? (Who is participating, how many individuals are involved, the timelines.)

c) Do the instructions provide adequate background for the Delphi question?

d) Is the purpose of the study clearly understood?

e) Does the layout of the Delphi response form seem logical?

f) How much time was needed to complete this Delphi response form?

Results Of The Pilot Test: All of the reviewers commented that the topic of the study was of interest to them. This gave the researcher an indication of the study's value to individuals involved in developing Expert System and optical data storage technologies, conducting research into Expert Systems, and in developing learning systems.

In examining the Round One pilot question materials, all of the reviewers indicated that the telephone conversation, cover letter, and instructions fulfilled their objectives. The purpose of the study was clear to all and the structure of the Delphi response form posed no problems. Four of the reviewers completed the response form within the estimated 20 - 30 minutes. One reviewer required 45 minutes to complete the form, but indicated that some text research was included in that time in order to develop his ideas. Two additional comments resulted in modifications to the pilot materials:

a) Three of the reviewers interpreted `formal education' in the Delphi instructions to exclude training situations. As such, `training' was added to the first sentence.

b) Two reviewers mentioned that this study would require participants knowledgeable in the areas of expert system and optical data storage technologies, and adult learning. Item 3c was added to the telephone script to help screen for these individuals.

With these edits, the development of the Round One Question was finalized and sent to participants.

Round Two Question: The purpose of this round was two fold. First, to clarify the suggestions obtained in Round One through supportive statements and criticisms. Second, to establish a preliminary ranking of which technologies would most likely be combined in the next five years and have the greatest impact on adult learners.

The participants responded to the Round One question with 153 suggestions regarding the ways that expert systems could be combined with optical data storage technologies and the resulting impact on adult learners. The researcher constructed a composite list of these 153 suggestions (Appendix E). Because 153 suggestions would be an excessive number for most participants to offer judgements on in the second round, a process of systematic elimination was used to reduce this number. Suggestions were combined and grouped according to the following criteria:

a) **Group suggestions based on their impact on adult learners.** Suggestions were grouped together based on the impact these technologies might have on adult learners. Many of the suggestions contained compound ideas as to the impact the combining of these technologies might have on adult learners. These compound ideas were extracted from the original suggestion and placed in a group of related ideas. As such, a single participant's suggestion could contribute ideas to more than one group. When this sorting was complete, 26 groups had been formed.

b) **Group non-related suggestions.** One of the 26 groups was composed of 17 suggestions that did not seem to relate to any of the other suggestions based on the impact that combining these technologies might have on adult learners. After reviewing each of these 17 suggestions, the researcher decided to retain them for the second round as each seemed insightful and had the potential to stimulate ideas in the participants.

c) **Combine duplicate suggestions within groups.** Within each of the remaining 25 groups, duplicate suggestions were combined into a single statement. Suggestions within an area typically varied with regard to how the expert system and optical data storage technologies were combined. In the case of the three groups: IDENTIFIES STUDENT'S LEARNING STYLE, PORTABILITY, and CREATES PERFORMANCE SUPPORT SYSTEM, the resulting impact on adult learners also varied.

d) **Make statements grammatically correct.** Remaining suggestions were then edited to produce a grammatically correct statement. The participants who signed their Round One questionnaire received a copy indicating which statements in Round Two their suggestions had contributed to. If they disagreed with the way the researcher had handled their suggestion(s), they were to indicate their disagreement on the Round Two questionnaire.

Table 5 in Chapter 4 shows the relationship of participant's suggestions to the final statements.

Through this process the number of suggestions was reduced to 64 statements grouped into 26 areas which formed the first part of the Round Two questionnaire, the Statements Form (Appendix H). A Response Form (Appendix I) comprised the second part of the Round Two questionnaire. Only the Response Form was returned to the researcher. On the Instructions page of the Statements Form the researcher recommended that the participants note their judgements next to each statement. This would allow the participants to compare their Round Two judgements with the group values returned in Round Three.

In responding to the Round Two questionnaire the participants were asked to first consider the 26 areas into which the statements had been grouped before making judgements on the individual suggestions. Participants were also informed that the suggestions within an area may vary only in how the technologies are combined. Participants were then to choose the alternative on the Likert scales closest to their judgement and offer supporting comments.

Two cover letters were generated for the Round Two questionnaire. One, thanking those participants who signed their Question 1 form for returning it (Appendix F). The second letter to those participants who did not sign their returned questionnaire and for those participants who did not return their Round One questionnaire (Appendix G).

Round Three Question: The purpose of this final round was to permit the participants to review the ranking and comments generated from Round Two and to offer revised judgements and comments on this ranking.

The development of Round Three of the Delphi began by reviewing all of the Round Two comments for indications that the researcher had misinterpreted a Round One suggestion in creating the Statements Form. No indications of this nature were present. However, it was felt that in the non-grouped statements number 44 should have been with the SIMULATIONS group and number 51 should have been with the INDIVIDUALIZES LEARNING group. Upon review, these suggestions were considered valid.

Development proceeded with the construction of a spreadsheet for entering each participant's group (Training, Instructional Technology, Expert System Development, Expert System Research, Optical Data Storage) and their judgements from the Likert scales. This database was then used to calculate the averages for each of the 64 suggestions.

A word processing file was also set up to record the supporting comments for each suggestion. Most supporting comments were entered verbatim. The editing that occurred was for grammatical clarity, to remove shorthand abbreviations, and to abridge long comments for participants' convenience.

The Round Three questionnaire was also developed as two parts; a Comments Form (Appendix M) and a Response Form (Appendix N). Only the Response Form was returned to the researcher. Based on the analysis of the Round Two responses for all participants, Round Three suggestions were rank ordered on the Response Form ranging from 5.79, the technologies being combined within the next five years and having an advantage for adult learners, to 4.10, the technologies can not be combined in the next five years but there would be an advantage for adult learners. The area dealing with the four suggestions that combining the technologies would have negligible or no impact on adult learners was rank ordered separately from 3.76, mild agreement, to 2.21, mild disagreement.

The items on the Response Form for Round Three were not renumbered after they were placed in rank order. The researcher felt this would allow participants an easier reference to their Round Two judgements, if participants had noted their judgements on the Round Two Statements Form.

The Round Three Comments Form began with 6 comments addressing the research in general. The comments for the specific suggestions were retained in numerical sequence. Comments for each suggestion were arranged so that similar comments were contiguous and ranged from supporting the suggestions to disagreement.

In responding to the Round Three questionnaire the participants used the same Likert scales that were used in Round Two. Participants were asked to first review the general comments that were made regarding the research. Then, for each suggestion, before offering a revised judgement and supporting comments, consider: First, the group judgement and the supporting comments for the suggestion. Second, the two original questions from Round Two; 1) What is the possibility that the technologies described in the suggestion will be combined in the next five years? 2) Will this combination of technologies provide an advantageous impact on adult learners? And, third, their original judgement and reasons from Round Two.

Again, two cover letters were generated for the Round Three questionnaire. One for participants who signed the Round Two Response Form (Appendix K) and one for the remaining participants (Appendix L).

Analyzing The Data

Research questions 1 and 2 were answered from Round Three statement numbers 1 through 60 that had group means of 5.5 or greater. These statements were considered as technologically feasible to achieve and, if this technology was applied to adult learning situations, would be capable of affecting adult learners as described.

Research question 3 was answered by analyzing the 153 insights contributed by participants in responding to the Round One questionnaire which were used to develop the 64 statements for the Round Two questionnaire. A Statement was considered to be unique and to have originated solely from either the technology researchers and development group (DEV), composed of expert system developers and researchers and optical data storage developers, or the human resource developers group (HRD), composed of training and instructional technology professional, if it was developed from two or more insights contributed from one group and none from the other.

To test the null-hypothesis for the research question 4, the nonparametric Mann-Whitney test was employed. Because the assumptions of normality of distribution about the mean and equality of variance were not supported by the data, a standard parametric test, such as the t-test, could not be used. Of the nonparametric tests available, the Mann-Whitney was chosen as its purpose is to determine whether two uncorrelated means differ significantly from each other (Borg and Gall, 1979).

Research question 5 was answered from the statement numbers 61 through 64 in Round Three. Any of these statements with group mean of 3.5 or greater was considered as a factor with a negative impact on the effective application of these combined technologies on adult learners.

Data Collection Schedule

This Delphi technique involved three rounds of questionnaires over a period of eight months. The schedule of activities followed is outlined below.

DATE	ACTIVITY
6/03-10/91	Initial telephone contact was made with each of the (50 - 75) participants to obtain agreement to participate in the Delphi. The Round 1 question and cover letter were mailed out to the participant immediately following acceptance.
6/27/91	Mail postcards to Round 1 participants who had not yet responded to the questionnaire.
7/09/91	Telephone calls to Round 1 participants who had not yet responded to the questionnaire
10/11/91	Mail Round 2 question to participants.
10/18/91	Mail postcards to Round 2 participants who had not yet responded to the questionnaire.
10/29/91	Telephone calls to Round 2 participants who had not yet responded to the questionnaire
12/12/91	Mail Round 3 question to participants.
1/06/92	Mail postcards to Round 3 participants who had not yet responded to the questionnaire.
2/04/92	Telephone calls to Round 3 participants who had not yet responded to the questionnaire
2/28/92	Mail thank you postcards to Round 3 participants and indicate when they can expect to receive a final summary of the results.

Summary

In Chapter III, the Delphi research questions were identified. The participants in the study were defined as being drawn from five groups: computer scientists researching artificial intelligence/expert systems, optical data storage developers, expert systems developers, industrial training professionals, and instructional technology professionals. Participants were chosen from the 1990 membership lists of the American Association for Artificial Intelligence (AAAI), Industrial Training and Education Division (ITED) of the Association for Educational Communications & Technology (AECT), Instructional Technology Professional Practice Area of the American Society for Training and Development (ASTD), and from companies identified using the Training Marketplace Directory.

A Delphi exercise was employed in the data collection for this study. The rationale for using the Delphi exercise was discussed, as was the development of each question and the method of analysis. This development included a review of Question 1 by five individuals, representative of the participant groups before it was sent to the participants. The results of that review were largely positive, indicating the need for this study. The suggestions made by the reviewers for modifications to the questionnaire were provided.

How each of the research questions would be answered was then discussed. The answers to questions 1, 2, and 5 would be based on the rank ordering of the statements by the participants after Round Three. Question 3 would be answered by comparing the contributions of the participants' Round One insights to the development of the statements for the Round Two questionnaire. And, question 4 would be answered by an analysis of the Round Three rankings using the Mann-Whitney nonparametric statistical test for significant difference between uncorrelated means. Finally, a detailed schedule outlining the data collection procedure was included in Chapter Three.

CHAPTER IV

FINDINGS

Introduction

The purpose of this research was to determine expert judgements about possible technological combinations of expert systems and optical data storage systems that might occur within the next five years (1991 - 1996) and to determine the impact such combinations could have on adult learners if applied in the education and the training fields. This chapter presents an analysis and discussion of the data collected during the three rounds of the Delphi. Three research questions were posed as the focus of Round One, three research questions in Round Two, and four research questions in Round Three. Responses and analysis to each of these ten questions will be discussed in their order of collection later in this chapter. To begin the chapter, the response characteristics of the participants will be considered, examining both the response rate and quality of the responses.

Response Characteristics of the Participants

Response Rate For the Three Questionnaires: The first round questionnaire was sent to seventy four participants. Thirty six participants responded with insights on how expert system and optical data storage technologies might be combined and on what might be their impact on adult learning. Six participants indicated that after reviewing the question they did not feel qualified to respond and asked to drop out of the Delphi. Sixty eight questionnaires were sent out in the second round with thirty three participants offering judgements and one requesting to drop out of the Delphi. The final questionnaire was sent to sixty seven participants with forty responding. Table 3 summarizes these rates.

Table 3.
Response Rate of Mailed Questionnaires.

Round	Number Sent	Number Returned	Percent Returned	Number Dropping Out
1	74	36	49	6
2	68	33	49	1
3	67	40	60	0

The questionnaires were sent to five subgroups that made up the Delphi participants: 19 instructional technology professionals (IT); 16 professionals involved with the design, planning and managing of training programs (T); 16 expert systems developers (ESD); 11 researchers in the field of artificial intelligence/expert systems (ESR); and 12 optical data storage developers (ODS). In the first round, the six participants who dropped were distributed among the subgroups as follows: 1 IT, 2 T, 1 ESD, and 2 ESR. The single participant who dropped during the second round was a member of the ESR subgroup. Table 4 summarizes the response rates for each of these subgroups.

Table 4.
Response Rates for the Delphi Subgroups

Round	IT	%	T	%	ESD	%	ESR	%	ODS	%	Total # of Respondents
1	12	63	9	56	7	44	5	45	3	25	36
2	9	50	8	57	6	40	5	56	5	42	33
3	11	61	11	79	7	47	5	63	6	50	40

% = Percent returned for the subgroup based on the number of participants in the subgroup at the beginning of each round.

Delbecq, Van deVen and Gustafson (1986) suggest that 10 - 15 well-chosen participants can generate a full range of ideas in a Delphi with few new ideas being added once the group size exceeds thirty. In reviewing the literature on the Delphi technique no indication of a critical attrition rate that would invalidate the Delphi was found.

Because of the anonymity in responding to the Delphi rounds it was necessary to send round two and three questionnaires to all participants who had not officially requested to be dropped from the technique. As such, participation in subsequent rounds did not depend on participation in previous rounds. Keeping in mind that not all returned questionnaires could be tracked by the researcher, it was found that 19 participants responded to all three rounds, 6 responded to only Rounds One and Two, 4 responded to only Rounds One and Three, and 7 responded to only Round One. Table 5 summarizes these figures.

Table 5.
Estimated Individual Participation in the Delphi Rounds.
* Anonymous responses not included.

Participated in	Number of Individuals
All 3 Rounds	19
Only Rounds 1 & 2	6
Only Rounds 2 & 3	0
Only Rounds 1 & 3	4
Only Round 1	7
Only Round 2	0
Only Round 3	0

Quality of Participants' Responses: During the initial telephone conversations many individuals indicated enthusiasm for the topic. Several participants gave the researcher references to works that they felt could have bearing on the topic.

Once the Delphi was under way the consistency of the return rates between Rounds One and Two, the increase in the return rate between Rounds Two and Three, and the known number of individuals that responded to all three rounds indicated that there was a core of participants committed to this research. Participants apparently had no difficulty in understanding the instructions as all returned questionnaires were completed correctly.

Judging from the 153 suggestions offered in Round One and the liberal expression of comments to support judgements in Rounds Two and Three many of the participants spent a substantial amount of time on the questionnaires. In addition, several articles that participants felt would be of interest to the researcher were included with returned Round One and Two questionnaires.

Results of Round One

The purpose of the first questionnaire (Appendix C) was to solicit responses to the following research questions:

1. Which combinations of the expert system and optical data storage technologies are most likely to be achieved in the next five years?

2. What contribution(s) to adult learning could the combinations of these technologies be expected to produce?

3. Which insights were unique and originated solely from each of the five subgroups: instructional technology professionals (IT); professionals involved with the design, planning and managing of training programs (T); expert systems developers (ESD); researchers in the field of artificial intelligence/expert systems (ESR) and optical data storage developers (ODS).

The Round One Questionnaire provided participants with the opportunity to express their insights into how the technologies of expert systems and optical data storage systems might be combined in the next five years and the impacts that such technological combinations might have on adult learners. One hundred fifty three insights were suggested by the study participants (Appendix E). Three examples of these insights are provided in Table 6.

Table 6.
Examples of Insights Provided from Round One

How the Technologies Might Be Combined	The Impact On Adult Learners
12. Optical media will permit storage of more motion and audio with pictures.	Pictures can be used to clarify a learner's understanding of concepts or decisions solicited during an "expert system" session. The altering of motion video could be as easy as the present rearrangement of still video. For example, in landscape architecture the location of shrubbery and ornamentals and the resulting effect of their shadows as the Sun passes across the sky during the day.
22. Expert System and any of the optical data storage technologies	The general impact will be negligible. Many aspects of learning, as an example the affective domain, cannot be reduced to a level capable of being programed into a computer. As such, it is believed that Expert Systems will not be capable of capturing or analyzing the nuances and individual characteristics of learners, their styles of learning or their reaction to mediated instruction.
41. Expert System and CD-ROM database	Continual monitoring of the student's learning process.

Because 153 suggestions would be an excessive number for most participants to offer judgements on in the second round, a process of systematic elimination was used to reduce this number. Suggestions were combined and grouped according to the following 3 criteria:

a) **Group suggestions based on their impact on adult learners.** The researcher began by grouping the suggestions together based on the impact combining these technologies might have on adult learners. Many of the suggestions contained compound ideas as to the impact the combining of these technologies might have on adult learners. These compound ideas were extracted from the original suggestion and placed in a group of related ideas. As such, a single participant's suggestion could contribute ideas to more than one group. When this sorting was complete, 26 groups had been formed.

b) **Group non-related suggestions.** One of the 26 groups was composed of 17 suggestions did not seem to relate to any of the other suggestions based on the impact that combining these technologies might have on adult learners. After reviewing each of these 17 suggestions, the researcher decided to retain them for the second round as each seemed insightful and had the potential to stimulate ideas in the participants. The researcher felt that this simulation might reflect elsewhere in the Round Two Questionnaire.

c) **Combine duplicate suggestions within groups.** Within each of the 25 groups having related suggestions, duplicate suggestions were combined into a single statement. Suggestions within a group typically varied with regard to how the expert system and optical data storage technologies were combined.

In the case of the three groups; IDENTIFIES STUDENT'S LEARNING STYLE, PORTABILITY, and CREATES PERFORMANCE SUPPORT SYSTEM the resulting impact on adult learners also varied.

Through this process the number of suggestions was reduced to 64 statements distributed across the following 26 groups:

1. Identifies Student's Learning Style
2. Performs Needs Analysis
3. Adjusts Program to Student's Pace
4. Maintains Motivation/Interest
5. Facilitates Interactive Learning
6. Facilitates Creativity
7. Individualizes Learning
8. Facilitates Self-Directed Learning
9. Facilitates Discovery Learning
10. Provides Realistic Simulations
11. Illustrates Dynamics of Complex Problems
12. Improves Basic Skills Instruction
13. Increases Retention
14. Assists in Retrieving Information from Databases
15. Acts as an Intelligent Evaluator During Learning
16. Expert System Has the Ability to Learn
17. Portability, Learning Can Occur Anywhere
18. Creates Performance Supports Systems
19. Lowers Cost of Training
20. Simplifies CAI Through a Graphic User Interface
21. Increases Use of Visuals
22. Increases Use of A/V
23. Facilitates Cost Effective Repurposing of Materials
24. Provides for Easier/More Efficient Updating of Materials
25. Non-Grouped Responses
26. Negligible or No Impact on Adult Learners

Table 7 shows the relationship of participant's suggestions to the final statements used in the Round Two questionnaire.

Table 7.
Suggestion Contributions to Final Statements

Suggestion # From Appendix E	Contributed to Rnd. 2 Statement #	Suggestion # From Appendix E	Contributed to Rnd. 2 Statement #
1	34	44	2,10
2	16	45	4,12
3	22	46	36
4	12	47	60
5	12,38	48	47
6	19	49	8,40,42
7	44	50	42
8	14	51	40
9	25	52	40
10	13	53	2,5
11	37,38	54	30
12	41	55	17
13	13	56	22
14	55	57	29
15	27	58	22
16	37	59	36
17	22	60	21,41
18	18	61	13
19	30	62	36
20	27	63	27
21	56	64	57
22	61	65	22
23	16	66	31
24	16,36	67	22
25	15,16,20	68	16
26	10	69	40,42
27	11,23	70	40,42
28	14,62	71	12,41
29	6	72	17
30	7,20,40	73	22
31	45	74	43
32	1	75	11
33	1	76	53
34	3	77	54
35	19	78	18
36	51	79	17,39
37	13	80	13
38	23	81	4,12
39	1	82	25
40	46	83	21,36
41	23	84	42
42	52	85	25
43	8,41	86	2,4,5,12

Table 7 (cont'd).

Suggestion # From Appendix E	Contributed to Rnd. 2 Statement #	Suggestion # From Appendix E	Contributed to Rnd. 2 Statement #
87	5,17	120	21,30
88	2,4	121	21,30
89	2,41	122	40
90	24	123	33
91	2	124	2,24,41
92	4,12	125	49
93	7,12,15,24	126	63
94	4,12,41	127	22
95	38	128	30
96	24	129	4,12,31
97	58	130	64
98	12,24,41	131	17
99	22	132	26
100	48	133	38
101	7,41	134	50
102	2,24,41	135	22
103	4,6,23,39	136	21,30
104	59	137	17
105	32	138	7,12,24
106	2,7,12,24	139	2,12
107	14,41	140	30
108	8,9,41	141	8
109	17	142	43
110	31	143	2,4,12
111	35	144	31
112	22	145	17
113	14,22	146	2,9
114	12,41	147	4,12
115	14	148	28
116	17	149	24
117	24	150	31
118	12,15,24	151	22
119	21,30	152	22
		153	64

Table 8 reports the distribution of suggestions that contributed to the final statements used in the Round Two Questionnaire across the participant subgroups: instructional technology professionals (IT); professionals involved with the design, planning and managing of training programs (T); expert systems developers (ESD); researchers in the field of artificial intelligence/expert systems (ESR); and optical data storage developers (ODS). Three columns have been added to this table, HRD, DEV, and TOT. This was done based on Delbecq, Van deVen and Gustafson's (1986) guideline that 10 - 15 participants can generate a full range of ideas in a Delphi. Table 4 shows that there were enough total participants in the Delphi to satisfy this guideline. However, low participant response rate did impact the study of the subgroups. An examination of Table 4 reveals that ESD, ESR, and ODS were each well below 10 in all three rounds. IT and T response rates were marginal. In order to maintain a subgroup component of the study with valid numbers of participants the IT and T subgroups were combined into a single Human Resource Developers (HRD) subgroup. ESD, ESR, and ODS were similarly combined to form the technology researchers and developers (DEV) subgroup. The third column (TOT) gives the total number of suggestions that contributed to the final statement.

Table 8.
Distribution of the Participants' Suggestions to the Round Two Statements by Participant Subgroup

Round Two	Number of Times Suggested By:							
Statement #	IT	T	ESD	ESR	ODS	HRD	DEV	TOT
1	-	3	-	-	-	3	0	3
2	4	-	4	2	2	4	8	12
3	-	1	-	-	-	1	0	1
4	3	-	3	3	1	3	7	10
5	-	-	2	-	-	0	2	2
6	-	1	-	1	-	1	1	2
7	1	1	-	3	-	2	3	5
8	1	1	-	1	1	2	2	4
9	1	-	-	1	-	1	1	2
10	-	1	-	-	1	1	1	2
11	1	1	-	-	-	2	0	2
12	7	2	3	5	1	9	9	18
13	-	3	2	-	-	3	2	5
14	2	2	-	1	-	4	1	5
15	1	1	-	1	-	2	1	3
16	-	4	1	-	-	4	1	5
17	5	-	3	-	1	5	4	9
18	-	2	1	-	-	2	1	3
19	-	2	-	-	-	2	0	2
20	-	2	-	-	-	2	0	2
21	4	-	2	-	-	4	2	6
22	6	2	3	1	2	8	6	14
23	-	3	-	1	-	3	1	4
24	5	-	1	5	-	5	6	11
25	-	1	2	-	-	1	2	3
26	1	-	-	-	-	1	0	1
27	-	2	1	-	-	2	1	3
28	1	-	-	-	-	1	0	1
29	-	-	-	-	1	0	1	1
30	6	1	-	-	1	7	1	8
31	4	-	1	-	-	4	1	5
32	-	-	-	1	-	0	1	1
33	1	-	-	-	-	1	0	1
34	-	2	-	-	-	2	0	2
35	1	-	-	-	-	1	0	1
36	-	1	2	-	2	1	4	5
37	-	2	-	-	-	2	0	2
38	1	1	-	1	-	2	1	3
39	-	-	1	1	-	0	2	2
40	1	1	2	-	3	2	5	7
41	2	2	3	6	-	4	9	13
42	-	-	3	-	2	0	5	5
43	1	-	1	-	-	1	1	2
44	-	1	-	-	-	1	0	1
45	-	1	-	-	-	1	0	1
46	-	1	-	-	-	1	0	1

Table 8 (cont'd).

Round Two Statement #	Number of Times Suggested By: IT	T	ESD	ESR	ODS	HRD	DEV	TOT
47	-	-	-	-	1	0	1	1
48	-	-	-	1	-	0	1	1
49	1	-	-	-	-	1	0	1
50	1	-	-	-	-	1	0	1
51	-	1	-	-	-	1	0	1
52	-	1	-	-	-	1	0	1
53	-	-	1	-	-	0	1	1
54	-	-	1	-	-	0	1	1
55	-	1	-	-	-	1	0	1
56	-	1	-	-	-	1	0	1
57	-	-	1	-	-	0	1	1
58	-	-	-	1	-	0	1	1
59	-	-	-	1	-	0	1	1
60	-	-	-	-	1	0	1	1
61	-	1	-	-	-	1	0	1
62	-	1	-	-	-	1	0	1
63	1	-	-	-	-	1	0	1
64	2	-	-	-	-	2	0	2

Table 9 reports the distribution of suggestions across the participant subgroups as organized for the Round Two Questionnaire for 25 of the 26 statement groups. The group that is not included on Table 9 is for the NON-GROUPED RESPONSES, statements 44 - 60 in Table 8, as these statements have no common relationship to any other statements based on the impact that combining these technologies might have on adult learners. Examples of five of these non-grouped statements are provided in Table Ten.

Table 9.
Distribution of the Participants' Suggestions to the Round Two Groups by HRD and DEV
(NON-GROUPED Responses not included)

Group	HRD	DEV	TOT
Identifies Student's Learning Style	8	8	16
Performs Needs Analysis	3	7	10
Adjusts Program to Student's Pace	0	2	2
Maintains Motivation/Interest	3	4	7
Facilitates Interactive Learning	2	2	4
Facilitates Creativity	1	1	2
Individualizes Learning	12	10	22
Facilitates Self-Directed Learning	7	3	10
Facilitates Discovery Learning	2	1	3
Provides Realistic Simulations	9	5	14
Illustrates Dynamics of Complex Problems	2	1	3
Improves Basic Skills Instruction	2	0	2
Increases Retention	6	2	8
Assists in Retrieving Information from Databases	8	6	14
Acts as an Intelligent Evaluator During Learning	8	7	15
Expert System has the Ability to Learn	2	2	4
Portability, Learning can Occur Anywhere	3	2	5
Creates Performance Supports Systems	15	3	18
Lowers Cost of Training	1	4	5
Simplifies CAI Through a Graphic User Interface	2	0	2
Increases Use of Visuals	2	1	3
Increases Use of A/V	6	16	22
Facilitates Cost Effective Repurposing of Materials	0	5	5
Provides for Easier/More Efficient Updating of Materials	1	1	2
Negligible or No Impact on Adult Learners	5	0	5

Table 10.
Examples of Non-grouped Suggestions

48. An Expert System combined with any of the optical data storage technologies that assist in the development of instruction could make it easier and faster to develop quality educational programs.

53. An Expert System combined with a CD-ROM database could result in more attractive learning.

54. An Expert System combined with a CD-ROM database could result in more experimental data being available to the learner.

59. An Expert System combined with a CD-ROM knowledge base could explain and justify what it is doing so the student could acquire the skills of the Expert System as well as the background information to support those skills.

60. An Expert System combined with any of the optical data storage technologies could provide consistency in the training.

Results of Round Two

The purpose of the second questionnaire (Appendices H & I) was to solicit participants' judgements to the statements generated from the first questionnaire in addressing the following research questions:

1. Which combinations of the expert system and optical data storage technologies are most likely to be achieved in the next five years?

2. What contribution(s) to adult learning could the combinations of these technologies be expected to produce?

Data from the first round questionnaire enabled the researcher to add a third research question in the second round:

3. What are the factors that may negatively impact the effective application of these combined technologies as an instructional system for adult learners?

The Round Two Questionnaire provided participants with the opportunity to express their judgements on the first 60 statements concerning the feasibility of the expert system and optical data storage technologies being combined in the next five years and the impact the combinations might have on adult learning. Judgements were also offered on the last 4 statements describing factors that may negatively impact the effective application of these combined technologies on adult learners.

Participants were asked to offer judgements for the first 60 statements based on a six-point Likert scale offering the following choices:

6 = Advantage for adult learners, Will be achieved technologically
5 = Advantage for adult learners, Possible to achieve technologically
4 = Advantage for adult learners, Impossible to achieve technologically
3 = No advantage for adult learners, Will be achieved technologically
2 = No advantage for adult learners, Possible to achieve technologically
1 = No advantage for adult learners, Impossible to achieve technologically

A separate five-point Likert scale was used for the judgements offered on the last 4 statements. This Likert scale providing the following choices:

5 = Strongly Agree
4 = Agree
3 = No Opinion
2 = Disagree
1 = Strongly Disagree

Participants used the form presented in Appendix I to offer their judgements on the 64 statements.

Table 11 reports the judgements offered on Appendix I by the Delphi participants for Round 2. The first 60 statements are ranked, based on the group average, from being an advantage for adult learners and will be achieved technologically in the next five years to being of no advantage for adult learners and impossible to achieve technologically in the next five years. Statements with identical averages were ranked based on their standard deviation, from smallest to largest. The last four statements are also ranked on the group average, from strongly agree to strongly disagree.
The Likert Distribution of the participants' responses to each statement is also shown.

Table 11.
Judgements In Response To Round Two N = 33

Ranked Statement Number	Likert Distribution 1	2	3	4	5	6	GROUP Mean
39					7	26	5.7879
41					8	25	5.7576
40					9	24	5.7273
32					10	23	5.6970
27			1	1	7	23	5.6250
35				1	11	21	5.6061
30		1		1	10	21	5.5152
44				1	5	17	5.4848
22			3		9	21	5.4545
16		1	2		8	21	5.4375
8		1	1	1	11	19	5.3939
28			2	2	10	18	5.3750
29			2	1	11	16	5.3667
4			1	4	10	18	5.3636
12		1	1		14	17	5.3636
18	1	1			12	19	5.3636
17		1	2		11	18	5.3438
11		1	1	1	13	17	5.3333
23	1			4	9	19	5.3333
10		1	1	2	12	17	5.3030
51	1		2		12	18	5.3030
43	1			3	12	16	5.2813
52			3	4	7	19	5.2727
1	1		1	1	14	16	5.2727
24	1			4	11	17	5.2727
38		1	4		8	20	5.2727
5	1		1	4	9	18	5.2424
33		1	2	1	14	14	5.1875
2	1		1	1	17	13	5.1818
37	1	1	2		12	17	5.1818
31	2	1	1		10	19	5.1818
9			1	5	14	12	5.1563
15	2			3	12	16	5.1515
14	1		2	3	12	15	5.1212
46	1		2	2	15	13	5.0909
13	1		2	4	11	15	5.0909
42		2	1	3	13	13	5.0625
6	1	1	1	2	15	13	5.0606
7	1	1	1	1	18	11	5.0303
36	2	1		4	12	13	4.9375
55	2	1	2		13	12	4.9000
54	1	3	2		13	13	4.8750
56	1	2	3	1	11	13	4.8710
59	1	2	2	3	13	12	4.8485
34	5			1	11	16	4.8485

Table 11 (cont'd).

Ranked Statement Number	Likert Distribution 1	2	3	4	5	6	GROUP Mean
48	1		3	3	17	8	4.8438
53	3	1	2		12	14	4.8438
3	1	1	2	4	16	9	4.8182
60	1	2	3	3	10	13	4.8125
19	1	5	3		7	17	4.7576
58	1	3	3	1	14	11	4.7273
20	1	4	4		9	15	4.7273
26	1	2	1	3	18	5	4.6667
21	1	4	4		11	13	4.6667
25	3		3	5	12	8	4.5161
45	3	1	4	3	13	8	4.4375
57	1	4	4	2	12	8	4.4194
50	2	5	2	1	14	6	4.2667
47	4	2	2	3	14	5	4.2000
49	4	2	4	3	11	6	4.1000
64	3	5	1	12	12	NA	3.7576
62	9	7	4	10	3	NA	2.7273
63	7	10	3	9	3	NA	2.7188
61	11	15		3	4	NA	2.2121

NA = Not Applicable as the last four statements only used a 5 point Likert scale.

Appendix J presents the information in Table 11 in an expanded form. Each statement is written out in rank order with the Likert distribution below the statement. The GROUP Means column is to the right of each statement. An example from Appendix J for statements 39 and 41 follows:

Judgements In Response To Round Two **N = 33**

*** Number of Participants responding to the Likert scale are beneath each statement**

Ranked Statement	Likert Distribution	GROUP Mean
39. An Expert System combined with CD-ROM could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and		

to better match the instruction to the student's learning style.	
1=0 2=0 3=0 4=0 5=7 6=26	5.7879
41. An Expert System combined with any of the optical data storage technologies could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.	
1=0 2=0 3=0 4=0 5=8 6=25	5.7576

Participants were also encouraged to offer rationales to support their judgements. Appendix M reports the comments for each statement. The comments for a statement are presented with those that support the statement first, followed by the comments that refute the statement. The comments for Statement 34 is an example:

Statement 34: CD-ROM or DVI can be used to provide very large databases or "facts" or real world knowledge that will allow expert systems to have very "deep and broad" intelligence. These expert systems could provide "job performance aids" that would minimize the importance or need for students to remember or learn factual details of tools, products, and procedures.

Comments: There is too much data out there to memorize. Harvard Medical school stresses using databases instead of memorizing trivia. / Currently being done, both with and without Expert Systems. / Believe this exists now. / Boo! Hiss! / It is necessary to memorize facts so that when immediately needed they are available. Also, job aides are not always readily available./...

Results of Round Three

The third questionnaire (Appendices M & N) gave participants the opportunity to reevaluate their round two judgements in light of the group average and the supporting comments for each statement. The research questions addressed in this round were:

1. Which combinations of the expert system and optical data storage technologies are most likely to be achieved in the next five years?

2. What contribution(s) to adult learning could the combinations of these technologies be expected to produce?

3. What are the factors that may negatively impact the effective application of these combined technologies as an instructional system for adult learners?

The data from this round of the Delphi allowed the researcher to answer an additional related question:

4. Is there a significant difference between the group judgements of the HRD and DEV participants for any of the statements?

Of the Round Three Questionnaire responses the first 60 statements were rank ordered, based on the Round Two group mean and standard deviation for each statement. Statements were rank ordered from those considered to be technologically achievable within the next five years and having the greatest impact on adult learners, to those not technologically achievable within this time frame and of no advantage for adult learners. The participants' supporting comments for each statement were also provided. Participants were asked to consider the group judgement for each statement, review the supporting comments for each statement and then to offer a second judgement on the statement. Second judgements were also offered on the last 4 statements. These statements were also ranked, from Strongly Agree to Strongly Disagree based on the group mean for each statement. The same six-point and five-point Likert scales were used in Round Three as were used in Round Two for offering judgements on the first 60 statements and last 4 statements, respectively.

Table 12 reports the judgements offered by the Delphi participants for Round 3. As in Table 8, the first 60 statements are ranked, based on the group average, from being an advantage for adult learners and will be achieved technologically in the next five years to being of no advantage for adult learners and impossible to achieve technologically in the next five years. Statements with identical averages were ranked based on their stability (discussed later in this chapter) from most stable to least stable. The last four statements are also ranked on the group average, from strongly agree to strongly disagree. Distribution of the participants' responses to each statement is shown, as are the subgroup averages for HRD and DEV.

Table 12.
Judgements In Response To Round Three N = 40

Ranked Statement Number	Likert Distribution 1	2	3	4	5	6	HRD Mean	DEV Mean	GROUP Mean
39			1		12	27	5.6818	5.5556	5.6250
35		1		1	10	28	5.5909	5.6111	5.6000
41			1	1	11	27	5.6364	5.5556	5.6000
28		1	1		9	28	5.7273	5.4118	5.5897
22			1	1	12	26	5.5000	5.6667	5.5750
32		1	2		7	30	5.5455	5.6111	5.5750
40			1	1	12	26	5.5909	5.5556	5.5750
30	1			2	10	27	5.2727	5.8333	5.5250
12				2	15	23	5.5000	5.5556	5.5250
10				2	16	22	5.4545	5.5556	5.5000
31			2		16	22	5.4091	5.5000	5.4500
27		2	1	1	9	27	5.5455	5.3333	5.4500
51			2		16	21	5.4545	5.4118	5.4359
37			2	2	14	22	5.3636	5.4444	5.4000
52		1	3		11	25	5.5909	5.1667	5.4000
44		2	1	1	11	25	5.4545	5.3333	5.4000
17			2	1	15	20	5.6000	5.1667	5.3947
4	1			4	12	23	5.2727	5.5000	5.3750
11		1	1	3	13	22	5.4091	5.2778	5.3500
16	1		3		12	23	5.5714	5.0556	5.3333
8		1	4	1	9	25	5.4545	5.1667	5.3250
1	1		1	5	10	23	5.3182	5.2778	5.3000
43	1	1		2	15	20	5.1429	5.4444	5.2821
5	1	1	2	1	13	22	5.2273	5.2778	5.2500
6		1	2	3	17	17	5.0909	5.2778	5.1750
7			3	2	20	15	5.2727	5.0556	5.1750
29	1	1	2		16	17	5.0455	5.3333	5.1622
2	1		1	5	15	17	5.2381	5.0556	5.1538
23	2		1	6	10	21	5.0000	5.2778	5.1250
38		2	5	1	10	22	5.2727	4.9444	5.1250
42	1	1	2	2	16	17	5.2727	4.8824	5.1026
14	1	1	1	6	12	19	5.1364	5.0556	5.1000
33			6	2	14	17	5.2381	4.8889	5.0769
13	1	1	2	4	14	18	5.1818	4.9444	5.0750
53	1	2	3	1	14	17	5.3000	4.6667	5.0000
24	2		2	5	15	16	5.0455	4.8889	4.9750
15	2		1	6	16	15	5.0000	4.9444	4.9750
34	1	1	3	4	14	16	4.6818	5.3529	4.9744
60	1	2	3	2	13	17	5.4286	4.4118	4.9737
59			6	4	16	14	4.9091	5.0000	4.9500
58		2	4	2	15	14	4.7619	5.1875	4.9459
18	2	3	1		13	17	4.9000	5.0000	4.9444
46	1	2	4	2	14	17	4.9545	4.8889	4.9250
56		3	2	4	16	13	5.0000	4.7647	4.8947
9	1		6	6	13	14	4.9545	4.6111	4.8000
20	1	2	4	3	16	13	4.7619	4.8333	4.7949

Table 12 (cont'd).

Ranked Statement Number	Likert Distribution 1	2	3	4	5	6	HRD Mean	DEV Mean	GROUP Mean
54	1	2	6	2	16	13	4.6818	4.7778	4.7250
21	1	2	5	4	14	13	4.6190	4.8333	4.7179
36	4	1		5	17	12	4.9091	4.4118	4.6923
19	1	3	6	2	12	14	4.8000	4.5000	4.6579
55	2	5	1	1	15	13	4.8500	4.4118	4.6486
48	1	3	3	5	17	9	4.5500	4.6667	4.6053
50	3	2	3	4	18	7	4.5789	4.2778	4.4324
3	2	2	6	6	14	9	4.5714	4.2222	4.4103
45	2	2	5	8	14	8	4.4286	4.3333	4.3846
57	2	7	4	3	13	9	4.3333	4.0000	4.1842
26	3	4	3	6	17	4	4.2000	4.0588	4.1351
25	6	2	2	10	11	7	4.2381	3.7647	4.0263
49	6	1	4	9	13	6	4.1905	3.8333	4.0256
47	4	3	5	4	16	3	4.1579	3.7500	3.9714
64	4	5	2	18	11	NA	3.8182	3.5000	3.6750
63	6	10	5	11	7	NA	2.9048	3.2778	3.0769
62	10	13	2	10	5	NA	2.7727	2.5556	2.6750
61	11	21	1	3	4	NA	2.3636	2.0000	2.2000

NA = Not Applicable as the last four statements only used a 5 point Likert scale.

Appendix P presents the information in Table 12 in an expanded form. Each statement is written out in rank order with the Likert distribution below the statement. The HRD, DEV and GROUP Means columns are to the right of each statement. An example from Appendix P for statements 39, 35 and 41 follows:

Judgements In Response To Round Two **N = 40**

*** Number of Participants responding to the Likert scale are beneath each statement**

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
39. An Expert System combined with CD-ROM could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.	1=0 2=0 3=1 4=0 5=12 6=27	5.6818	5.5556	5.6250
35. A portable computer with an Expert System and an optical data storage system would allow learning, review of previously learned material, or consultation with the knowledge base to take place anywhere.	1=0 2=1 3=0 4=1 5=10 6=28	5.5909	5.6111	5.6000
41. An Expert System combined with any of the optical data storage technologies could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.	1=0 2=0 3=1 4=1 5=11 6=27	5.6364	5.5556	5.6000

Again, participants were encouraged to offer rationale to support their second judgements. Appendix Q reports the comments for each statement. As with the second round, comments within a statement are presented with those that support the statement first, followed by the comments that refute the statement.

Comparison of the HRD and DEV Group Judgements

The data under analysis for comparing the DEV and HRD groups in this last round of the Delphi did not meet the assumptions of normality nor equality-of-variance required of parametric analyses such as the t-test. Of the nonparametric tests available, the Mann-Whitney test was chosen to determine if these two groups significantly differed on their judgements for each of the 64 statements. The Mann-Whitney test requires only that the observations be from a random sample and that the values can be ordered from smallest to largest (Norusis, 1988). These criteria were met by the Round Three data. The null hypothesis to be disproven for each statement was that the DEV group's judgement does not differ significantly from the HRD group's judgement. The level of significance was set at .05. Table 13 reports the results of the Mann-Whitney test.

Table 13.
Mann-Whitney Comparison of the DEV and HRD Groups' Judgements to each statement In Round Three

Ranked Statement Number	N=22 HRD Mean	N=18 DEV Mean	Mann-Whitney Corrected for Ties 2-Tailed P
39	5.6818	5.5556	.8286
35	5.5909	5.6111	.3868
41	5.6364	5.5556	.8945
28	5.7273	5.4118	.7186
22	5.5000	5.6667	.6963
32	5.5455	5.6111	.7195
40	5.5909	5.5556	.8836
30	5.2727	5.8333	.0422
12	5.5000	5.5556	.7194
10	5.4545	5.5556	.5355

Table 13 (cont'd).

Ranked Statement Number	N=22 HRD Mean	N=18 DEV Mean	Mann-Whitney Corrected for Ties 2-Tailed P
31	5.4091	5.5000	.5355
27	5.5455	5.3333	.8433
51	5.4545	5.4118	.8976
37	5.3636	5.4444	.8068
52	5.5909	5.1667	.3103
44	5.4545	5.3333	.7512
17	5.6000	5.1667	.1891
4	5.2727	5.5000	.6558
11	5.4091	5.2778	.8792
16	5.5714	5.0556	.2212
8	5.4545	5.1667	.4125
1	5.3182	5.2778	.4544
43	5.1429	5.4444	.8755
5	5.2273	5.2778	.5432
6	5.0909	5.2778	.3915
7	5.2727	5.0556	.8104
29	5.0455	5.3333	.4130
2	5.2381	5.0556	.9757
23	5.0000	5.2778	.4397
38	5.2727	4.9444	.4519
42	5.2727	4.8824	.6446
14	5.1364	5.0556	.8952
33	5.2381	4.8889	.3887
13	5.1818	4.9444	.7813
53	5.3000	4.6667	.4782
24	5.0455	4.8889	.4781
15	5.0000	4.9444	.6744
34	4.6818	5.3529	.1481
60	5.4286	4.4118	.0807
59	4.9091	5.0000	.7953
58	4.7619	5.1875	.3184
18	4.9000	5.0000	.8087
46	4.9545	4.8889	.7609
56	5.0000	4.7647	.6284
9	4.9545	4.6111	.1598
20	4.7619	4.8333	.8347
54	4.6818	4.7778	.9657
21	4.6190	4.8333	.4177
36	4.9091	4.4118	.3586
19	4.8000	4.5000	.5927
55	4.8500	4.4118	.4281
48	4.5500	4.6667	.6429
50	4.5789	4.2778	.4652
3	4.5714	4.2222	.5502
45	4.4286	4.3333	.8957
57	4.3333	4.0000	.6066
26	4.2000	4.0588	.9743

Table 13 (cont'd).

Ranked Statement Number	N=22 HRD Mean	N=18 DEV Mean	Mann-Whitney Corrected for Ties 2-Tailed P
25	4.2381	3.7647	.5667
49	4.1905	3.8333	.7717
47	4.1579	3.7500	.3636
64	3.8182	3.5000	.2037
63	2.9048	3.2778	.3702
62	2.7727	2.5556	.8328
61	2.3636	2.0000	.3961

Only statement 30 was found to have a significant difference between the HRD and DEV groups with a value of .0422 for the Mann-Whitney test. Statement 30 considers the use of a performance support system at the work site. The DEV group apparently believes that performance support systems utilizing expert system and optical data storage technologies will be possible to achieve within the next five years and have a wide range of capabilities. The HRD group is less sure of this statement. An in-depth discussion of the possible causes for the disagreement in statement 30 is covered in Chapter Five.

Termination of the Delphi

Based on the research of Scheibe, Skutsch and Schofer (1975) the criteria for terminating this Delphi was based on the measure of stability for each statement, where stability measures the variations from the mode(s) of the respondents' votes over successive rounds of the Delphi. Scheibe, et. al point out that:

> Empirical examination of the responses in the Delphi...showed that at any point in time a certain amount of oscillatory movement and change within the group is inevitable. This might be conceptualized as a sort of underlying error function, a type of internal noise. What is needed is a "confidence" measure which allows the distinction to be drawn between this kind of movement and strong group movements that represent real changing opinion. Such an estimate has tentatively been made from studies of observed probability of movement.

The estimate taken to represent the base oscillatory movement between rounds in a Delphi was 15% at the mode.

Using this value as an indicator of stability the researcher compared the mode in the Round Two responses to the value in the same Likert scale position in the Round Three responses. Statements 33, 42 and 54 had identical numerical Round Two values for the Likert scale choices 5 and 6. The scale choice to use as the mode for these three statements was determined based on the Round Three mode. For example: in the case of statement 33, the Round Three mode was Likert choice 6 so the values to compare between Rounds Two and Three were based on choice 6. Statements 62 - 64 were bimodal and were evaluated for stability as bimodal.

In determining the stability of a statement the researcher first calculated the Round Three value for a zero percent (0%) change. This was necessary due to the difference in sample sizes between the two rounds, 33 participants in Round Two and 40 participants in Round

Three. The 0% change value for Round Three was calculated using:

P_2 = Number of participants responding to the statement in Rnd. 2
P_3 = Number of Participants responding to the statement in Rnd. 3
M_2 = Number of participants responding to the statement in Rnd. 2 that were at the mode
EM_3 = Number of participants needed to respond to the statement in Rnd. 3 at the mode for 0% change

$$EM_3 = \frac{M_2 \text{ X } P_3}{P_2}$$

The actual Round Three value, M_3, was then compared to the 0% Change value, EM_3, to determine the percent change for the mode using the following formula:

M_3 = Number of participants responding to the statement in Rnd. 3 that were at the mode
PC = The percent change between the mode in Rnd. 2 and the value for the same position on the Likert scale in Rnd. 3

$$PC = \frac{\text{Absolute Value } (M_3 - EM_3) \text{ X } 100}{EM_3}$$

Table 14 summarizes the results of the percent change for each statement.

Table 14.
Stability of Each Statement After Round 3

Round 3 Statement	Round 2 Likert Scale Mode(s)	M2	P2	P3	EM3	M3	% Change	Stability S = Stable NS = Not Stable
39	6	26	33	40	31.51515	27	14.33	S
35	6	21	33	40	25.45455	28	10.00	S
41	6	25	33	40	30.30303	27	10.90	S
28	6	18	32	39	21.9375	28	27.64	NS
22	6	21	33	40	25.45455	26	2.14	S
32	6	23	33	40	27.87879	30	7.61	S
40	6	24	33	40	29.09091	26	10.63	S
30	6	21	33	40	25.45455	27	6.07	S
12	6	17	33	40	20.60606	23	11.62	S
10	6	17	33	40	20.60606	22	6.76	S
31	6	19	33	40	23.0303	22	4.47	S
27	6	23	32	40	28.75	27	6.09	S
51	6	18	33	39	21.27273	21	1.28	S
37	6	17	33	40	20.60606	22	6.76	S
52	6	19	33	40	23.0303	25	8.55	S
44	6	17	33	40	20.60606	25	21.32	NS
17	6	18	32	38	21.375	20	6.43	S
4	6	18	33	40	21.81818	23	5.42	S
11	6	17	33	40	20.60606	22	6.76	S
16	6	21	32	39	25.59375	23	10.13	S
8	6	19	33	40	23.0303	25	8.55	S
1	6	16	33	40	19.39394	23	18.59	NS
43	6	16	32	39	19.5	20	2.56	S
5	6	18	33	40	21.81818	22	.83	S
6	5	15	33	40	18.18182	17	6.50	S
7	5	18	33	40	21.81818	20	8.33	S
29	6	16	30	37	19.73333	17	13.85	S
2	5	17	33	39	20.09091	15	25.34	NS
23	6	19	33	40	23.0303	21	8.82	S
38	6	20	33	40	24.24242	22	9.25	S
42	6	13	32	39	15.84375	17	7.30	S
14	6	15	33	40	18.18182	19	4.50	S
33	6	14	32	39	17.0625	17	.37	S
13	6	15	33	40	18.18182	18	1.00	S
53	6	14	32	38	16.625	17	2.26	S
24	6	17	33	40	20.60606	16	22.35	NS
15	6	16	33	40	19.39394	15	22.66	NS
34	6	16	33	39	18.90909	16	15.38	NS
60	6	13	32	38	15.4375	17	10.12	S
59	5	13	33	40	15.75758	16	1.54	S
58	5	14	33	37	15.69697	15	4.44	S
18	6	19	33	36	20.72727	17	17.98	NS
46	5	15	33	40	18.18182	14	23.00	NS
56	6	13	31	38	15.93548	13	18.42	NS
9	5	14	32	40	17.5	13	25.71	NS
20	6	15	33	39	17.72727	13	26.67	NS

Table 14 (cont'd).

Round 3 Statement	Round 2 Likert Scale Mode(s)	M2	P2	P3	EM3	M3	% Change	Stability S = Stable NS = Not Stable
54	5	13	32	40	16.25	16	1.54	S
21	6	13	33	39	15.36364	13	15.38	NS
36	6	13	32	39	15.84375	12	24.26	NS
19	6	17	33	38	19.57576	14	28.48	NS
55	5	13	30	37	16.03333	15	6.44	S
48	5	17	32	38	20.1875	17	15.79	NS
50	5	14	30	37	17.26667	18	4.25	S
3	5	16	33	39	18.90909	14	25.96	NS
45	5	13	32	39	15.84375	14	11.64	S
57	5	12	31	38	14.70968	13	11.62	S
26	5	18	30	37	22.2	17	23.42	NS
25	5	12	31	38	14.70968	11	25.22	NS
49	5	11	30	39	14.3	13	9.09	S
47	5	14	30	35	16.33333	16	2.04	S
64	2	5	33	40	6.06061	5	17.50	NS
	4	12	33	40	14.54545	18	23.75	NS
63	2	10	32	39	12.1875	10	17.95	NS
	4	9	32	39	10.96875	11	.28	S
62	1	9	33	40	10.90909	10	8.33	S
	4	10	33	40	12.12121	10	17.50	NS
61	2	15	33	40	18.18182	21	15.50	NS

With 64% of the statements stable, and 88% of the top ranked 32 statements stable, the researcher decided to terminate the Delphi after three rounds.

In examining Table 12, ten statements have group means equal to or greater than 5.5. With reference to the first two research questions for Round Three, this would imply that participants were predicting that the combination of the technologies as suggested in these ten statements will be accomplished within the next five years and, if utilized in education/training, could have the stated impact on adult learners. These ten statements, in rank order are:

39. An Expert System combined with CD-ROM could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.

35. A portable computer with an Expert System and an optical data storage system would allow learning, review of previously learned material, or consultation with the knowledge base to take place anywhere.

41. An Expert System combined with any of the optical data storage technologies could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.

28. By combining an Expert System on the same medium as any of the optical data storage technologies, the portability of training will be increased. An entire course, stored on the optical medium, could be sent to any remote site with the equipment to use it.

22. An Expert System combined with any of the optical data storage technologies and possibly integrated with hypermedia software, could assist or "guide" learners in locating and cross referencing the information needed from large knowledge bases.

32. An Expert System combined with CD-ROM could produce a limited expert system embedded in the CD-ROM based material to provide help in specific areas of performing a job. For Example, a CD-ROM database on appliance repair might include an Expert System to troubleshoot and diagnose problems as well as diagrams and text on the appliances.

40. An Expert System combined with interactive video could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.

30. An Expert System combined with any of the optical data storage technologies could create a Performance Support System at the job site. This type of system would benefit the learner by

providing access to information when it is needed or convenient. The Performance Support System could review and reinforce previous training, offer new training that would transfer directly to the job, or act as a consultant to solve a problem with the worker at the work site.

12. An Expert System combined with any of the optical data storage technologies could benefit the adult learner by providing instruction that is individualized for the learner.

10. An Expert System combined with interactive video could benefit the adult learner by providing instruction that is individualized for each learner.

Referencing Table 14, only one of these top ten statements does not have group stability, statement number twenty eight.

Table 12 also indicates how participants responded to the Research Question regarding the factors that may negatively impact the effective application of these combined technologies on adult learners. Only one statement, number 64, had a mean greater than 3.5 indicating agreement with the statement. Statement 64 reads as follows:

64. An Expert System combined with any of the optical data storage technologies will have minimal impact on adult learners and training until the optical data storage technology is much cheaper, easier to produce and modify, and the cost/benefit value makes it an attractive training option.

An examination of Table 14 indicates that judgements on statement 64 resulted in a bimodal distribution, at 2 (Disagree) and 4 (Agree), with stability achieved on neither mode.

Summary

This chapter has examined the data collected from the Delphi process. It appears that a core of approximately half of the individuals who indicated that they would like to participate in the Delphi actually did participate. Based on Delbecq, Van deVen and Gustafson's (1986) guideline that 10 -15 participants can generate a full range of ideas in a Delphi, this reduction in numbers had little impact on the overall research. It did, however, necessitate the combining of the subgroups ESD, ESR and ODS to form DEV and the combining of IT and T to form HRD in order to maintain a subgroup component of the study with valid numbers of participants.

The Delphi process asked participants to first brainstorm and then judge ideas on how expert system and optical data storage technologies might be combined in the next five years and the impact such combinations could have on adult learners. In the first round 153 suggestions were offered. These were reduced to 64 statements in 26 areas. In the second round participants were asked to judge the feasibility that the combining of the expert system and optical data storage technologies in a statement would be possible in the next five years and its impact on adult learners. Comments supporting the judgements were also solicited. In the third round participants were presented with the ranked group judgements for the 64 statements along with the supporting comments. After reviewing this group ranking and information participants were asked to again make judgements on the statements and offer supporting comments.

An analysis of the statements between Rounds Two and Three indicated that 64% of the statements had changed less than 15% at the mode, a measure the group had arrived at stability for those statements and that little change would be likely in further rounds. A closer analysis of the top ranked 32 statements revealed that 88% were stable. With these high rates of stability, the Delphi was terminated.

Examination of the Round Three survey revealed that 10 statements had been ranked by the participants as 5.5 or higher. This indicated the belief that the technologies in these statements would be combined within the next five years and that if applied to adult education could have the stated impact on adult learners. Further analysis of the Round Three survey using the Mann-Whitney nonparametric test revealed that the HRD and DEV groups were in general agreement on their judgements of 63 of the 64 statements. Statement 30 showed a significant difference in the two groups' judgements.

Chapter V will focus on a more in depth analysis of the data presented in Chapter IV, making observations and drawing conclusions, and offering recommendations for future research.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter will begin with a brief discussion of the purpose of this research. A summary of the previous four chapters will follow, reviewing this study from the statement of the problem through the literature review, the Delphi process, and the general findings of the research. The bulk of this chapter will then be devoted to examining the five research questions posed in Chapter One; reviewing the findings, drawing conclusions and making recommendations for each question.

Purpose of the Research

The purpose of this research was to determine expert judgements about possible technological combinations of expert systems and optical data storage systems that might occur within the next five years (1991 - 1996) and to determine the impact such combinations could have on adult learners if applied in the education and the training fields. For example, consider combining an expert system with CD-ROM. This combination of technologies could provide learning experiences containing not only text descriptions but audio and video as well. The proposed benefit to the learner would be that more of the human senses are brought into the learning process with the expert system identifying and favoring instruction matching the student's learning style. Another application might be more self directed learning as a result of having greater storage capacities on the optical medium. This would provide more varied instructional materials from which the learner could choose, guided by questions from the expert system.

Research Summary

Statement of the Problem: Education and training systems have always faced the problem of matching the instruction to the student. This problem has included identifying three factors: 1) what instruction needs to be delivered while avoiding instruction where the student already has competence, 2) the student's style of learning, and 3) the pace at which the material is to be presented. In the case of adult learners this problem is somewhat amplified because their lifetime of experiences, skills and knowledge influences how new ideas are received, how new skills are acquired and how the experiences of others are interpreted. Because of this complexity in adult learners, this research examined how combining expert systems and optical data storage technologies through computer assisted instruction (CAI) might be able to accommodate the adult learner in such areas as identifying, monitoring and adjusting the instruction for the appropriate knowledge/skill level, learning style and pace which best suits the individual.

In studying this problem, the review of the literature examined the works of the adult learning theorists Malcolm Knowles, K. Patricia Cross, Howard McClusky, Alan Knox, Jack Mezirow, Paulo Freire and Stephen Brookfield. Common elements of adult learners identified among these theories were a) self-directedness, b) the importance of relating life experiences to learning, c) the value of self-evaluation of what one has learned and d) the desire for immediate application of new learning. An examination of the research on each of these elements supported their value in adult learning.

Expert systems and optical data storage technologies were then discussed and their applications in education and training were reviewed. Notable support for this research came from the review of expert systems such as the Minnesota Adaptive Instructional System, Geometry Tutor, Kimball's and O'Shea's self-improving tutors, SOPHIE, GUIDON and SCHOLAR. All of these expert systems display the ability to monitor and adjust certain aspects of the instruction in a manner very similar to that of a teacher or instructor.

The effectiveness and efficiency of computer-assisted instruction was reviewed next, as an expert system and optical data storage technology would undoubtedly be drawn together through this instructional method. Though there is debate as to whether CAI is superior to any other instructional methodology based on outcomes, there seems to be agreement that CAI is as effective as other instructional methodologies and can reduce the time needed for instruction (Ebner, et al., 1984, Deigan & Duncan, 1987)

Data for this research were collected through three rounds of the Delphi technique. This technique permits the best judgements to be drawn from experts in an efficient manner, and it assists the members in coming to a consensus on the issues to which they respond. Only half of the individuals who initially agreed that they would participate in the Delphi actually did participate. However, these numbers ensured sufficient participation to conduct a valid Delphi study based on the guidelines of Delbecq, Van deVen and Gustafson (1986).

The first round of the Delphi generated 153 suggestions on how expert system and optical data storage technologies might be combined in the next five years and the impacts such combinations could have on adult learning. These 153 suggestions were collated into 64 statements for use in the second round. The second round question asked participants to rate each statement based on the following considerations. First, would the impact on adult learners as proposed in the statement be an advantage, or not, for adult learners? Second, would the proposed combination of expert system and optical data storage technologies: 1) be achieved in the next five years, 2) possibly be achieved in the next five years, or 3) not be achieved in the next five years? Participants were also asked to provide supporting comments for their choices. The third round of the Delphi provided feedback to the participants in the form of the ranked results from Round Two along with the supporting comments for each statement. Participants were asked to re-rate each statement using this feedback and the same criteria as in Round Two.

A fourth round of the Delphi was not considered necessary as 64% of the statements had reached group stability after the third round and the top half of the ranked statements had reached 88% group stability. Of the top ranked statements, 10 were believed to be technologically feasible in the next five years and that they would have the advantage to adult learners as stated.

Research Questions, Findings, Conclusions & Recommendations

The initial Round One question for generating responses from participants was:

> Over the next five years, what specific contributions to adult learning can be expected by the combining of expert system and optical disc storage technologies in computer assisted instruction?

In the directions to the respondents, Question One was broken into two questions:

1. Which combinations of the expert system and optical data storage technologies are most likely to be achieved in the next five years?

2. What contribution(s) to adult learning could the combinations of these technologies be expected to produce?

Data from round one also enabled the researcher to begin answering three additional related questions:

3. Which insights were unique and originated solely from the those participants involved in human resource development (HRD), as a group, and those participants involved in the development of the hardware and software technologies (DEV), as another group?

4. Is there a significant difference between the group judgements of the HRD and DEV participants for any of the statements?

5. What are the factors that may negatively impact the effective application of these combined technologies as an instructional system for adult learners?

The following sections focus on the 5 research questions stated above, examine the findings related to each, present conclusions based on these findings and propose additional research to further clarify the findings and conclusions of this study.

Question #1: Which combinations of the expert system and optical data storage technologies are most likely to be achieved in the next five years?

Findings: There were three different responses from the participants for this question, suggesting that an expert system could be technologically combined with:

1. any of the optical data storage technologies,
2. only the CD-ROM optical data storage technology,
3. only the interactive video disc (IVD) optical data storage technology.

These findings came from the Round Three data (i.e., the first 60 ranked statements) as reported in Appendix P. Ten of the 60 statements had a group mean of 5.5 or greater. These 10 statements predicted that the expert system and optical data storage technologies, as suggested in the statements, will be successfully combined in some form within the next five years. Six of these statements indicated that an expert system could be combined with any of the optical data storage technologies. Two statements suggested a combination with only CD-ROM and another two suggested only a combination with interactive video disc (IVD) technologies.

Conclusions:

1. Combinations of expert systems with any one of the optical data storage systems will be technologically possible within the next five years.
2. Combinations of expert systems with only CD-ROM or Interactive Video Disc will be technologically possible within the next five years.

Ten statements had a group mean of 5.5 of higher, which predicted the combining of the technologies would be achieved within the next five years. Six of those ten statements indicated that an expert system could be combined with any of the optical data storage technologies, the implication being that no one optical data storage technology will be better suited to combine with an expert system than another. This prediction was reinforced in the following 42 Round Three statements, with group means ranging from 4.5 to 5.49, where participants indicated the technologies might be achieved within the next five years.

The researcher observed that 25 of these 42 statements suggested the technologies could be combined as easily with any one of the optical data storage technologies as with another. The remaining eight Round Three statements, those with group means ranging from 3.97 to 4.49, predicted that the technologies would not be combined within the next five years. Seven of these eight statements suggested that an expert system could be combined with any of the optical data storage technologies. All totaled, 31 of 60 statements suggested that an expert system could be combined with any of the optical data storage technologies.

Of the remaining 4 statements in the top 10, two statements predicted that only CD-ROM and an expert system could be successfully combined within the next five years, while two other statements predicted only IVD will be successfully combined with an expert system in the same time period. This minority view was reinforced in the following 42 statements where the researcher found only 13 of these statements supporting the prediction for combining only CD-ROM with an expert system and just 2 supported only IVD. The final 8 statements provided only one statement predicting that an expert system could not be combined with a CD-ROM. Table 15 summarizes this discussion.

Table 15.
Number of Statements Predicting an Expert System Being Combined With:

Any Optical Data Technology	Only CD-ROM	Only IVD
31	15	4

Two of the statements on the Delphi did not mention the combining of an expert system with an optical data storage technology. Statement 42 suggested combining an expert system with existing film and magnetic audio/visual materials and statement 56 referred to only using an expert system in computer assisted instruction. The researcher thought these statements were insightful and so retained them for the participants' judgements.

Recommendations For Further Research:

1. Determine suitable hardware interfaces for combining these technologies.
2. Determine suitable software for interaction between these technologies.
3. Determine the advantages of combining any one of these optical data storage systems with an expert system as compared to others.
4. Determine which expert systems available would be most easily combined with an optical data storage technology for instructional purposes.

Researchers and developers presently engaged in projects to combine these technologies should be encouraged to continue their effects by these predictions. Others may wish to enter this arena of research to facilitate the proliferation of these systems.

Question #2: What contribution(s) to adult learning could the combinations of these technologies be expected to produce?

Findings: Combining expert system and optical data storage technologies could benefit the adult learner by:

1. providing instruction that is individualized for each learner.
2. creating a performance support system at the work site.
3. increasing the portability of computer assisted instruction (CAI) systems.

Of the first 60 statements in Appendix P offering suggested contributions to adult learning if expert system and optical data storage technologies were combined, none were rejected by having a group mean of 3.5 or less. Participants felt that all of the statements offered advantages to adult learners. However, participants predicted that only ten of the contributions to adult learning would be achieved technologically within the next five years. These were the ten statements in Appendix P with group means of 5.5 or higher. These ten statements, in turn, identified three areas where an expert system combined with an optical data storage technology could have contributions to adult learning. First, the instruction could be more individualized to the learner. Specifically mentioned in this area was the ability of such systems to match the instruction to the individual's learning style. Second, participants predicted an increased use of performance support systems at the work site. Third, portability of instruction was predicted as a contribution to adult learning.

Conclusions: Expected advantages to adult learners in the next five years as a result of combining expert system and optical data storage technologies in CAI will be:

1. greater individualized instruction.
2. the ability of the CAI to match the individual's learning style.
3. an increase of performance support systems at the work site to provide: on-site, on-demand review; reinforcement of training; new training; advice and assistance in problem solving.
4. greater availability of CAI where it is needed if combined with a portable computer.

From the findings it can be concluded that the participants see immediate contributions to adult learning by combining expert system and optical data storage technologies in CAI. These contributions are in the areas of 1) individualized learning, 2) accommodation to adult learning styles, 3) creation of work site performance support systems, and 4) increased portability of learning systems. Another indication of the participant's consideration of importance for these areas is from Table 9, Chapter 4. In responding to Round One, 38 of the 153 statements contributed by participants indicated the advantage to adult learners as being individualized learning or identifying the student's learning style (Sixteen suggestions contributed to the category

"Identifies Student's Learning Style", while twenty two suggestions contributed to the category "Individualizes Learning"). Twenty three of the Round One statements referred to performance support systems and portability as the advantage for adult learners (Eighteen suggestions contributed to the category "Creates Performance Support Systems", while Five suggestions contributed to the category "Portability, Learning Can Occur Anywhere").

The first two conclusions, individualized learning and accommodation to adult learning styles as the advantages for adult learners, are consistent with the theories and models of adult learning proposed by Knowles (1984), Cross (1981), McClusky (1963), Knox (1980), Mezirow (1981), Freire 1970), and Brookfield (1980, 1981) which identify the common characteristics of adult learners as self-direction, unique life experiences, self-evaluation and immediate application of the learning. Implicit in the third conclusion, that there will be an increase in the number of performance support systems in use at the work site, are the adult characteristics of self-direction, self-evaluation, and immediate application of the learning. Performance support systems also share a common characteristic with the fourth conclusion which states that adults will benefit from an increased portability of CAI. The common characteristic between performance support systems and portability is that of the instruction taking place in non-formal settings. This advantage for adult learners is finding support in the field of distance education or the transmission of educational or instructional programming to geographically dispersed individuals or groups ("Linking for Learning", 1989).

Distance education at the adult level has, for years, been a part of corporate, military and university continuing education programs ("Linking for Learning", 1989). Kaye (1988) reported that, worldwide, approximately 10 million students take degree granting courses at a distance. The effectiveness of distance education has been documented through research conducted at the corporate, military and university level and has shown consistently that: "...there is no significant difference [in achievement] between distance learning and traditional [face-to-face] instruction methods... ("Linking for Learning ", 1989, p. 44)." Consequently, "...distance education is now seen as an effective, appropriate, and acceptable method of extending education... (Kaye, 1988, p. 44)."

Broadcast signals and computers with modems have been the predominant carrier to link instructors with learners in distance education. However, with the development of CAI based on an expert system and optical data storage medium, distance education may begin to include the mailing of floppy disks and optical data storage media as well.

Recommendations For Further Research:

Six research possibilities are drawn from the previous conclusions:

1. Determine how an expert system can assess not only the appropriate starting point for a specific learner in a CAI program, but also to continually monitor an individual's progress in order to adjust the instruction.
2. Determine how learning style assessments can be programed into an expert system and then having that expert system monitor the individual and adapt the CAI to accommodate changes in the individual's learning style.
3. Quantify the amount of materials required to meet the need for varying the pace and adapting to the individual's learning style in CAI using an expert system.
4. Describe how to incorporate the necessary instructional approaches into CAI using an expert system to accommodate individual learning styles.
5. Identify potential roles for the performance support system at the work site.
6. Identify the hardware and software that will be needed to link expert systems and large knowledge bases into laptop and notebook computers in order to increase the portability of these systems.

The process of conducting an analysis to determine what instruction the learner needs and adjusting the pace at which the instruction is delivered are two of the factors that must be considered for individualized instruction. The consideration for including a needs analysis in the expert system is consistent with the research findings of Long (1983) and Sork and Buskey (1986) who found that all adult education program models include some type of individual learner needs assessment. Being able to adjust the pace of the instruction is supported by Barr's (1975) research where she characterized the need to monitor and adjust the pace of instruction as a reactive consideration undertaken during the instruction. Schuller (1990) denounces fixed time segments for instruction and is in favor of monitoring the instructional process to determine a "natural" finish based on the identification of the learner's capacity to deal with more material as opposed to the need to digest what has already been covered. Determining how such analyses can be coupled with an expert system to assess not only the appropriate starting point for CAI but also to continually monitor an individual's progress in order to adjust the pace of the instruction should be fertile ground for research activities.

Another factor that should be taken under consideration for individualizing instruction is learning style. A great deal of research has been conducted on how individuals learn and on how an individual's learning style can be evaluated. Major models for evaluating learning style include Dunn and Dunn's Productivity Environmental Preference Survey, Hill's Cognitive Style Profile, Schmeck's Inventory of Learning Processes, Kolb's Learning Style Inventory and McCarthy's 4 MAT System (DeBello, 1989). Determining how learning style assessments can be programed into an expert system and then having that expert system continually monitor the individual and adapt the CAI to accommodate changes in the individual's learning style is going to be a challenge for future research and development.

Instructional designers will feel this challenge of applying expert systems to CAI in order to monitor and adjust for pace and change in learning style, during instruction. As an expert system identifies how to best reach a student, the instructional techniques and resources must be available in the instructional program. Adjusting the pace of the instruction implies the ability of CAI to provide less or more materials as needed, and presenting materials that accommodate an individual's learning style will require that the materials on the CAI be available for presentation in various ways. Designing instruction for this type of system may require new instructional models capable of adjusting to the range and depth of materials necessary for maximizing learning for the individual student.

There exists yet another challenge for the instructional designer with regard to learning style. Computer based instruction is usually thought of as the interaction of the individual with a computer program. For example, if an expert system in CAI were to identify an individual as someone who liked learning on their own, through an audio/video mode, the instructional materials could certainly be contained within a CAI program. But, what if the individual was found to learn best in small group settings, would it be possible for the instructional designer to facilitate this individual's needs through CAI? Research is needed that describes how to incorporate CAI using an expert system with group instructional approaches.

The role of the performance support system at the work site is still developing. Geber (1991), in discussing the rise of performance support systems, and Raybould (1990), in a case study of a performance support system, both stress the importance of these systems in the work place. Researchers need to determine to what extent the concept of a performance support system can be taken into various occupations, e.g., a sales representative in the field or the operator of a computer numeric controlled machine in manufacturing. Should the performance support system simply be an answer system with an expert system guiding the user's questions? Should it be a trainer, mentor, coach, or collaborative problem solver? Should it be all of the above depending on the circumstances? Further research is needed to identify the potential roles of the performance support system at the work site.

Portability will have an impact on adult learning by taking instruction beyond formal instructional locations, such as the computer learning laboratory of a human resources development center. Increased portability of expert systems combined with optical data storage technologies will allow learning, review of previously learned material, or consultation with a knowledge base to take place anywhere. While the size of laptop and notebook computers continues to decrease and their power continues to increase, research into identifying the hardware and software that will be needed to link expert systems and large knowledge bases into these smaller computers is needed. An initial step in this direction has been taken by several companies with the introduction of the "docking station" that a notebook computer can plug into to expand its hardware capabilities. It is interesting to note that the combination of notebook computer and docking station as a portable unit weighs less than many of the original portable computers.

Question #3: Which insights were unique and originated solely from HRD or DEV participants?

A reminder to the reader to clarify the participants in these two groups. The HRD participants were comprised of instructional technology professionals and trainers. The DEV participants included expert system researchers, expert system developers, and optical data storage system developers.

Findings:

1. Only the HRD group suggested that an expert system combined with any of the optical data storage technologies could better instruct adults in basic education concepts and skills than CAI without this combination of technologies (Statement 19).
2. Only the HRD group suggested that an expert system, combined with any of the optical data storage technologies capable of using visuals as a graphic

user interface, will simplify the use of CAI for learners (Statement 37).

3. Only the DEV group suggested that an expert system on a microcomputer could be combined with existing analog audio/video materials, i.e. films, videotape, interactive video disc (Statement 42).

The findings for research question 3 were derived from Table 8, in Chapter 4. Only three of the sixty four Round Two statements were found to have originated solely from the Round One contributions of either the HRD or DEV group. A statement was attributed to either the HRD or DEV group if it had two or more suggestions in one group and none in the other, e.g., statement number 11 was attributed to the HRD group. Each of these statements was then compared to all of the other statements for uniqueness. For example, statement number 1, "An expert system combined with CD-ROM could benefit the adult learner by being able to match the instruction to each individual's style," is not unique because statement number 2 is phrased the same way only stating for "any of the optical data storage technologies", which includes CD-ROM.

Conclusions:

1. The HRD group's stated value of applying this combination of technologies to instruct adults in basic education concepts and skills reflects the need of adult learners for more effective instructional materials in this area.
2. The HRD group valued not only the combining of the expert system and optical data storage technologies but the possibility of expanding the optical data storage portion to include a graphic user interface (GUI) in order to reduce the adult learner's dependence on keyboarding skills.

3. The DEV group stated a value for repurposing existing audio/visual materials to interface with the expert system and optical data storage technologies for CAI.

A closer examination of the data (Table 8, Chapter 4), from which these conclusions were generated, reveals that the HRD group's value for applying this technology to adult basic education came exclusively from the Trainers in the HRD group. This concern by the trainers for basic skills is not surprising if one reviews the first paragraph of the IMPORTANCE OF THIS RESEARCH in Chapter One which discusses the numbers of functionally illiterate adults in the United States population.

Also contributed by the HRD group was a statement that valued the combining of expert system and optical data storage technologies, with the possibility of utilizing the optical data storage portion to produce a graphic user interface (GUI). The HRD group believed that the use of a GUI in such an instructional system would facilitate its use by reducing the adult learner's dependence on keyboarding skills.

The DEV group stated a value for repurposing existing udio/visual materials and equipment to interface with the pert system and optical data storage technology for CAI. ile several participants indicated that the repurposing existing audio/visual materials and equipment for CAI is ready underway, this statement was particularly concerned th the importance of such an interface with the expert system. Being able to interface these existing pieces of A/V materials and equipment with a microcomputer containing an expert system might breathe new life into old material, and provide more interactive, self-paced, competency-based adult education. It also implied that such a repurposing might have cost advantages since many organizations already have numerous pieces of A/V equipment already in place.

Recommendations For Further Research:

1. Ongoing studies involving trainers to determine which basic skills, at any given time, are in greatest need for training among adults.
2. Comparison of different configurations of expert system and optical data storage technologies for instructing adults in basic skills.
3. Determine the advantages of developing a graphic user interface based on an optical data storage system technology as compared to already existing GUIs.
4. Identification of extant and needed hardware and software to repurpose existing A/V materials for operation with expert system and optical data storage technologies to create CAI.
5. Comparison of the instructional effectiveness of original to repurposed A/V materials.
6. Determine the cost advantages of repurposing existing A/V materials to interface with an expert system and optical data storage technology for CAI to encourage its adoption.

Trainers are the grass roots individuals working with the population in need of improving their skills. Studies involving trainers to determine which basic skills they believe are in the greatest need for training could precede the mass development and marketing of an expert system combined with an optical data storage system as CAI to meet this need. As a result of the mass development nature of such a project, it might be possible to hold the individual unit cost at a low level.

Other research might involve comparing different configurations of the expert system and optical data storage technologies for instructing adults in basic skills. Would the combination of an expert system with the large storage capacity of IVD and the ability for long segments of video have advantages over an expert system and CD-ROM? Would each of the basic skills require the same hardware/software configurations?

Several participants indicated that graphic user interfaces already exist independent of any optical data storage system. Yet Statement 37, suggesting the use of the GUI, received a relatively high group rating of 5.4, indicating that an optical data system used to generate a GUI would be an advantage for adult learners and might be possible to achieve within the five year time frame. A study to determine the advantages of developing a graphic user interface based on an optical data storage system technology might help to clarify this apparent discrepancy.

Repurposing existing audio/visual instructional materials requires hardware and software interfaces. The identification of extant and needed hardware and software to repurpose these materials for operation with expert system and optical data storage technologies to create CAI could form the basis of another study.

One may ask if it is even necessary to repurpose existing audio/visual instructional materials. A comparison of the effectiveness of the original material to the repurposed material might prove enlightening.

Finally, a determination of the cost advantages of repurposing existing audio/visual instructional materials to interface with an expert system and optical data storage technology for CAI will be needed to encourage its adoption.

Question #4: Is there a significant difference between the group judgements of the HRD and DEV participants for any of the statements?

Finding:

1. There was a significant difference in the mean judgements between the HRD and DEV groups in only statement 30.

A review of the Mann-Whitney statistics in Table 13 indicates that only one statement had a significant difference between the HRD and DEV groups at the .05 level of significance, statement 30, with a 2-tailed P value of .0422. In this statement the DEV group predicted that an expert system combined with any of the optical data storage technologies could create a performance support systems at the job site. These performance support systems would be capable of review and reinforcement of previous training, offering new training that would transfer directly to the job, or could act as consultant to solve a problem with the worker, all of which could be achieved within the next five years. The HRD group felt that such a performance support system was only a possibility of being achieved within the next five years.

Conclusions:

1. The DEV group predicts that it will be possible to develop performance support systems based on an expert system combined with an optical data storage medium within the next five years which will have the following capabilities. These systems will be convenient for the worker to use, provide reviews of previous training, provide training for new skills which will transfer immediately to the job, and act as a consultant in problem solving.

2. The HRD group predicts that it might be possible to develop performance support systems based on an expert system combined with an optical data storage medium within the next five years which will have the following capabilities. These systems will be convenient for the worker to use, provide reviews of previous training, provide training for new skills which will transfer immediately to the job, and act as a consultant in problem solving.

The above conclusions were based on the mean scores for each group for statement thirty. Both groups were in agreement that the performance support system would be an advantage to adult learners. The disagreement came with regard to how soon this type of performance support system will be implemented. The DEV group had a mean of 5.8333, predicting that it would be possible to have this type of a performance support system within the next five years. The HRD group had a mean of 5.2727, predicting only the possibility of developing such a performance support system within the next five years.

The exact nature of this disagreement in predictions is unclear based on the compound nature of statement thirty. The areas responsible for the disagreement could be any of the following:

1. The combining of an expert system with any of the optical data storage technologies.
2. The idea of having a performance support system provide access to information when it is needed or convenient at the work site.
3. The ability of the performance support system to review and reinforce previous training.
4. The ability of the performance support system to offer new training that would transfer directly to the job.
5. Having the performance support system act as a consultant to solve a problem with the worker at the work site.

It is also possible that a combination of the above five areas may have caused the disagreement.

Based on the results for research question one, that the majority of the participants favored the prediction that an expert system could be combined in the next five years with any one of the optical data technologies, the combining of an expert system with any of the optical data storage technologies does not seem to be the likely cause of the disagreement in the statement. In considering the other possibilities for disagreement, the researcher compared the group responses of four additional statements from the Delphi. These four statements either directly refer to or imply the use of a performance support system. They are statements: 35, 32, 31, and 27. Table 16 compares each of these statements, along with statement 30, to the possible areas of disagreement between the HRD and DEV groups and how each group responded within the statement.

Table 16.
Performance Support System Statements Compared To Each Other and HRD/DEV Group Predictions
W = Will Achieve Within Five Years
M = Might Achieve Within Five Years

Statement Number	Convenience		Ability to Review		New Training		Act as Consultant	
	HRD	DEV	HRD	DEV	HRD	DEV	HRD	DEV
35	W	W			W	W	W	W
32							W	W
30	M	W	M	W	M	W	M	W
31	M	W			M	W		
27			W	M	W	M	W	M

Statement 32 addresses only the single concept of the ability of the system to act as a consultant. In this statement both the HRD and DEV groups are in agreement, based on their individual group means, that expert systems using optical data storage will be acting as consultants within the next five years. Establishing this agreement between the groups on the single item of acting as a consultant removes it as a probable cause for the disagreement in statement 30.

Statements 35, 31 and 27 again address compound applications of a performance support system with respect to convenience, the ability to review and reinforce training, and the ability to provide new training. On Table 16 these areas also indicate differences in predictions between the HRD and DEV groups. It is likely that one or a combination of these three areas is the cause for the significant disagreement on statement thirty.

Recommendation For Further Research:

1. Identify the potential roles for the performance support system at the work site as perceived by HRD and DEV personnel.

The finding and conclusions discussed in this question lend support to the fifth recommendation for further research in question two, ie., identify potential roles for the performance support system at the work site.

Question #5: What are the factors that may negatively impact the effective application of these combined technologies as an instructional system for adult learners?

Findings:

1. It could be too expensive to incorporate this type of CAI into a training program.
2. It could be too difficult to produce materials that will be used on these types of systems for instruction.
3. It could be too difficult to modify the instruction that will operate on these types of systems
4. There needs to be a demonstrable cost/benefit value to make this type of CAI an attractive training option.

A review of statements 61 - 64 in Appendix P indicates that participants agreed with only statement 64, which has a group mean greater than 3.5. This statement highlighted the four findings above that may result in the combination of these technologies having negligible or no impact on adult learners.

Conclusions:

1. CAI utilizing an expert system and an optical data storage system will be too costly to produce to be an attractive instructional option.
2. A more efficient means for producing instructional materials for use on these systems needs to be developed.
3. The instructor or trainer should have the ability to modify or update existing instructional materials used on such systems.
4. The cost/benefit value of delivering instruction on such systems needs to be demonstrated to potential users.

Participants agreed that before any combination of an expert system and an optical storage medium in CAI can have a significant impact on adult learning the above four conclusions must be dealt with. Participants felt that it was not the cost of the hardware that would make adoption of this instructional medium prohibitive but that of producing the materials to operate on the systems; the instructional design, preparing the video/audio, preparation of the graphics, etc. In direct correlation to the first conclusion, the cost of production, instructional materials for use on such systems need to be easier to produce. Participants felt that, at present, there would be too many variables that must be kept track of in an original CAI production which would utilize an expert system and an optical data storage medium.

The ability to quickly and efficiently modify or update existing instructional materials used on such systems needs to be available to instructors and trainers. With the exception of electro-magneto storage, once the information is placed on the optical medium it cannot be changed without remastering the entire disc. Participants are looking for systems that will allow in-house changes to be made in the audio, graphics, and computer-learner interface. As with any innovation, the cost/benefit value of delivering instruction on such systems needs to be demonstrated to potential users.

While it was not a significant difference, the HRD and DEV means (Table 12, Chapter 4) for statement 64 indicate that the HRD personnel are slightly more concerned (a mean of 3.8182) with these conclusions than are the DEV personnel (a mean of 3.5). Developers of the hardware and software necessary to implement CAI which will include an expert system and an optical data storage medium need to keep these four conclusions in mind.

Recommendations For Further research

1. Determine where the production process for CAI utilizing an expert system and optical data storage medium can be simplified and its costs reduced.
2. Determine which combinations of hardware will allow CAI utilizing an expert system and optical data storage medium to be developed and modified with the greatest efficiency.
3. Determine the attributes for development software that could simplify the production and modification of CAI utilizing an expert system and optical data storage medium.
4. Conduct a quantitative cost/benefit analyses of CAI utilizing combinations of expert system with optical data storage technologies to determine its value in instruction.
5. Determine what end users consider reasonable for production costs, simplifying production, ease in modifying or updating this type of CAI and a favorable cost/benefit value.

Based on the first two findings, the cost and complexity of producing original instructional material for these systems, an examination of the production process is needed to identify where the process can be simplified and other measures to reduce production costs. When the third finding, ease of modifying or updating the instruction, is added to the first two a study to determine which combinations of hardware will allow this type of CAI to be developed and modified with the greatest ease is suggested. Another study that would combine the concerns of the first three factors would be to determine the features required of software that could assist in the production and modification of this type of CAI. With regard to the fourth factor, quantitative cost/benefit analyses could be conducted of CAI utilizing combinations of expert system with optical data storage technologies, to determine values.

Still another piece of research might focus on the HRD group in an attempt to identify the desired characteristics for each of these four factors. What would be regarded as acceptable pricing for the production of such CAI? In what ways would HRD personnel like to see materials for use on CAI combining an expert system and an optical data storage medium easier to produce? In what ways should they be easier to modify? What benchmarks would indicate a favorable cost/benefit value of such systems to HRD personnel? Answering questions like these would seem to facilitate the marketing of this technology as it is developed.

In reviewing statements 61 - 64 the researcher noted that participants disagreed with only one statement that might result in these technologies having negligible or no impact on adult learners, statement 61, with a group mean less than 2.5.

Finding:

1. Analyzing the individual characteristics of learners, such as their styles of learning or their reaction to mediated instruction, will not be too complex for a CAI computer system utilizing an expert system designed to perform such a task.

Conclusion:

1. Within the next five years it will be possible for an expert system in CAI to be able to analyze the individual characteristics of learners such as their learning styles and reactions to mediated learning.

It appears that comments from Round Two influenced participants to disagree with statement 61 in the third round. The number of participants expected to disagree with this statement, if it were stable, in the third round was 18, the actual number was 21 (Table 14, Chapter 4). In addition, those participants who either disagreed or strongly disagreed with the statement numbered 32 out of the 40 respondents (Table 12, Chapter 4).

Recommendation For Further Research:

1. Compare the same CAI material with and without an expert system to determine the ability of the expert system to adapt the instruction to the individual learner.

To justify this faith in being able to develop computer systems capable of analyzing the individual characteristics of learners, research will have to measure the success of such systems. Comparisons of CAI with an expert system designed to monitor the student to the same material presented on CAI without the expert system will be needed.

<u>Summary</u>

Participants in this study predicted that it will be possible to combine an expert system with an optical data storage technology (eg. CD-ROM, interactive video, CD-I) in CAI within the next five years. Further, if such an instructional system for CAI were applied to adult learners the following benefits were predicted:

1. the instruction could be individualized for the learner,

2. performance support systems would become more practical at the work site,

3. computer assisted instruction would not have to occur in the formal computer laboratory setting, it would become more portable.

However, it was also noted that the effective application of these combined technologies in an instructional system for adult learners may be hindered by:

1. production costs,

2. the technical and production difficulties of creating such systems,

3. the technical and production difficulties of updating such systems,

4. the lack of cost/benefit analyses which demonstrate the value of these instructional systems.

Participants in this study were composed of Human Resource Developers (HRD), trainers and instructional technologists, and hardware/software developers (DEV), expert system developers/researchers and optical data storage system developers. An analysis of the suggestions submitted during the first round of the Delphi technique identified three topics which were unique to either the HRD or DEV participants. First, the HRD participants believed that an instructional system composed of an expert system and optical data storage technology in CAI would produce a benefit for adult learners in the area of basic educational concepts and skills. The HRD group also identified the development of improved graphic user interfaces for such systems. These graphic user interfaces would benefit the adult learner by simplifying the use of the instructional system. The DEV participants suggested a production idea whereby existing audio/visual materials, such as video tapes, interactive video discs, and audio tapes could be used in developing instructional systems composed of an expert system and optical data storage technology in CAI. The DEV participants believed that such a capability could breath new life into old A/V materials and help to contain production costs.

Finally, a comparison between the HRD and DEV participants revealed that there was only one case where there was a significant difference between their rankings of the statements in the third round of the Delphi technique. In this single case the DEV participants predicted that it <u>will</u> be possible to develop multipurpose performance support systems using expert system with optical data storage within the next five years. The HRD participants predicted that this might be possible within the five year time frame.

These conclusions suggested that further research might be conducted in several areas. Of interest to hardware developers, how the expert system and optical data storage technologies might be interfaced. For expert system software developers, how to create systems capable of performing needs assessments for individuals, monitoring learning styles and the pace of the instruction and making the necessary adjustments. Instructional developers will have a new tool and be faced with new challenges in designing programs. Instructors and trainers may see their roles change to include working with learners who are many miles away. Finally, cost/benefit analyses should be available to program administrators as they consider implementation of these new instructional systems into their programs.

Final Thoughts

As this research progressed, comments from the participants, discussions with my committee members and insights from my readings gave rise to some additional thoughts related to this research.

As expert systems begin to influence computer assisted instruction, the focus of instructional design models will need to accommodate the interaction of the learner, as a unique individual, with the computerized learning system.

Some components of the instructional design process, such as needs assessments, will require additional restructuring in order to identify the needs of the individual rather than the needs of the organization. Other factors, which have previously not been considered in many instruction design models, such as learning styles, will take on greater importance in these new models.

The field of accelerated learning, based on the work of Dr. Greogi Lozanov (1978) and more recently drawing on the research of how the brain develops and memory works (Rose, 1985 and Herrmann, 1989), applies what proponents term as a holistic approach to learning. This approach considers not only the student's learning style but the importance of addressing linguistic, musical, mathematical-logical, spatial, bodily-kinesthetic, interpersonal, and intrapersonal aspects in learning. Expert systems combined with optical data storage technologies in computer assisted instruction may find many applications in accelerated learning. For example, the expert system portion of the computer assisted instruction might be involved in monitoring a student's activities and responsible for determining when it would be appropriate to introduce a different learning technique in order to promote the development of a holistic approach to the material under study. The optical data storage system could provide key aspects of the various learning techniques such as, full motion video lecturettes, timed musical interludes while a student reflects on the subject matter, rhythmic presentations to music, or actually participating in kinesthetic activities with the student by demonstrating and allowing the student to review what is to be accomplished in the activity.

The ability to update instructional systems was considered, by the experts in this study, as an important factor in the effective application of these systems with learners. Updating instructional systems involving lecture materials or overhead projections has never posed a problem nor been a difficult task. Soon, the technology may be available, through authoring systems and erasable optical data storage, which will allow CAI to be readily modified. For CAI which is developed in-house for on-site training and education this will be a great advantage. However, commercially developed material for mass distribution will, undoubtedly, be copyrighted. Consideration for the rights of these commercial developers and the need for instructional systems to be accurate in content will pose a challenge to both software developers and the legal system.

This conflict of interest may be resolved, in part, in the same manner that CD-ROM databases are presently kept current, by reissuing updated data files at regular intervals. Another method may involve erasable optical data storage. Standard floppy disks could be used to modify the erasable optical data in the same manner as patch disks currently correct defects in programs installed on a computer's hard disks.

Another consideration is in the area of learning referred to as the affective domain. As Tough (1979) and other referred to in this research have indicated, adults initiate self-directed learning projects even though the system of education has never allowed them a great latitude to develop such a desire. How the desire in adults for learning might change as the result of experiencing more self-directed learning throughout their lives poses an interesting speculation.

Finally, this research is important because it indicates a future trend for adult learning, as expressed by experts, in a very rapidly changing technology. However, even among the experts who participated in this study, diametric comments for statements were occasionally noted, usually of the nature, "This is already being done" and, "Not in five years". Business, industry and education, who are all involved in the urgency of resolving the functional illiteracy problem in this country, need to be made aware of such training and educational trends so as to be ready to take full advantage of them when they become available.

APPENDICES

APPENDIX A

TELEPHONE SCRIPT

The following outline includes the basic information presented to and solicited from all of the individuals contacted to participate in the Delphi exercise.

The purpose of this initial telephone contact was four fold: 1) to inform the prospective participant of the study's purpose and its methodology, 2) to ascertain the individual's interest in participating in the study, 3) to ensure the person's eligibility for participation, and 4) to secure a verbal commitment to participate in the Delphi.

1. <u>The Purpose of the Telephone Call</u>

    a. Dr./Mr./Ms._____, I am calling you because you are recognized in the XXXX directory as a person knowledgeable in the field of Expert Systems research/Expert Systems development/optical data storage development/instructional technology/ training.

    b. I am currently working on a doctoral dissertation.

    c. My study concerns the impact that may occur on adult education if the technologies of Expert Systems and optical data storage (such as IVD, CD-ROM, CD-I, CD-V, etc.) can be combined in computer-assisted instruction.

2. <u>Benefits of the study for participants</u>

    a. Gain some insight as to where people like yourself think adult computer-assisted instruction is headed in the next five years. This might impact:
        - the kinds of recommendations you will make to a training department,
        - the kinds of CAI materials you will purchase,
        - the hardware you will purchase,
        - the direction you want new training programs to take.
    b. Stimulate the development of new software for Adult CAI.
    c. Encourage hardware developers re-examine or expand a field of development.

3. Determining the Individual's Eligibility

a. Are you currently working in:
- training
- instructional technology
- expert systems development
- expert systems research
- optical data storage development

b. Approximately how long have you been in this field?

c. How much awareness or experience do you have with
- expert systems
- optical data storage technologies
- adult learning

4. Backgound of the Research

a. Functional illiteracy in the workplace

1983 - "A Nation At Risk: The Imperative for Educational Reform" reported that 23 million American adults were functionally illiterate

1988 - "Report of the Literacy 2000 Task Force" indicated that, nationally, over 54 million adults were functionally illiterate and at risk literate.

1990 - David T. Kearns, Chairman and CEO of Xerox Corporation, and Adam Smith, of Adam Smith's Money World, pointed out that American public high schools are currently graduating 700,000 functionally illiterate students every year.

Illiteracy is not only the result of inadequate preparation to enter the work force but also the result of a fast-changing workplace.

b. These functionally illiterate adults, including the high school graduates, need to learn additional skills to be able to continue to perform in our increasingly complex society.

c. U.S. companies have already recognized the need for additional training. According to Training Magazine's Industry Report 1990 survey of 2,645 U.S. companies with 100 or more employees, last year:

$45.5 billion were budgeted for formal training
39.5 million individuals
1.2 billion training hours

d. With this kind of investment, the results need to be cost effective.

   Provide what the individual needs in an environment matched to the way the adult learns. This is somewhere on the continuum between directed learning and self-directed learning.

e. The instructor's/facilitator's role, in this learning, is to identify the juncture where the student falls on the continuum so as to provide the most effective and efficient learning environment for the individual student.

f. Again, this research is seeking to identify the impact that might occur on adult learning by combining Expert Systems and optical data storage technologies in computer-assisted instruction. The results may be of significance in helping to reduce the functional illiteracy rate in this country.

5. <u>The Research Methodology</u>

a. 60 - 75 individuals will participant in this research, including yourself.

b. They will be drawn from the areas of:
   - computer scientists researching artificial intelligence/expert systems,
   - optical data storage system developers,
   - expert systems developers,
   - training professionals,
   - instructional technology professionals.

c. We will use a Delphi exercise, which will include no more than four rounds of one question each. After each round I will analyze and aggregate the responses, then send them back for your review and additional comments.

6. <u>Individual's Interest In Participating</u>

Are you willing to participate in this study?

7. Conclusion

a. I will send the first question out immediately. Each question will come with complete instructions, and should take you no more that 30 minutes to complete.

b. Please complete each questionnaire and return it to me as soon as possible. Turn around within a week would be best. I am anticipating that you should receive rounds 2, 3, and 4 on July 8, July 29, and August 19.

c. Do you have any questions?

d. Confirm participant's address.

e. What is your preferred salutation (Dr./Mr./Ms.)?

APPENDIX B

Date

Participant's Name
Position
Organization
Address
City, State Zip

Dear XXXXX,

A few days ago, we spoke on the telephone about a research effort seeking to identify specific contributions to adult learning through combining the technologies of expert systems and optical disc storage systems in computer-assisted instruction.

As we discussed, a Delphi questioning technique will be used to gather and analyze the opinions of 75 experts, including yourself, on this topic. The experts are drawn from the fields of Expert System research, Expert System development, optical data storage development, industrial training, and instructional technology.

The enclosed questionnaire is the first in a series of no-more-than four rounds and should take you approximately 20 - 30 minutes to complete. This will probably be the most time consuming of the four rounds. The second round question is scheduled to be to you the week of July 8; third round - July 29; and the fourth round (if a fourth round is necessary) - August 19.

In order to maintain the anonymity of the participants, the response sheets that you return have no individual identifying marking on them. Please understand that your participation is strictly voluntary; if at any point you feel uncomfortable with the process, you are free to discontinue your role in the study.

You may wish to make a copy of your responses for comparison with the collated list developed by the group in Round Two. If you voluntarily choose to sign the response sheet, I will return a copy of your responses with the Round Two question.

I would like to thank you again, XXXX, for your willingness to participate in this research. Your insights will be most helpful in identifying how the combining of these technologies may impact adult learning.

Sincerely,

Tim McLaughlin

Phone Numbers: Office - ###/###-#### 9:00 am - 5:00 pm
Home - ###/###-#### Evenings, Collect

APPENDIX C

COMBINING EXPERT SYSTEMS AND OPTICAL DISC STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED ADULT LEARNING

QUESTION 1

INSTRUCTIONS

Some Thoughts For This Question:

Adult learners, defined for this study as those individuals who have left high school either as drop-outs or graduates, re-enter formal education and training with very diverse backgrounds. Through the years, each individual has collected ever increasing volumes of experiences, skills, and knowledge, in varying degrees of quality. These individual experiences, skills, and knowledge bases influence how new ideas are received, how new skills are acquired and how the experiences of others are interpreted. As a result, educators and trainers can never predict, with total certainty, how one adult will respond to being presented with new ideas, interpretations, skill sets, experiences, or materials. And, this problem is compounded when a group of adults is involved.

Therefore, in this adult setting, the educator's/trainer's role may become one of facilitator whose function spans a broad spectrum. For the adult who is a self-directed learner, one with a high degree of self-knowledge and critical awareness, this function may be solely as a guide, directing the adult learner to sources of information. But for those learners who are unaware of alternative ways of thinking, believing or behaving a more structured approach may be in order to challenge them to consider alternatives and expand their paradigms.

This study is attempting to identify and rank the feasibility of potential linkages between optical disc storage (e.g. IVD, CD-ROM, CD-I, CD-V, etc.) and Expert Systems technologies that may enable computer-assisted instruction to facilitate adult learning in much the same way as the human counterpart.

What You Are Asked To Do:

I have enclosed the first in a series of not-more-than four questions designed to seek your assistance in identifying and ranking the feasibility of these linkages and their impacts on adult learning. Please offer as many linkages and their resultant impacts on adult learning as you can and return this questionnaire to me in time for analysis on June 18, 1991.

Again, thank you for your help.

COMBINING EXPERT SYSTEMS AND OPTICAL DISC STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED ADULT LEARNING

QUESTION 1

(Participant Group)

Consider the following question:

> "Over the next five years, what specific contributions to adult learning can be expected by the combining of expert system and optical disc storage technologies in computer-assisted instruction?"

With respect to your field of expertise, please answer this question in two parts as indicated below, maintaining a one-to-one correspondence between how the technologies will be combined and the resultant impact on adult learning.

These technologies will be combined in the following ways...	The impact this combination will have on adult learning is...

(Please Continue)

These technologies will be combined in the following ways...	The impact this combination will have on adult learning is...

(Please Continue)

These technologies will be combined in the following ways...	The impact this combination will have on adult learning is...

If you require additional space, please continue on a separate paper.

Signature: ______________________
(Voluntary)

What Happens Next:

Please return this questionnaire in the enclosed envelope. The researcher will collate your ideas with those of the other participants to produce a list of all the ideas for ranking in the second round questionnaire which you will receive the week of July 8.

Thank you again for your valuable time and ideas.

APPENDIX D

Date

Tim McLaughlin
133 E Erickson Hall
Michigan State University
East Lansing, MI 48824

Reviewer's Name
Address

Dear XXXX,

Thank you for taking the time to review the materials for the first Delphi question in my study. Enclosed is the Question 1 Cover Letter and Question 1 with the accompanying instructions. Please reflect on our telephone conversation, as the material we discussed during that conversation is also intended to prepare the participant for the Delphi exercise.

Any feedback that you can offer will be helpful. As a guide, please consider the following questions as you review these materials:

a) Does the initial telephone conversation prepare the individual for this Delphi exercise?

b) Does the cover letter provide enough detail as to the structure of the study? (Who is participating, how many individuals are involved, the timelines.)

c) Do the instructions provide adequate background for the Delphi question?

d) Is the purpose of the study clearly understood?

e) Does the layout of the Delphi response form seem logical?

f) How much time was needed to complete this Delphi response form?

g) Please feel free to offer any other suggestions.

Thank you, again, for your help. I will be sure to send you a copy of the results of this study.

Sincerely

Tim McLaughlin
Phone Numbers

Appendix E

Suggestions Offered by Participants in Response to Round One of the Delphi Arranged by Subgroup

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN TRAINING

	How the Technologies Might Be Combined	The Impact On Adult Learners
1.	CD-ROM or DVI can be used to provide very large databases of "facts" or real world knowledge that will allow expert systems to have very "deep and broad" intelligence.	Expert Systems can provide "job performance aids" that minimize the importance or need for people to remember or learn factual details of tools, products, and procedures.
2.	Optical media can provide full motion video knowledge bases reducing the current limitation to textual information in expert systems.	Provide "experiential" learning environments fully equivalent to apprenticeship or face-to-face training.
3.	AI will be used to provide intelligent agents that can find and analyze information from very large databases stored on optical media. In essence, these agents are electronic assistants.	Access to information becomes easier (technical expertise is not required) and faster. In essence, this development takes the usability revolution one step further - computer technology can be used by everyone - not just "techies".
4.	Optical disk, read/write technology with an Expert System	Provide training catering to the individual.
5.	Video capture technology with higher resolution graphics and an Expert System	Provide custom training catering to the individual. The integration of video into learning will enhance the education of the visual adult learner.
6.	Expert System and any of the optical data storage technologies	Better instruct adults in basic education concepts by providing more learning devices for adults. Especially in learning to read and other basic skills areas.
7.	Expert System and any of the optical data storage technologies	Provide better "real world" experiences in updating job skills and in cross training for different job skills.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN TRAINING

How the Technologies Might Be Combined	The Impact On Adult Learners
8. Expert System and any of the optical data storage technologies	Will supplement existing training methods. More self-study will be available for adults who may not work well in traditional classrooms.
9. An expert system carried on optical media may help an expert prepare an expert system and retain it on the same media in a form which can be duplicated and distributed.	Rapid expert system development and distribution will facilitate prototyping. Prototyping appears to improve development of input-process-output systems. An expert system which could grow and adapt after it has been placed in service seems to be a target.
10. The random text search capabilities of CD-ROM software and databases (ie. encyclopedias) will affect linear learning habits of the "home" computer audience and eventually the older linear look of many expert systems.	As learners begin to adapt to random learning along "hyper-buzzword" themes, teachers will also need to adapt their materials to enable the hop-skip-jump decision process. Any "expert systems" I've observed seemed very linear, with one path to a solution.
11. Optical media will enable better storage of more "picture quality" graphics supporting an expert system.	Pictures can be used to clarify a learner's understanding of concepts solicited during an "expert system" session. Or, they may be used as part of the input or decision process as a graphical user interface (GUI) where the learner uses a point-and-shoot or touch-screen approach to moving along.
12. Optical media will permit storage of more motion and audio with pictures.	Pictures can be used to clarify a learner's understanding of concepts or decisions solicited during an "expert system" session. The altering of motion video could be as easy as the present rearrangement of still video. For example, in landscape architecture the location of shrubbery and ornamentals and the resulting effect of their shadows as the Sun passes across the sky during the day.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN TRAINING

How the Technologies Might Be Combined	The Impact On Adult Learners
13. Expert system coupled with optical media permits greater storage capacity on a popular media.	With optical data storage systems (CD-ROM) becoming more common in the home, the market may be opening for the general population to have self-help expert systems much like we currently have self-help videos.
14. Expert Systems and CD-ROM (eventually CD-read/write)	Large databases may support expert systems. The pace at which the public is accepting large text database CD-ROM applications hints at further acceptance of similarly large expert system applications.
15. Expert system, optical storage, and portable computer	Availability of ES while traveling coupled with privacy that may not be available through access to large databases via telecommunications.
16. Visually-based expert systems	Easier to use for people with limited language skills.
17. Larger expert systems knowledge base	Less for people to learn. Ease the burden of memorizing facts and procedures.
18. Larger expert systems knowledge base	More complex problems can be addressed.
19. Larger expert systems knowledge base	Move from training to performance support.
20. Portable expert systems (ie. laptop and CD-ROM)	People who travel (sales reps., field engineers, repair people) will have access to expert systems on the job.
21. Expert systems to model student within CAI	More flexible, responsive CAI.
22. Expert System and any of the optical data storage technologies	The general impact will be negligible. Many aspects of learning, as an example the affective domain, cannot be reduced to a level capable of being programmed into a computer. As such, it is believed that Expert Systems will not be capable of capturing or analyzing the nuances

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN TRAINING

How the Technologies Might Be Combined	The Impact On Adult Learners
	and individual characteristics of learners, their styles of learning or their reaction to mediated instruction.
23. Expert Systems with interactive videodisc for role playing	Practice situations before they actually occur. Immediate feedback on decisions made while learning.
24. Expert Systems with interactive videodisc for learning job skills	Practice and perfect manual skills without wasting materials. This could result in more practice of manual skills than normally available because of the reduced expense on materials.
25. Expert Systems with interactive videodisc for learning job skills	Practice and perfect potentially dangerous manual skills without risk to the learner. Promote discovery learning with subsequent increase in retention of learning.
26. Expert Systems with interactive videodisc	More individualized learning with a minimum of instructor's influence.
27. Expert system with CD-ROM database	Tracking of an individual's progress with changes in the instructional program to accommodate different abilities.
28. Expert System and any of the optical data storage technologies	Increases self-directed learning but could allow for under-motivated students to bypass reviews or less interesting sections resulting in a decrease in retention of the material.
29. Expert system coupled with CD-ROM for data storage	Development of more sophisticated learning programs will better hold the interest of adults. Highly specialized topics will be available to the adult learner.
30. Expert systems combined with analog full motion video/audio and digital graphics from optical data storage	More of the human senses will be brought to bear on the learning process, therefore, increasing interest and retention.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN TRAINING

How the Technologies Might Be Combined	The Impact On Adult Learners
31. Expert System and any of the optical data storage technologies	As the field grows, the best minds in the various fields of study will be tapped to solve problems and train students. Thus, adults will be challenged by the best thinking in the field.
32. Expert System and CD-ROM database	Assessment of a student's current level of education and preferred learning style and storage of the assessment.
33. Expert System and CD-ROM database	Formatting instruction into the learner's optimum style.
34. Expert System and CD-ROM database	Translating optimum learning style into other formats so that the learner can develop other modes of learning as well as the preferred style.
35. Expert System and any of the optical data storage technologies	Remedial instruction for those lacking skills or knowledge.
36. Expert System and CD-ROM database	Regulation of the instructional sequence for those learners needing direction.
37. Expert System and CD-ROM database	Random access to information for self-directed learners.
38. Expert System and CD-ROM database	Assessment of a student's knowledge base at the start and end of an instructional sequence.
39. Expert System and CD-ROM database	Identification and recording of the student's information seeking pattern.
40. Expert System and any of the optical data storage technologies	Could provide empirical research on adult learning processes, therefore, furthering the field of study.
41. Expert System and CD-ROM database	Continual monitoring of the student's learning process.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN TRAINING

How the Technologies Might Be Combined	The Impact On Adult Learners
42. Expert System and CD-ROM database	Instructor's use of information collected by the system about the students to make modifications in future coursework.
43. Expert System and any of the optical data storage technologies	Interactive learning possibilities based on the scenarios stored on optical media: text, video, audio.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN OPTICAL DATA STORAGE DEVELOPMENT

How the Technologies Might Be Combined	The Impact On Adult Learners
44. Expert System combined with video	Individualized training matched to a style of learning.
45. Expert System and any optical data storage technology	The workplace is where most adults will require and receive additional training. The specific needs of the employee, in order to adapt to a changing job, can be addressed on an individual "need to know" basis.
46. Expert System and any optical data storage technology	Offer training programs at a cost more attractive to smaller organizations, therefore, making the training available where it may not have been possible otherwise.
47. Expert System and any optical data storage technology	Provide consistency in the training.
48. Expert System and any optical data storage technology	Greater self-esteem among participants if feedback on these systems results in changes within the company.
49. Expert systems combined with digital data and analog video/audio from optical data storage	Combining current digital Hard Disk and analog technologies (such as interactive video disks) would encourage interactive training as many organizations already have this hardware in place, thus, making the medium more accessible for adult learning.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN OPTICAL DATA STORAGE DEVELOPMENT

	How the Technologies Might Be Combined	The Impact On Adult Learners
50.	Expert systems combined with digital data and analog video/audio from optical data storage	Existing linear videodisc libraries could be economically "repurposed" with relative ease and combined with an expert system to provide self-paced, competency-based adult education.
51.	Expert systems combined with digital data and analog video/audio from optical data storage	The increased use of graphic and video images in adult education will more easily cross language and cultural barriers.
52.	Expert systems combined with digital data and analog video/audio from optical data storage	A reawakening of the cultural and social arts with the computer providing the individual with greater visual freedom of expression than is available in print.
53.	Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and ES) offer the potential of/for creating	online context based help that will cater to the inquisitive learner while permitting other adults to learn at a pace more in tune with their cognitive learning styles.
54.	Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and ES) offer the potential of/for creating	intelligent training systems that will enable adult learners to receive immediate transfer of training to the demands of their job.
55.	Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and ES) offer the potential of/for creating	intelligent problem solving simulation programs that will enable adults to learn by integrating past experiences and new knowledge with practice problem solving.
56.	Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and ES) offer the potential of/for creating	intelligent database systems that will revolutionize the practice of professional consulting services in medical diagnosis, systems analysis and maintenance, etc.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN OPTICAL DATA STORAGE DEVELOPMENT

How the Technologies Might Be Combined	The Impact On Adult Learners
57. Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and ES) offer the potential of/for creating	training programs that will make distance education more meaningful effective, and efficient.
58. Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and ES) offer the potential of/for creating	intelligent "encyclopedic" systems that will lead to the discovery of new knowledge which would otherwise have been impossible.
59. Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and ES) offer the potential of/for creating	training systems that compare to traditional training methods will reduce training costs and learning time by 50%.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN EXPERT SYSTEM DEVELOPMENT

How the Technologies Might Be Combined	The Impact On Adult Learners
60. Expert System and any optical data storage technology	Combined use of text, graphics, photos, video and audio representations of knowledge will result in increased retention through multi-sensory impact.
61. Expert System and CD-ROM database	Broader, more in-depth topic coverage. Wider range of responses to students input gives a broader context to the learning experience. Such a system could accommodate "fuzzy" logic to evaluate answers and complex "what if" learning models.
62. Expert System and any of the optical data storage technologies	Lower cost of the knowledge bases will make them more accessible to learning situations.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN EXPERT SYSTEM DEVELOPMENT

How the Technologies Might Be Combined	The Impact On Adult Learners
63. Expert system, optical storage, and portable computer	Learning can take place anywhere.
64. Expert System shell and any of the optical data storage technologies	Developing an Expert System from an existing knowledge base and an Expert System shell would provide the adult learner who must structure the knowledge about a particular domain the opportunity to learn about the boundaries and extent of that knowledge in great detail.
65. Expert System and CD-ROM database	An expert system could assist or "guide" the learner accessing a massive database in locating the information needed.
66. Expert System and any of the optical data storage technologies	Expert Systems combined with optical data storage in instruments, machines, equipment and software could dramatically reduce before job training periods while supporting on-the-job training.
67. Expert System and any of the optical data storage technologies	An expert system could assist or "guide" the learner accessing a massive database in locating the information needed.
68. Expert System combined with video	Improve heuristic student modeling in exploratory CBT environments by enabling coaching through the use of video to demonstrate "how to".
69. Expert System combined with video	Existing video footage in cinema and television can be combined with an expert system knowledge base about the video to create new courseware.
70. Expert System combined with interactive video	Existing interactive video could be enhanced by adding an expert system.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN EXPERT SYSTEM DEVELOPMENT

How the Technologies Might Be Combined	The Impact On Adult Learners
71. Expert System and any of the optical data storage technologies	Creating sophisticated programmed instruction for cognitive learning in a step-by-step shaping process using text and/or an audio/video vignette stored on optical disc and multiple choice or limited free response (fill in the blank) questions. The adult learner would be guided by the expert system to a desired conclusion based on the learner's responses in the question-answer process.
72. Expert System and any of the optical data storage technologies	Creation of realistic simulations of critical/emergency situations, presented with all of the sights and sounds. These simulations (hospital emergency rooms, nuclear power plants, pilots, etc.) would require the learner to make decisions against a real-time clock. Three elements must be included in the simulation: 1) verisimilitude to the critical situation, 2) interactivity - the learner responds through some input device to the situation, 3) timeliness - the learner is responding against real time.
73. Expert System and any of the optical data storage technologies	Extraordinarily "deep" expert systems, with vast numbers of options and responses could assist in the retrieval of information from massive databases.
74. Expert systems combined with digital data, audio and video on optical data storage	Computer-based instruction, contained in a digital format, could allow for relatively easy modifications to not only the text but also the audio and video portions of the instruction, ensuring up to date instructional materials. This would be especially attractive to companies if the digital material were at a central site, networked to remote learning stations. Modifications to the

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN EXPERT SYSTEM DEVELOPMENT

How the Technologies Might Be Combined	The Impact On Adult Learners
	instruction could then be accomplished on a single optical disc for the entire network.
75. Expert System and CD-ROM	The larger storage capacity will allow for larger, more sophisticated programs and knowledge bases. This might improve formative evaluation as the learner progresses through the instruction, resulting in the CBT being "customized" to the learner.
76. Expert System and CD-ROM	The combination of these two technologies could result in more attractive learning.
77. Expert System and CD-ROM	The combination of these two technologies could result in more experimental data being available to the learner.
78. Expert System and CD-ROM	The combination of these two technologies could result in a greater ability to illustrate the dynamics of a problem.
79. Expert System and CD-ROM	The combination of these two technologies could result in more realistic simulations, containing not only text descriptions but audio and video as well.
80. Expert System and CD-ROM	The combination of these two technologies could result in a greater ability for the students to experiment, to create their own experiences in the computer and see the results.
81. Expert System and any of the optical data storage technologies	To provide training which adapts itself to the student's interest, need and achievement, an "Intelligent Pointer."

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN EXPERT SYSTEM DEVELOPMENT

How the Technologies Might Be Combined	The Impact On Adult Learners
82. Expert System (based on a neural network) and any of the optical data storage technologies	An expert system based on a neural network framework would have the ability to utilize fuzzy logic. This would provide the system with the capability to adapt, generalize and learn based on previous information and new information as it becomes available.
83. Expert System (based on a neural network) and any of the optical data storage technologies	An improvement in training skills and retention while decreasing the cost of the training process.
84. Expert System (based on a neural network) and any of the optical data storage technologies	Expert systems based on neural networks could greatly expand the instructional materials available through their capability to integrate the vast information which is either arriving or currently available in the form of optical disks.
85. Expert System (based on a neural network) and any of the optical data storage technologies	These systems will prove to be much more adaptive than traditional approaches, providing greater flexibility in the training system and a much longer effective life cycle for both the process and the training itself.
86. Expert System and any of the optical data storage technologies	Expert Systems will guide students through individualized training programs. Selection of the program will be based on the student's skill level, learning style and goals. Students will learn at their own pace using methods which best suit their needs.
87. Expert System and any of the optical data storage technologies	Simulations are the most effective way for most students to learn procedures. Expert Systems will be used to help guide students through the process at their own pace.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN EXPERT SYSTEM DEVELOPMENT

How the Technologies Might Be Combined	The Impact On Adult Learners
88. Expert System and any of the optical data storage technologies	Expert Systems will guide the student through an unlimited combination of assessment tests and questionnaires which are stored on optical disk. Test or questionnaire selection will be made in real-time, based on test responses made by the student at the computer. As such, the adult student's personal needs, skill level, and learning style will be better defined, resulting in more appropriate course placement and provision of academic and non-academic support.
89. Expert System and any of the optical data storage technologies	A greater variety of diagnostic tools will be developed which take advantage of graphics and sound. Expert Systems will assist in the selection of tests, by determining the respondent's learning style. Students can then be assessed in the style most compatible with their learning.
90. Expert System combined with neural networks and any of the optical data storage technologies	Data collection during testing and instruction could be analyzed in real-time using combinations of Expert Systems and Neural Networks to improve assessment and student placement. This could improve the student's chances of success in the course.
91. Expert System combined with neural networks and any of the optical data storage technologies	Neural Networks could be trained to associate student characteristics with learning styles. This could result in better diagnosis and placement of students in instructional programs, leading to better student outcomes.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN EXPERT SYSTEM RESEARCH

How the Technologies Might Be Combined	The Impact On Adult Learners
92. Expert System and any of the optical data storage technologies	An Expert System could be used to drive an optical disc presentation according to a student's needs. This could result in greater flexibility in the presentation order and more responsiveness to the student.
93. Expert System and any of the optical data storage technologies	An Expert System can "watch" the student's browsing of the material stored on the optical medium and then tailor instruction to the student's interests. This could keep the motivation level high and facilitate "discovery learning" by pointing things out.
94. Expert System and any of the optical data storage technologies	With text, audio and video available on the optical storage medium the Expert Systems could match the instruction to the needs of the student.
95. Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and ES)	The Expert System could help the student navigate in the hypermedia space presenting instruction through a sophisticated combination of text and graphics.
96. Expert System and DVI	An Expert System could write out a set of "deductions" that could be used to drive animation from a DVI. These animations would be tailored to reinforce the student's current learning needs.
97. Expert System and any of the optical data storage technologies	An Expert System combined with optical data storage could assist adult learners in planning their curriculum. It could give the learner more control over what they are to learn, explain why they are learning, and present an overview of the task at hand.
98. Expert System and any of the optical data storage technologies	Expert System could be used to guide the training based on the user's responses/skill. The training would be able to adjust to meet the

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN EXPERT SYSTEM RESEARCH

How the Technologies Might Be Combined	The Impact On Adult Learners
	student's needs drawing from the text, audio and video available on the optical medium.
99. Expert System and any of the optical data storage technologies	An expert system could assist or "guide" the learner accessing a massive database in locating the information needed and associate it with additional information in interesting ways.
100. Expert System and any of the optical data storage technologies	Expert Systems that assist in the development of instruction could make it easier and faster to develop quality educational programs.
101. Expert System and any of the optical data storage technologies	The main boon to adult learning through the combining of these technologies, will be to provide a rich environment, both visually and auditorily (because of the mass storage capabilities), to better encourage learning, better impart information, and to maintain the interest of the student.
102. Expert System and any of the optical data storage technologies	Because the Expert System could monitor the student's activities on the system and the optical media can store vast amounts of various type of data (text, audio, video) for the same subject, information could be presented in the student's learning style.
103. Expert Systems and CD-ROM	The Expert System could select the appropriate material (text, audio, video) from the CD-ROM to present to the learner based on the student's current skills, interests, and needs.
104. Expert Systems and CD-ROM	The Expert System could explain and justify what it is doing so the student could acquire the skills of the Expert System as well as the background information to support those skills.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN EXPERT SYSTEM RESEARCH

How the Technologies Might Be Combined	The Impact On Adult Learners
105. Expert Systems and CD-ROM	Limited Expert Systems could be embedded in CD-ROM based material to provide help in specific areas of performing a job. For example, a CD-ROM database on appliance repair might include and Expert System to troubleshoot and diagnose problems as well as diagrams and text on the appliances.
106. Expert System and any of the optical data storage technologies	Optical storage media could contain a wide variety of learning paradigms on a single disk. An Expert System could select from this variety to present material in a way that is most effective for the individual. By continual monitoring of the student the Expert System could ensure that material is presented to match the student's learning style. As a result, motivation should remain high and students should have a high success rate.
107. Expert System and any of the optical data storage technologies	The optical storage medium with its ability to store vast amounts of text, audio, and video combined with an expert system could provide a computer based experimental laboratory allowing students to ask "what if" questions and see the results modelled on the computer.
108. Expert System and any of the optical data storage technologies	The basic impact of combining Expert Systems with optical data storage technologies will be that the learning will be more interactive and more multi-modal. This implies that the learning will be deeper and more intuitive, improving the student's creative processes. Having improved the individual's creativity should optimize long term productivity, especially in a dynamic environment.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN INSTRUCTIONAL TECHNOLOGY

How the Technologies Might Be Combined	The Impact On Adult Learners
109. Expert System and any of the optical data storage technologies	Greater exposure to "real-life" situations (simulations) without the actual physical danger or consequences. This could be possible if optical disc storage provides enough room for numerous possibilities and if the information can be accessed quickly.
110. Expert System and any of the optical data storage technologies	More training will be transferred from the classroom and workshop settings to on-the-job (performance support system).
111. Expert system, optical storage, and portable computer	On-site, on-demand training and technical expertise and assistance.
112. Expert System and any of the optical data storage technologies	An expert system could assist or "guide" the learner accessing a massive database in locating the information needed by asking questions of the searcher in order to focus the questions and narrow the search.
113. Expert System and any of the optical data storage technologies	An expert system could assist or "guide" the learner accessing a massive database in locating information and associating it with additional information to help the learner form new viewpoints and conclusions.
114. Expert System and any of the optical data storage technologies	Intelligent tutorials that can "individualize" instruction by drawing on the text, audio and video stored on the optical medium.
115. Expert System and any of the optical data storage technologies	Intelligent tutorials capable of allowing the student to play "what if" games with a knowledge base. This places greater reliance on the student's own explorations as an avenue of instruction. This could result in greater responsibility placed on the student and more training in how to "inquire" and

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN INSTRUCTIONAL TECHNOLOGY

How the Technologies Might Be Combined	The Impact On Adult Learners
	"experiment" in order to gain knowledge.
116. Expert System and any of the optical data storage technologies	As a result of "intelligent simulation models" capable of demonstrating realistic reactions in complex systems, more instruction will be carried out in the form of "guided demonstration" and less in the form of tutorials or "telling".
117. Expert System and any of the optical data storage technologies	"Intelligent evaluators" could simulate problem environments and be capable of providing feed back for extended sequences of decision-making and performance. This would place greater stress in the adult learning area on performance as the basis for progress through instruction and less reliance on verbal tests.
118. Expert System and any of the optical data storage technologies combined with actual hands-on materials	"Intelligent learning coaches" in laboratory type environments may lead students through hands-on experiences with actual equipment. Based on the student's input, the Expert System and knowledge base would be able to adapt the presentation and instruction to circumstances and results arising during the laboratory exercise. Students would benefit by having virtual one-on-one instruction while actually working with real equipment.
119. Expert System and any of the optical data storage technologies	Systems at the job site capable of reviewing previous training either in full or in skeleton representation. (Performance support system) This would benefit the learner by refreshing the instruction over time and, therefore, improving retention of training and skills.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN INSTRUCTIONAL TECHNOLOGY

How the Technologies Might Be Combined	The Impact On Adult Learners
120. Expert System and any of the optical data storage technologies	Systems at the job site capable of coaching the worker, acting as a resource and prompting mechanism for the worker and acting as a record keeper. (Performance support system) This would benefit the learner by refreshing the instruction over time and, therefore, improving retention of training and skills.
121. Expert System and any of the optical data storage technologies	Systems at the job site capable of entering into a consulting and co-worker role with the worker, actually capable of taking task assignments from the human and being responsible for them on a continuing basis. (Performance support system) This would benefit the learner by refreshing the instruction over time and, therefore, improving retention of training and skills.
122. Expert System and CAV Interactive Video	Where text, audio and video are important to the instruction, either in a training center or near the job (Performance support system), and/or the student must have feedback on the consequences of the choices made during instruction.
123. Expert System and CD-ROM	In an instructional setting where data and text are critical, but visual images are not, CD-ROM coupled with an Expert System could have tremendous advantages in assisting students with data entry, retrieval, and manipulation.
124. Expert System and any of the optical data storage technologies	Because of the massive storage capacity of the optical system, the learner will have access to voluminous amounts of information including text, audio and video to inspect under the guidance of the Expert System. Learning experiences will be tailored to the student's optimum learning style as discerned

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN INSTRUCTIONAL TECHNOLOGY

How the Technologies Might Be Combined	The Impact On Adult Learners
	and then directed by the Expert System.
125. Expert System and any of the optical data storage technologies	Optical disc storage device will "drive" the Expert System; i.e., contain deep elements of the Expert System called upon by the system's heuristics. As such, the Expert System will be virtually transparent to the learner because its breadth and depth can be so expanded by the disc's storage capacity.
126. Expert System and any of the optical data storage technologies	The impact on adult learning in the next 5 years will not be meaningful as these technologies will not effectively by combined for instructional purposes within this time period.
127. Expert System and any of the optical data storage technologies	An expert system could assist or "guide" the learner accessing a massive database in locating the information needed by asking questions of the searcher in order to focus the questions and narrow the search.
128. Expert System and any of the optical data storage technologies	Expert Systems, supported by massive knowledge bases on optical storage, could act as performance support systems assisting personnel diagnose problems and then providing step-by-step instructions in resolving the problem. This could minimize up-front training needs by providing just-in-time support at the job site.
129. Expert System and CAI	Greater individualized instruction based on just-in-time learning to meet the needs of the job. (Performance support system)
130. Expert System and any of the optical data storage technologies	No great impact on training until the optical data storage technology is much cheaper, easier to produce, and easier to modify.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN INSTRUCTIONAL TECHNOLOGY

How the Technologies Might Be Combined	The Impact On Adult Learners
131. Expert System, Virtual Reality and CAI	This combination of technologies may produce learning environments that engulf the learner in a hands-on simulation.
132. Expert Systems, optical data storage, and magneto optical memory technologies	Large knowledge bases could be stored on the optical data storage medium while the magneto optical memory provides the higher amounts of RAM the Expert Systems will need. This will result in CAI that will "know" more than present systems and be capable of growing as information is added and it works with the student.
133. Expert System and any of the optical data storage technologies	Expert Systems will depend more on the graphic interface with the student rather than text on the screen. Instruction won't tell students so much as it will show them.
134. Expert System and any of the optical data storage technologies	Because of the large knowledge bases available through optical data storage coupled with the Expert System, adult learning will be spent more confronting the possible rather than the actual.
135. Expert System and any of the optical data storage technologies	An expert system could assist or "guide" the learner accessing a massive database in locating the information needed by asking questions of the searcher in order to focus the questions and narrow the search.
136. Expert System and any of the optical data storage technologies	As a performance support system to allow the worker to get immediate instruction when it is needed. The learner would benefit by being more productive and probably more self-satisfied. This would also benefit the learner by refreshing previous instruction over time and, therefore, improving retention of training and skills .

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN INSTRUCTIONAL TECHNOLOGY

How the Technologies Might Be Combined	The Impact On Adult Learners
137. Expert System and any of the optical data storage technologies	Students could work their way through real-life simulations. Their efforts could then be compared to how an "expert" would have handled the same situation on a step-by-step basis. The student could learn through their own experience and that of an expert.
138. Expert System and any of the optical data storage technologies	Using the knowledge base stored on an optical medium, an Expert System could act as an "intelligent evaluator" capable of providing feed back and remediation based on extended sequences of decision-making and performance. Evaluation and recommendation for a course of action based on several student responses has a better chance of determining what the student understands and doesn't understand than recommendations made after individual responses. This could provide better instruction to the student, reduce frustration and increase motivation.
139. Expert System and any of the optical data storage technologies	The adult learner could have individualized instruction matched to the learning style.
140. Expert System and any of the optical data storage technologies	More students could have access to the information at times convenient to them or at times when it is needed on the job (performance support system).
141. Expert System and any of the optical data storage technologies	There would be more learner interaction with the instructional materials, thus the student would not be passive in the learning situation.
142. Expert System and any of the optical data storage technologies	Instructional materials, especially if they were on a network, could be updated with relative ease so

<u>SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN INSTRUCTIONAL TECHNOLOGY</u>

How the Technologies Might Be Combined	The Impact On Adult Learners
	students would always have the most current information.
143. Expert System and any of the optical data storage technologies	One of the main advantages of combining an Expert System with optical data storage will be the responsiveness of the CAI to unique user learning conditions such as previous experience, specific learning style and the rate of content assimilation. These technologies could make every learning experience highly individual and productive.
144. Expert System and any of the optical data storage technologies	Expert Systems, supported by massive knowledge bases on optical storage, could act as performance support systems assisting personnel diagnose problems and then providing step-by-step instructions in resolving the problem. This could minimize up-front training needs by providing just-in-time support at the job site.
145. Expert System and any of the optical data storage technologies	The use of real-world simulations which would be sufficiently realistic to actively involve the student would greatly increase the effectiveness of training.
146. Expert System and any of the optical data storage technologies	These systems will not only provide the adult learner with mastery over a set body of knowledge, but will also enhance basic reasoning and creative skills through their ability to match instruction to the student's cognitive capacity.
147. Expert System and any of the optical data storage technologies	Optical discs will provide the tremendous storage capacity required for an Expert System to draw upon to be able to provide training tailored to the needs of the individual learner.

SUGGESTIONS OFFERED BY PARTICIPANTS INVOLVED IN INSTRUCTIONAL TECHNOLOGY

How the Technologies Might Be Combined	The Impact On Adult Learners
148. Expert System and any of the optical data storage technologies	The portability of training will be increased. An entire course on an optical disc could be sent to any remote site with the equipment to use it.
149. Expert System and any of the optical data storage technologies	A well designed system could begin as a tutor, taking full responsibility for the student's progress. From that point, it could move to a coach, in which responsibility will be shared. Finally, it could perform as a mentor, responding only when requested to do so by the student. Here, the needs of the student and the teaching situation drive the technology.
150. Expert System and any of the optical data storage technologies	Training could be moved from the classroom to the job site through a performance support system. Support could be provided from learning new skills to refreshing latent skills.
151. Expert System and any of the optical data storage technologies	Very little impact on automated tutoring over the next five years. The greatest impact may be in providing assistance in accessing and cross indexing large databases of text and video in the areas of medicine, science, and other scholarly pursuits.
152. Expert Systems and classification representation indexing videos	This will be the first practical combination of these technologies. It is currently being done but limited to fortune 500 companies and exploratory systems in universities. It is increasing interest in the technologies.
153. Expert Systems combined with text and video	Mostly as demonstration systems. Little impact on learning systems due to expense of production and questionable cost/benefit.

APPENDIX F

Date

Participant's Name
Position
Organization
Address
City, State   Zip

Dear XXXXX,

Thank you for responding to and signing your first questionnaire in the Delphi.

Over the Summer, 153 insights were received identifying impacts on adult learning that might be possible if the technologies of expert systems and optical disc storage systems could be combined in computer-assisted instruction. All of the responses were of excellent quality and provided me with hours of thought while collating them in preparing this second round of the Delphi.

Responses were received from experts in all five of the participating fields: Expert System research, Expert System development, optical data storage development, industrial training, and instructional technology.

This second round of the Delphi should take you approximately 30 - 40 minutes to complete. The time will vary depending on the number and detail of supporting comments that you offer. As in round one, in order to maintain the anonymity of the participants, the response sheets that you return have no individual identifying marking on them.

I would like to thank you again for your willingness to participate in this research. Your judgements in this round will be most helpful in identifying how the combining of these technologies may impact adult learning.

Sincerely,

Tim McLaughlin

Phone Numbers: Office - ###/###-#### 9:00 am - 5:00 pm
Home - ###/###-#### Evenings, Collect

APPENDIX G

Date

Participant's Name
Position
Organization
Address
City, State Zip

Dear XXXXX,

Over the Summer, 153 insights were received identifying impacts on adult learning that might be possible if the technologies of expert systems and optical disc storage systems could be combined in computer-assisted instruction. All of the responses were of excellent quality and provided me with hours of thought while collating them in preparing this second round of the Delphi.

A few participants did not respond to the first round questionnaire. Because of the anonymity of the response form, I do not know if you were one of those individuals. If you were, your judgements on this second round are still greatly valued.

Responses were received from experts in all five of the participating fields: Expert System research, Expert System development, optical data storage development, industrial training, and instructional technology.

This second round of the Delphi should take you approximately 30 - 40 minutes to complete. The time will vary depending on the number and detail of supporting comments that you offer. As in round one, in order to maintain the anonymity of the participants, the response sheets that you return have no individual identifying marking on them.

I would like to thank you again for your willingness to participate in this research. Your judgements in this round will be most helpful in identifying how the combining of these technologies may impact adult learning.

Sincerely,

Tim McLaughlin

Phone Numbers: Office - ###/###-#### 9:00 am - 5:00 pm
Home - ###/###-#### Evenings, Collect

APPENDIX H

COMBINING EXPERT SYSTEMS AND OPTICAL DISC STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED ADULT LEARNING

RANKING THE RESPONSES

INSTRUCTIONS
10/11/91

Background For This Step Of The Delphi:

As stated in the first round, this Delphi is attempting to identify and rank the feasibility of potential linkages between optical disc storage (e.g. IVD, CD-ROM, CD-I, CD-V, etc.) and Expert Systems technologies that may enable computer-assisted instruction to facilitate adult learning in much the same way as the human counterpart. The researcher has collated the first round responses and attemped to combine similar suggestions into a single idea without compromizing the intent of the respondant. As a result, 64 statements have been grouped into 26 areas.

Two forms are enclosed for this round of the Delphi: a Statements Form (page 1), containing the 64 statements, and a Response Form (page 9). Those participants who signed their Question 1 form in the first round will note that a copy has been returned with these forms. The number circled in red on your Question 1 form indicates the statement your response contributed to on the Statements Form. For example, if the number 28 circled in red is next to your first response on the Question 1 form, the researcher has used all or part of that response to construct statement number 28 on the Statement Form. More than one number circled in red next to a response on the Question 1 form indicates that the response was used to construct more than one idea on the Statement Form.

What You Are Asked To Do:

The second round of this Delphi will ask you to offer a judgement for each item on the Statements Form, beginning on page 1, by circling your choice on a Likert type scale on the Response Form, beginning on page 9. In formulating your judgement consider the following two questions. First, does the statement describe or imply some adventageous impact on the adult learner? And second, what is the possibility that the technologies described in the statement will be combined in the next five years to produce this impact on adult learners?

A "KEY" to the response scale is provided on both the Statements Form and the Response Form. Space has also been provided on the Response Form for you to include desired comments which support your numeric judgement. You may wish to note your judgement on the Statements Form and retain it for comparison to the group value in round 3.

Please return only the completed Response Form to me by **10/21/91** in the enclosed, self-addressed, stamped envelope.

Again, thank you for your help.

COMBINING EXPERT SYSTEMS AND OPTICAL DISC STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED ADULT LEARNING

STATEMENTS FORM

In offering your judgement, you may first want to consider the 26 areas that the statements have been placed in. These areas are denoted in underlined upper case letters. Note that the only difference between some of the statements within an area is how the technologies will be combined, e.g. an Expert System with CD-ROM or Interactive Video or any of the optical data storage technologies.

Place this Statement Form side by side with the Response Form. Item 1 here is matched with item 1 on the Response Form. All of your responses will be recorded on the Response Form. Use the KEY below to indicate the alternative closest to your judgement for each item.

KEY:

6 Advantage for adult learners, Will be achieved technologically
5 Advantage for adult learners, Possible to achieve technologically
4 Advantage for adult learners, Impossible to achieve technologically
3 No advantage for adult learners, Will be achieved technologically
2 No advantage for adult learners, Possible to achieve technologically
1 No advantage for adult learners, Impossible to achieve technologically

IDENTIFIES STUDENT'S LEARNING STYLE

1) An Expert System combined with **CD-ROM** could benefit the adult learner by being able to match the instruction to each individual's learning style.

2) An Expert System combined with **any of the optical data storage technologies** could benefit the adult learner by being able to match the instruction to each individual's learning style.

3) An Expert System combined with CD-ROM could benefit the adult learner by being able to assist in the translation of a student's optimum learning style into other formats so that the learner can develop other modes of learning as well as the preferred style.

PERFORMS NEEDS ANALYSIS

4) An Expert System combined with any of the optical data storage technologies could benefit the adult learner by being able to match the instruction to each individual's needs.

ADJUSTS PROGRAM TO STUDENT'S PACE

5) An Expert System combined with any of the optical data storage technologies and possibly integrated with hypermedia software, could guide students through individualized training programs. Selection of the program would be based on the student's skill level, learning style and goals. Students would learn at their own pace using methods which best suit their needs.

MAINTAINS MOTIVATION/INTEREST

6) An Expert system, combined with **CD-ROM**, could maintain a high level of motivation and interest in the learner through its ability to monitor the learner and adjust the use of instructional materials.

7) An Expert system, combined with **any of the optical data storage technologies**, could maintain a high level of motivation and interest in the learner through its ability to monitor the learner and adjust the use of instructional materials.

FACILITATES INTERACTIVE LEARNING

8) An Expert System combined with any of the optical data storage technologies could lead to learning that will be more interactive and more multi-modal. The student will become actively involved in the learning situation.

FACILITATES CREATIVITY

9) An Expert System combined with any of the optical data storage technologies could result in learning that would be more interactive, multi-modal and matched to the student's cognitive style. This implies that the learning could be deeper and more intuitive, improving the student's creative processes. Having improved the individual's creativity should optimize long term productivity, especially in a dynamic environment.

INDIVIDUALIZES LEARNING

10) An Expert System combined with **interactive video** could benefit the adult learner by providing instruction that is individualized for each learner.

11) An Expert System combined with **CD-ROM** could benefit the adult learner by providing instruction that is individualized for each learner.

12) An Expert System combined with **any of the optical data storage technologies** could benefit the adult learner by providing instruction that is individualized for each learner.

FACILITATES SELF-DIRECTED LEARNING

13) An Expert System combined with **CD-ROM** could enable the learner to ask "what if" questions of the knowledge base. This could benefit the learner by making self-directed learning available, allowing the learner to follow their interests in a subject.

14) An Expert System combined with **any of the optical data storage technologies** could enable the learner to ask "what if" questions of the knowledge base. This could benefit the learner by making self-directed learning available, allowing the learner to follow their interests in a subject.

<u>FACILITATES DISCOVERY LEARNING</u>

15) An Expert System might be combined with interactive video or any of the other optical data storage technologies. Actual hands-on materials might also be available, as in the case of a laboratory. By monitoring the student input, this type of a system could promote discovery learning by adapting the presentation and instruction to circumstances and results arising from the student's actions.

<u>PROVIDES REALISTIC SIMULATIONS</u>

16) An Expert System combined with **interactive video** could provide the adult learner with simulations that better express reality than those we are currently using.

17) An Expert System combined with **any of the optical data storage technologies** could provide the adult learner with simulations that better express reality than those we are currently using.

<u>ILLUSTRATES DYNAMICS OF COMPLEX PROBLEMS</u>

18) A CD-ROM or any of the optical data storage technologies could hold a very large knowledge base for the Expert System. The learner could benefit from this combination by having CAI with a greater ability to illustrate the dynamics of a problem and/or more complex problems.

<u>IMPROVES BASIC SKILLS INSTRUCTION</u>

19) An Expert System combined with any of the optical data storage technologies could better instruct adults in basic education concepts and skills (i.e. reading, writing, math) by providing more learning devices for the adults.

<u>INCREASES RETENTION</u>

20) An Expert System combined with **interactive video discs and digital graphics** could benefit the adult learner by being able to increase the retention of material learned. This might be done by involving more of the human senses in the learning process and allowing for periodic review of previously learned materials through a Performance Support System at the job site.

21) An Expert System combined with **any of the optical data storage technologies** could benefit the adult learner by being able to increase the retention of material learned. This might be done by involving more of the human senses in the learning process and allowing for periodic review of previously learned materials through a Performance Support System at the job site.

<u>ASSISTS IN RETRIEVING INFORMATION FROM DATABASES</u>

22) An Expert System, combined with any of the optical data storage technologies and possibly integrated with hypermedia software, could assist or "guide" learners in locating and cross-referencing the information needed from large knowledge bases .

ACTS AS AN INTELLIGENT EVALUATOR DURING THE LEARNING

23) An Expert System combined with **CD-ROM** could produce a system that acts as an intelligent evaluator of student's interactions with the system. This type of a system could continually monitor a learner's current knowledge, needs, pace of learning, and learning style and then present the materials necessary to accommodate the learner.

24) An Expert System combined with **any of the optical data storage technologies** could produce a system that acts as an intelligent evaluator of student's interactions with the system. This type of a system could continually monitor a learner's current knowledge, needs, pace of learning, and learning style and then present the materials necessary to accommodate the learner.

EXPERT SYSTEM HAS THE ABILITY TO LEARN

25) An Expert System (based on a neural network) could be combined with any of the optical data storage technologies. An expert system based on a neural network framework would have the ability to utilize fuzzy logic. This would provide the system with the capability to adapt, generalize and learn based on previous information and new information as it becomes available. These systems will prove to be much more adaptive than traditional approaches, providing greater flexibility in the training system and a much longer effective life cycle for both the process and the training itself.

26) Expert Systems could be combined with optical data storage and magneto optical memory technologies. Large knowledge bases could be stored on the optical data storage medium while the magneto optical memory provides the higher amounts of RAM the Expert Systems will need. This will result in CAI that will "know" more than present systems and be capable of growing as information is added and it works with the student.

PORTABILITY, LEARNING CAN OCCUR ANYWHERE

27) A portable computer with an Expert System and an optical data storage system would allow learning, review of previously learned material, or consultation with the knowledge base to take place anywhere.

28) By combining an Expert System on the same medium as any of the optical data storage technologies, the portability of training will be increased. An entire course, stored on the optical medium, could be sent to any remote site with the equipment to use it.

29) Intelligent hypermedia-based systems (including the integrati on of hypermedia software, optical disc storage technologies, and ES) offer the potential of/for creating training programs that will make distance education more meaningful, effective, and efficient.

CREATES PERFORMANCE SUPPORT SYSTEMS

30) An Expert System combined with any of the optical data storage technologies could create a Performance Support System at the job site . This type of system would benefit the learner by providing access to information when it is needed or convenient. The Performance Support System could review and reinforce previous training, offer new training that would transfer directly to the job, or act as a consultant to solve a problem with the worker at the work site.

31) An Expert System combined with any of the optical data storage technologies could create a Performance Support System at the job site. Reducing classroom training time and transferring it to the work site on a just-in-time basis.

32) An Expert System combined with CD-ROM could produce a limited expert system embedded in the CD-ROM based material to provide help in specific areas of performing a job. For example, a CD-ROM database on appliance repair might include and Expert System to troubleshoot and diagnose problems as well as diagrams and text on the appliances.

33) An Expert System could be combined with CD-ROM in an instructional setting where data and text are critical, i.e. administrative assistant, but visual images are not important. A Performance Support System in this setting could have tremendous advantages in assisting students with data entry, retrieval, and manipulation.

34) CD-ROM or DVI can be used to provide very large databases of "facts" or real world knowledge that will allow expert systems to have very "deep and broad" intelligence. These Expert Systems could provide "job performance aids" that would minimize the importance or need for students to remember or learn factual details of tools, products, and procedures.

35) A portable computer with an Expert System and an optical data storage system could provide for on-site, on-demand training and technical expertise and assistance.

LOWERS THE COST OF TRAINING

36) An Expert System combined with any of the optical data storage technologies and possibly integrated with hypermedia software, could result in decreasing the cost of the training process. (Researcher's extrapolation: The benefit to the learner is that a broader training program might be offered for the same budgeted amount.)

SIMPLIFIES CAI THROUGH A GRAPHIC USER INTERFACE

37) An Expert System combined with any of the optical data storage technologies capable of using visuals as a graphic user interface will simplify the use of the system for learners.

INCREASES USE OF VISUALS

38) An Expert System combined with the higher resolution graphics made possible by optical data storage will better serve the visual adult learner by providing more show than tell in the instruction.

INCREASES USE OF AUDIO AND VIDEO

39) An Expert System combined with **CD-ROM** could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.

40) An Expert System combined with **interactive video** could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.

41) An Expert System combined with **any of the optical data storage technologies** could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.

FACILITATES COST EFFECTIVE REPURPOSING OF EXISTING MATERIALS

42) Combining existing analog audio/video (cinema, video, videodisc libraries, interactive videodisc) with a microcomputer containing an Expert System could encourage interactive training as many organizations already have these pieces of hardware in place. This increase in interactive training could benefit the learner by providing more self-paced, competency-based adult education.

PROVIDES FOR EASIER/MORE EFFICIENT UPDATING OF MATERIALS

43) An Expert System combined with digital data, audio and video on optical data storage, could allow for relatively easy modifications to not only the text but also the audio and video portions of the instruction, ensuring up to date instructional materials for the learners. This would be especially attractive to companies if the digital material were at a central site, networked to remote learning stations. Modifications to the instruction could then be accomplished on a single optical disc for the entire network.

NON-GROUPED RESPONSES (Responses 44 - 60 did not seem to fit in any of the preceding areas. If you believe that any of these responses could be placed in one or more of the preceding areas please write the name of the area in the Supporting Comments column on the Response Form.)

44) An Expert System combined with any of the optical data storage technologies could provide better "real world" experiences in updating job skills and in cross training for different job skills.

45) An Expert System combined with any of the optical data storage technologies will lead to the best minds in the various fields of study being be tapped to solve problems and train students. Thus, adults will be challenged by the best thinking in the field.

46) An Expert System combined with any of the optical data storage technologies could provide a means to do empirical research on adult learning processes, therefore, furthering the field of study.

47) An Expert System combined with any of the optical data storage technologies could lead to greater self-esteem among participants if feedback on these systems results in changes within the company.

48) An Expert System combined with any of the optical data storage technologies that assist in the development of instruction could make it easier and faster to develop quality educational programs.

49) An Expert System combined with any of the optical data storage technologies where the optical disc storage device will "drive" the Expert System; i.e., contain deep elements of the Expert System called upon by the system's heuristics. As such, the Expert System will be virtually transparent to the learner because its breadth and depth can be so expanded by the disc's storage capacity.

50) Adult learning will be spend more time confronting the possible rather than the actual because of the large knowledge bases available through optical data storage coupled with the Expert System.

51) An Expert System combined with a CD-ROM database could provide regulation of the instructional sequence for those learners needing direction.

52) An Expert System combined with a CD-ROM database could collect information about the adult learners' interaction with the coursework and store it for the instructor to review as a guide for future modifications to the course.

53) An Expert System combined with a CD-ROM database could result in more attractive learning.

54) An Expert System combined with a CD-ROM database could result in more experimental data being available to the learner.

55) An Expert System combined with a CD-ROM database (eventually CD-read/write) may gain wide public acceptance. The pace at which the public is accepting large text CD-ROM applications hints at this trend.

56) An Expert System to model students within CAI could lead to more flexible and responsive CAI.

57) The adult learner using an Expert System shell combined with a knowledge base from any of the optical data storage technologies would learn a great deal about the boundaries and extent of that knowledge.

58) An Expert System combined with any of the optical data storage technologies could assist adult learners in planning their curriculum. It could give the learner more control over what they are to learn.

59) An Expert System combined with a CD-ROM knowledge base could explain and justify what it is doing so the student could acquire the skills of the Expert System as well as the background information to support those skills.

60) An Expert System combined with any of optical data storage technologies could provide consistency in the training.

<u>NEGLIGIBLE OR NO IMPACT ON ADULT LEARNERS</u> (Please offer a judgement on responses 61 - 64 based on the following KEY.

5	Strongly Agree
4	Agree
3	No Opinion
2	Disagree
1	Strongly Disagree

61) An Expert System combined with any of the optical data storage techniques will have a negligible impact on adult learning. Many aspects of learning, the affective domain as an example, cannot be reduced to a level capable of being programmed into a computer. As such, it is believed that Expert Systems will not be capable of capturing or analyzing the nuances and individual characteristics of learners, their styles of learning or their reaction to mediated instruction.

62) An Expert System combined with any of the optical data storage techniques could allow for under-motivated students to bypass reviews or less interesting sections resulting in a decrease in retention of the material.

63) An Expert System combined with any of the optical data storage techniques will not have a meaningful impact on adult learning in the next 5 years as these technoloies will not effectively be combined for instructional purposes within this time peiod.

64) An Expert System combined with any of the optical data storage techniques will have minimal impact on adult learners and training until the optical data storage technology is much cheaper, easier to produce and modify, and the cost/benefit value makes it an attractive training option.

APPENDIX I

COMBINING EXPERT SYSTEMS AND OPTICAL DISC STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED ADULT LEARNING

RESPONSE FORM
Expert System Research

Item 1 on the Statements Form is equivalent to Item 1 on this Response Form.
Read the item on the Statements Form and consider the following two questions:

1. Does the statement describe or imply some adventageous impact on the adult learner?
2. Will the technologies described be combined in the next five years?

Use the KEY below to indicate the alternative closest to your judgement and circle your decision.

KEY:

6 Advantage for adult learners, Will be achieved technologically
5 Advantage for adult learners, Possible to achieve technologically
4 Advantage for adult learners, Impossible to achieve technologically
3 No advantage for adult learners, Will be achieved technologically
2 No advantage for adult learners, Possible to achieve technologically
1 No advantage for adult learners, Impossible to achieve technologically

Item	Scale	Supporting Comments, if desired. (Attach additonal pages if necessary. Preceed your comments with the item number.)
1)	Example: 6 5 4 3 2 1	1) Non-Expert System software is already available to analyze a student's learning style. It should be a short step to place an Expert System knowledge base on a CD-ROM to analyze and then present instruction that matches the student's learning style.
1)	6 5 4 3 2 1	
2)	6 5 4 3 2 1	
3)	6 5 4 3 2 1	
4)	6 5 4 3 2 1	

Item	Scale	Supporting Comments, if desired. (Attach additonal pages if necessary. Preceed your comments with the item number.)
5)	6 5 4 3 2 1	
6)	6 5 4 3 2 1	
7)	6 5 4 3 2 1	
8)	6 5 4 3 2 1	
9)	6 5 4 3 2 1	
10)	6 5 4 3 2 1	
11)	6 5 4 3 2 1	
12)	6 5 4 3 2 1	
13)	6 5 4 3 2 1	
14)	6 5 4 3 2 1	
15)	6 5 4 3 2 1	
16)	6 5 4 3 2 1	

Item	Scale	Supporting Comments, if desired. (Attach additonal pages if necessary. Preceed your comments with the item number.)
17)	6 5 4 3 2 1	
18)	6 5 4 3 2 1	
19)	6 5 4 3 2 1	
20)	6 5 4 3 2 1	
21)	6 5 4 3 2 1	
22)	6 5 4 3 2 1	
23)	6 5 4 3 2 1	
24)	6 5 4 3 2 1	
25)	6 5 4 3 2 1	
26)	6 5 4 3 2 1	
27)	6 5 4 3 2 1	
28)	6 5 4 3 2 1	

Item	Scale	Supporting Comments, if desired. (Attach additonal pages if necessary. Preceed your comments with the item number.)
29)	6 5 4 3 2 1	
30)	6 5 4 3 2 1	
31)	6 5 4 3 2 1	
32)	6 5 4 3 2 1	
33)	6 5 4 3 2 1	
34)	6 5 4 3 2 1	
35)	6 5 4 3 2 1	
36)	6 5 4 3 2 1	
37)	6 5 4 3 2 1	
38)	6 5 4 3 2 1	
39)	6 5 4 3 2 1	
40)	6 5 4 3 2 1	

Item	Scale	Supporting Comments, if desired. (Attach additonal pages if necessary. Preceed your comments with the item number.)
41)	6 5 4 3 2 1	
42)	6 5 4 3 2 1	
43)	6 5 4 3 2 1	
44)	6 5 4 3 2 1	
45)	6 5 4 3 2 1	
46)	6 5 4 3 2 1	
47)	6 5 4 3 2 1	
48)	6 5 4 3 2 1	
49)	6 5 4 3 2 1	
50)	6 5 4 3 2 1	
51)	6 5 4 3 2 1	
52)	6 5 4 3 2 1	

Item	Scale	Supporting Comments, if desired. (Attach additonal pages if necessary. Preceed your comments with the item number.)
53)	6 5 4 3 2 1	
54)	6 5 4 3 2 1	
55)	6 5 4 3 2 1	
56)	6 5 4 3 2 1	
57)	6 5 4 3 2 1	
58)	6 5 4 3 2 1	
59)	6 5 4 3 2 1	
60)	6 5 4 3 2 1	

Continued on the Next Page

KEY for statements 61 - 64

5	Strongly Agree
4	Agree
3	No Opinion
2	Disagree
1	Strongly Disagree

Item	Scale	Supporting Comments, if desired. (Attach additonal pages if necessary. Preceed your comments with the item number.)
61)	5 4 3 2 1	
62)	5 4 3 2 1	
63)	5 4 3 2 1	
64)	5 4 3 2 1	

Signature: ______________________
(Voluntary)

What Happens Next:

Please return only this Response Form in the enclosed envelope by 10/23/91. The researcher will calculate the numeric judgement for each statement and return these along with the supporting comments for your ratification or further discussion as soon as possible.

This has been the second in a series of three rounds.

Thank you again for your valuable time and opinions.

Appendix J

Judgements In Response To Round Two

N = 33

* Number of Participants responding to the Likert scale are beneath each statement

Ranked Statement	Likert Distribution	GROUP Mean
39. An Expert System combined with CD-ROM could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.	1=0 2=0 3=0 4=0 5=7 6=26	5.7879
41. An Expert System combined with any of the optical data storage technologies could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.	1=0 2=0 3=0 4=0 5=8 6=25	5.7576
40. An Expert System combined with interactive video could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.	1=0 2=0 3=0 4=0 5=9 6=24	5.7273
32. An Expert System combined with CD-ROM could produce a limited expert system embedded in the CD-ROM based material to provide help in specific areas of performing a job. For example, a CD-ROM database on appliance repair might include an Expert System to troubleshoot and diagnose problems as well as diagrams and text on the appliances.	1=0 2=0 3=0 4=0 5=10 6=23	5.6970
27. A portable computer with an Expert System and an optical data storage system would allow learning, review of previously learned material, or consultation with the knowledge base to take place anywhere.	1=0 2=0 3=1 4=1 5=7 6=23	5.6250
35. A portable computer with an Expert System and an optical data storage system could provide for on-site, on-demand training and technical expertise and assistance.	1=0 2=0 3=0 4=1 5=11 6=21	5.6061

Ranked Statement	Likert Distribution	GROUP Mean
30. An Expert System combined with any of the optical data storage technologies could create a Performance Support System at the job site. This type of system would benefit the learner by providing access to information when it is needed or convenient. The Performance Support System could review and reinforce previous training, offer new training that would transfer directly to the job, or act as a consultant to solve a problem with the worker at the work site.	1=0 2=1 3=0 4=1 5=10 6=21	5.5152
44. An Expert System combined with any of the optical data storage technologies could provide better "real world" experiences in updating job skills and in cross training for different job skills.	1=0 2=0 3=0 4=1 5=5 6=17	5.4848
22. An Expert System combined with any of the optical data storage technologies and possibly integrated with hypermedia software, could assist or "guide" learners in locating and cross-referencing the information needed from large knowledge bases.	1=0 2=0 3=3 4=0 5=9 6=21	5.4545
16. An Expert System combined with interactive video could provide the adult learner with simulations that better express reality than those we are currently using.	1=0 2=1 3=2 4=0 5=8 6=21	5.4375
8. An Expert System combined with any of the optical data storage technologies could lead to learning that will be more interactive and multi-modal. The student will become actively involved in the learning situation.	1=0 2=1 3=1 4=1 5=11 6=19	5.3939
28. By combining an Expert System on the same medium as any of the optical data storage technologies, the portability of training will be increased. An entire course, stored on the optical medium, could be sent to any remote site with the equipment to use it.	1=0 2=0 3=2 4=2 5=10 6=18	5.3750
29. Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and Expert Systems) offer the potential of/for creating training programs that will make distance education more meaningful, effective, and efficient.	1=0 2=0 3=2 4=1 5=11 6=16	5.3667

Ranked Statement	Likert Distribution	GROUP Mean
4. An Expert System combined with any of the optical data storage technologies could benefit the adult learner by being able to match the instruction to each individual's needs.	1=0 2=0 3=1 4=4 5=10 6=18	5.3636
12. An Expert System combined with any of the optical data storage technologies could benefit the adult learner by providing instruction that is individualized for each learner.	1=0 2=1 3=1 4=0 5=14 6=17	5.3636
18. A CD-ROM or any of the optical data storage technologies could hold a very large knowledge base for the Expert System. The learner could benefit from this combination by having CAI with a greater ability to illustrate the dynamics of a problem and/or more complex problems.	1=1 2=1 3=0 4=0 5=12 6=19	5.3636
17. An Expert System combined with any of the optical data storage technologies could provide the adult learner with simulations that better express reality than those we are currently using.	1=0 2=1 3=2 4=0 5=12 6=18	5.3438
11. An Expert System combined with CD-ROM could benefit the adult learner by providing instruction that is individualized for each learner.	1=0 2=1 3=1 4=1 5=13 6=17	5.3333
23. An Expert System combined with CD-ROM could produce a system that acts as an intelligent evaluator of student's interactions with the system. This type of a system could continually monitor a learner's current knowledge, needs, pace of learning, and learning style and then present the materials necessary to accommodate the learner.	1=1 2=0 3=0 4=4 5=9 6=19	5.3333
10. An Expert System combined with interactive video could benefit the adult learner by providing instruction that is individualized for each learner.	1=0 2=1 3=1 4=2 5=12 6=17	5.3030
51. An Expert System combined with a CD-ROM database could provide regulation of the instructional sequence for those learners needing direction.	1=1 2=0 3=2 4=0 5=12 6=18	5.3030
43. An Expert System combined with digital data, audio and video on optical data storage could allow for relatively easy modifications to not only the text but also the audio and		

Ranked Statement	Likert Distribution	GROUP Mean
video portions of the instruction, ensuring up to date instructional materials for the learners. This would be especially attractive to companies if the digital material were at a central site, networked to remote learning stations. Modifications to the instruction could then be accomplished on a single optical disc for the entire network.	1=1 2=0 3=0 4=3 5=12 6=16	5.2813
52. An Expert System combined with a CD-ROM database could collect information about the learner's interaction with the coursework and store it (on a hard disk) for the instructor to review as a guide for future modifications to the course.	1=0 2=0 3=3 4=4 5=7 6=19	5.2727
1. An Expert System combined with CD-ROM could benefit the adult learner by being able to match the instruction to each individual's style.	1=1 2=0 3=1 4=1 5=14 6=16	5.2727
24. An Expert System combined with any of the optical data storage technologies could produce a system that acts as an intelligent evaluator of student's interactions with the system. This type of a system could continually monitor a learner's current knowledge, needs, pace of learning, and learning style and then present the materials necessary to accommodate the learner.	1=1 2=0 3=0 4=4 5=11 6=17	5.2727
38. An Expert System combined with the higher resolution graphics made possible by optical data storage will better serve the visual adult learner by providing more show than tell in the instruction.	1=0 2=1 3=4 4=0 5=8 6=20	5.2727
5. An Expert System combined with any of the optical data storage technologies, and possibly integrated with hypermedia software, could guide students through individualized training programs. Selection of the program would be based on the student's skill level, learning style and goals. Students would learn at their own pace using methods which best suit their needs.	1=1 2=0 3=1 4=4 5=9 6=18	5.2424

Ranked Statement	Likert Distribution	GROUP Mean
33. An Expert System could be combined with CD-ROM in an instructional setting where data and text are critical, i.e. administrative assistant, but visual images are not important. A Performance Support System in this setting could have Tremendous advantages in assisting students with data entry, retrieval, and manipulation.	1=0 2=1 3=2 4=1 5=14 6=14	5.1875
2. Expert System combined with any of the optical data storage technologies could benefit the adult learner by being able to match the instruction to each individual's learning style.	1=1 2=0 3=1 4=1 5=17 6=13	5.1818
37. An Expert System combined with any of the optical data storage technologies capable of using visuals as a graphic user interface will simplify the use of the system for learners.	1=1 2=1 3=2 4=4 5=12 6=17	5.1818
31. An Expert System combined with any of the optical data storage technologies could create a Performance Support System at the job site, reducing classroom training time and transferring it to the work site on a just-in-time basis.	1=2 2=1 3=1 4=0 5=10 6=19	5.1818
9. An Expert System combined with any of the optical data storage technologies could result in learning that would be more interactive, multi-modal and matched to the student's cognitive style. This implies that the learning could be deeper and more intuitive, improving the student's creative processes. Having improved the individual's creativity should optimize long term productivity, especially in a dynamic environment.	1=0 2=0 3=1 4=5 5=14 6=12	5.1563
15. An Expert System might be combined with interactive video or any of the other optical data storage technologies. Actual hands-on materials might also be available, as in the case of a laboratory. By monitoring the student input, this type of system could promote discovery learning by adapting the presentation and instruction to circumstances and results arising from the student's actions.	1=2 2=0 3=0 4=3 5=12 6=16	5.1515
14. An Expert System combined with any of the optical data storage technologies could enable the learner to ask "what if" questions of the knowledge base. This could benefit the learner by making self-directed learning available, allowing the learner to follow his/her interests in the subject.	1=1 2=0 3=2 4=3 5=12 6=15	5.1212

Ranked Statement	Likert Distribution	GROUP Mean
46. An Expert System combined with any of the optical data storage technologies could provide a means to do empirical research on adult learning processes, therefore, furthering the field of study.	1=1 2=0 3=2 4=2 5=15 6=13	5.0909
13. An Expert System combined with CD-ROM could enable the learner to ask "what if" questions of the knowledge base. This could benefit the learner by making self-directed learning available, allowing the learner to follow his/her interests in the subject.	1=1 2=0 3=2 4=4 5=11 6=15	5.0909
42. Combining existing analog audio/video (cinema, video, videodisc libraries, interactive videodisc) with a microcomputer containing an Expert System could encourage interactive training, as many organizations already have these pieces of hardware in place. This increase in interactive training could benefit the learner by providing more self-paced, competency-based adult education.	1=0 2=2 3=1 4=3 5=13 6=13	5.0606
6. An Expert System combined with CD-ROM could maintain a high level of motivation and interest in the learner through its ability to monitor the learner and adjust the use of instructional materials.	1=1 2=1 3=1 4=2 5=15 6=13	5.0606
7. An Expert System combined with any of the optical data storage technologies could maintain a high level of motivation and interest in the learner through its ability to monitor the learner and adjust the use of instructional materials.	1=1 2=1 3=1 4=1 5=18 6=11	5.0303
36. An Expert System combined with any of the optical data storage technologies and integrated with hypermedia software, could result in decreasing the cost of the training process. (Researcher's extrapolation: The benefit to the learner is that a broader training program might be offered for the same budgeted amount.)	1=2 2=1 3=0 4=4 5=12 6=13	4.9375
55. An Expert System combined with a CD-ROM database (eventually CD-read/write) may gain wide public acceptance. The pace at which the public is accepting large text CD-ROM applications hints at this trend.	1=2 2=1 3=2 4=0 5=13 6=12	4.9000

Ranked Statement	Likert Distribution	GROUP Mean
54. An Expert System combined with a CD-ROM database could result in more experimental data being available to the learner.	1=1 2=3 3=2 4=0 5=13 6=13	4.8750
56. An Expert System to model students within CAI could lead to more flexible and responsive CAI.	1=1 2=2 3=3 4=1 5=11 6=13	4.8710
59. An Expert System combined with a CD-ROM knowledge base could explain and justify what it is doing so the student could acquire the skills of the Expert System as well as the background information to support those skills.	1=1 2=2 3=2 4=3 5=13 6=12	4.8485
34. CD-ROM or DVI can be used to provide very large databases of "facts" or real world knowledge that will allow expert systems to have very "deep and broad" intelligence. These Expert Systems could provide "job performance aids" that would minimize the importance or need for students to remember or learn factual details of tools, products, and procedures.	1=5 2=0 3=0 4=1 5=11 6=16	4.8485
48. An Expert System combined with any of the optical data storage technologies that assist in the development of instruction could make it easier and faster to develop quality educational programs.	1=1 2=0 3=3 4=3 5=17 6=8	4.8438
53. An Expert System combined with a CD-ROM database could result in more attractive learning.	1=3 2=1 3=2 4=0 5=12 6=14	4.8438
3. An Expert System combined with CD-ROM could benefit the adult learner by being able to assist in the translation of a student's optimum learning style into other formats so that the learner can develop other modes of learning as well as the preferred style.	1=1 2=1 3=2 4=4 5=16 6=9	4.8182
60. An Expert System combined with any of the optical data storage technologies could provide consistency in the training.	1=1 2=2 3=3 4=3 5=10 6=13	4.8125
19. An Expert System combined with any of the optical data storage technologies could better instruct adults in basic education concepts and skills (i.e. reading, writhing, math) by providing more learning devices for the adults.	1=1 2=5 3=3 4=0 5=7 6=17	4.7576

Ranked Statement	Likert Distribution	GROUP Mean
58. An Expert System combined with any of the optical data storage technologies could assist adult learners in planning their curriculum. It could give the learner more control over what they are to learn.	1=1 2=3 3=3 4=1 5=14 6=11	4.7273
20. An Expert System combined with interactive video discs and digital graphics could benefit the adult learner by being able to increase the retention of material learned. This might be done by involving more of the human senses in the learning process and allowing for periodic review of previously learned materials through a Performance Support System at the job site.	1=1 2=4 3=4 4=0 5=9 6=15	4.7273
26. Expert Systems could be combined with optical data storage and magneto optical memory technologies. Large knowledge bases could be stored on the optical data storage medium while the magneto optical memory provides the higher amounts of RAM the Expert Systems will need. This will result in CAI that will "know" more than present systems and be capable of growing as information is added and it works with the student.	1=1 2=2 3=1 4=3 5=18 6=5	4.6667
21. An Expert System combined with any of the optical data storage technologies could benefit the adult learner by being able to increase the retention of material learned. This might be done by involving more of the human senses in the learning process and allowing for periodic review of previously learned materials through a Performance Support System at the job site.	1=1 2=4 3=4 4=0 5=11 6=13	4.6667
25. An Expert System (based on a neural network) could be combined with any of the optical data storage technologies. An Expert System based on a neural network framework would have the ability to utilize fuzzy logic. This would provide the system with the capacity to adapt, generalize and learn based on previous information and new information as it becomes available. These systems will prove to be much more adaptive than traditional approaches, providing greater flexibility in the training system and a much longer effective life cycle for both the process and the training itself.	1=3 2=0 3=3 4=5 5=12 6=8	4.5161

Ranked Statement	Likert Distribution	GROUP Mean
45. An Expert System combined with any of the optical data storage technologies will lead to the best minds in the various fields of study being tapped to solve problems and train students. Thus, adults will be challenged by the best thinking in the field.	1=3 2=1 3=4 4=3 5=13 6=8	4.4375
57. The adult learner using an Expert System shell combined with a knowledge base from any of the optical data storage technologies would learn a great deal about the boundaries and extent of that knowledge.	1=1 2=4 3=4 4=2 5=12 6=8	4.4194
50. Adult learning will spend more time confronting the possible rather than the actual because of the large knowledge bases available through optical data storage coupled with the Expert System.	1=2 2=5 3=2 4=1 5=14 6=6	4.2667
47. An Expert System combined with any of the optical data storage technologies could lead to greater self-esteem among participants if feedback on these systems results in changes within the company.	1=4 2=2 3=2 4=3 5=14 6=5	4.2000
49. An Expert System combined with any of the optical data storage technologies where the optical disc storage device will "drive" the Expert System; i.e., contain deep elements of the Expert System called upon by the system's heuristics. As such, the Expert System will be virtually transparent to the learner because its breadth and depth can be so expanded by the disc's storage capacity.	1=4 2=2 3=4 4=3 5=11 6=6	4.1000
64. An Expert System combined with any of the optical data storage technologies will have minimal impact on adult learners and training until the optical data storage technology is much cheaper, easier to produce and modify, and the cost/benefit value makes it an attractive training option.	1=3 2=5 3=1 4=12 5=12 6=NA	3.7576
62. An Expert System combined with any of the optical data storage technologies could allow for undermotivated students to bypass reviews or less interesting sections resulting in a decrease in retention of the material.	1=9 2=7 3=4 4=10 5=3 6=NA	2.7273

Ranked Statement	Likert Distribution	GROUP Mean
63. An Expert System combined with any of the optical data storage technologies will not have a meaningful impact on adult learning in the next 5 years as these technologies will not effectively be combined for instructional purposes within this time period.	1=7 2=10 3=3 4=9 5=3 6=NA	2.7188
61. An Expert System combined with any of the optical data storage technologies will have negligible impact on adult learning. Many aspects of learning, the affective domain as an example, cannot be reduced to a level capable of being programmed into a computer. As such, it is believed that Expert Systems will not be capable of capturing or analyzing the nuances and individual characteristics of learners, their styles of learning or their reaction to mediated instruction.	1=11 2=15 3=0 4=3 5=4 6=NA	2.2121

APPENDIX K

Date

Participant's Name
Position
Organization
Address
City, State   Zip

Dear XXXXX,

Thank you for responding to and signing your second round questionnaire in the Delphi.

During October and November, 33 participants responded to the second round of the Delphi. Most of the respondents offered judgements on all 64 statements identifying impacts on adult learning that might be possible if the technologies of expert systems and optical disc storage systems could be combined in computer-assisted instruction. Eleven pages of supporting comments were also generated. These supporting comments provided me with hours of thought while collating them and ranking the judgements in preparing this third round of the Delphi.

Responses were received from experts in all five of the participating fields: expert system research, expert system development, optical data storage development, industrial training, and instructional technology.

This third round of the Delphi should take you approximately 30 - 40 minutes to complete. The time will vary depending on the number and detail of supporting comments that you offer. As in rounds one and two, in order to maintain the anonymity of the participants, the response sheets that you return have no individual identifying marking on them.

I would like to thank you again for your willingness to participate in this research. Your judgements in this round will be most helpful in identifying how the combining of these technologies may impact adult learning.

Sincerely,

Tim McLaughlin

Phone Numbers: Office - ###/###-#### 9:00 am - 5:00 pm
Home - ###/###-#### Evenings, Collect

APPENDIX L

Date

Participant's Name
Position
Organization
Address
City, State   Zip

Dear XXXXX,

During October and November, 33 participants responded to the second round of the Delphi. Most of the respondents offered judgements on all 64 statements identifying impacts on adult learning that might be possible if the technologies of expert systems and optical disc storage systems could be combined in computer-assisted instruction. Eleven pages of supporting comments were also generated. These supporting comments provided me with hours of thought while collating them and ranking the judgements in preparing this third round of the Delphi.

A few participants did not respond to the second round questionnaire. Because of the anonymity of the response form, I do not know if you were one of those individuals. If you were, your judgements on this third round are still greatly valued.

Responses were received from experts in all five of the participating fields: expert system research, expert system development, optical data storage development, industrial training, and instructional technology.

This third round of the Delphi should take you approximately 30 - 40 minutes to complete. The time will vary depending on the number and detail of supporting comments that you offer. As in rounds one and two, in order to maintain the anonymity of the participants, the response sheets that you return have no individual identifying marking on them.

I would like to thank you again for your willingness to participate in this research. Your judgements in this round will be most helpful in identifying how the combining of these technologies may impact adult learning.

Sincerely,

Tim McLaughlin

Phone Numbers: Office - ###/###-####   9:00 am - 5:00 pm
Home - ###/###-####   Evenings, Collect

APPENDIX M

COMBINING EXPERT SYSTEMS AND OPTICAL DISC STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED ADULT LEARNING

COMMENTS FORM

COMMENTS TO SUPPORT JUDGEMENTS

The following pages contain the comments that were offered for both the round two questionnaire as a whole and to support judgements for the corresponding item number. General comments regarding the entire questionnaire are below. Individual item comments begin on page 17. The comments within an item are presented with those that support the item first, followed by comments that refute the item. A forward slash (/) is used to separate each respondent's comments within an item.

General Comments:

This comment is for items 1 - 40. What we are talking about is the integration of existing technologies. This implies that they can be integrated. All that is required to do it is a financial motivation. In America, it is clear that the financial motivation will not come from wanting to educate our children. It will come from the military and/or from some business.

A lot of options are technologically possible but unlikely due to theoretical or implementation factors. The extent to which they benefit adult learners depends upon how the implementation is done. So, the selection of 5 or 2 on the Likert scale is arbitrary without specific details of this consideration.

Many of the same goals could be reached by other methods/media. This questionnaire does not deal with the relative effectiveness of Expert Systems and optical technologies.

Virtually everything in the questionnaire is possible using today's technology.

We, the "experts" have only projected today's concerns and knowledge, not come up with any innovative uses of the new technology.

In my opinion, expert systems are more valuable for evaluating learners then teaching. Optical media is just a media for storing the courseware and doesn't effect the quality or usefulness. Its primary advantage, at this time, is capacity which may or may not be required for the courseware. Any storage device with adequate capacity will do - magnetic storage is much faster and has large capacities (600MB) but are not easily distributed.

This comment is for items 1 - 64. To computer people, there is no such thing as AI or ever having something that can be a person. So, there is no "Expert System"

Individual Item Comments:

1. Can do this currently, don't need an Expert System. / Already exists! Some of these systems will actually be real systems used (and repackaged) for training. An example is the G-FIT application used at Rockwell to control the payload of the Space Shuttle...and teach engineers how to do it. / I have seen articles on a similar system being used in industry training. / This would be great for learners. / Not likely within the 5 year time frame. / Not in 5 years. A decade of research on learning styles has been inconclusive. / Our area of ignorance is learning and learning styles, not the technology and delivery methods. / Our knowledge of learning styles as it applies to specific tasks or content is very limited. / Only if valid and reliable measures for capturing learning styles could be established. / This requires the convergence of a second, more important technology: that of 1) being able to identify learning styles, and 2) being able to prescribe a treatment that benefits a particular style. Too often as we evaluate hardware changes we fail to realize the conceptual issues which underlie them.

2. Combined with video disk would be a great advantage to "visual" learners and, to some degree, an advantage for kinesthetic learners. / Not likely within the 5 year time frame. / Not in 5 years. A decade of research on learning styles has been inconclusive. / Our knowledge of learning styles as it applies to specific tasks or content is very limited. / Only if valid and reliable measures for capturing learning styles could be established. / Interactive Video has severe storage limitations for complex learning systems. / This requires the convergence of a second, more important technology: that of 1) being able to identify learning styles, and 2) being able to prescribe a treatment that benefits a particular style. Too often as we evaluate hardware changes we fail to realize the conceptual issues which underlie them.

3. Learning as a process is itself learned. Clearly, any form of instructions can influence learning style. / Would allow learners to address learning weaknesses, makes a more global learner. / I am not sure this is, at present, a possibility but since most persons in school are forced to be visual verbal learners it is possible. / Not likely within the 5 year time frame. / Our knowledge of learning styles as it applies to specific tasks or content is very limited. / A decade of research on learning styles has been inconclusive. / Very difficult to determine the variety of learning styles and then to teach a new one. / Only if valid and reliable measures for capturing learning styles could be established.

4. Already happening. / This is already being done with CD-ROM. / Don't even need optical technology. / Not likely within the 5 year time frame. / Possible but will require major funding. / It is not clear what "needs" means. There might be hands-on types of training that would not be easy to match the needs with this delivery system. / "Needs" must be informational needs.

5. Exists today. / I believe this is already being done within some industrial training applications. / Not likely within the 5 year time frame. / Not in 5 years. Even if started today, it will take years to build. / Research has shown that often in self-paced instruction students skip steps to get done quickly. / Development cost of complex courseware is a limiting factor. / The technology is here, the cost and effort and planning for implementation is a problem. / Expert Systems can help analyze the learner, but courseware must be developed with multiple styles and strategies - that is the most expensive part of courseware development. / This depends on the goals of the learning process. Technical mastery of highly intricate material may not lend itself to "student's own pace." Especially in a university setting. / This item is not thought out. Hypermedia puts at the student's control a host of interlinked resources, but the

item suggests that somehow it will become a part of the computer controlled "individualized training program." There is a conflict in most developers thinking between student control and system control. This item is a classic in this respect.

6. Already being done without "Expert Systems." / Currently being done with Level III Interactive Video Disc programs. / The possibility will be a function of proper applications for motivational design theories. / The weak points in this may be the lack of understanding of the needs of the learner and uninspired instructional design. / If students do not want to learn, nothing much will help. I know that computers are good for students with "people interface" problems, but I'm not sure computers actually motivate in and of themselves. Developing all of this would assist and promote learning at Purdue, for example, but the students are there because they want to be and are paying of it. / Assuming that "monitoring" and "adjusting" are truly sources of motivation, which is not established.

7. Already being done without "Expert Systems." / Currently being done with Level III Interactive Video Disc programs. / The possibility will be a function of proper applications for motivational design theories. / The weak points in this may be the lack of understanding of the needs of the learner and uninspired instructional design. / If students do not want to learn, nothing much will help. I know that computers are good for students with "people interface" problems, but I'm not sure computers actually motivate in and of themselves. Developing all of this would assist and promote learning at Purdue, for example, but the students are there because they want to be and are paying of it.

8. Already being done without "Expert Systems." / Currently being done with Level III Interactive Video Disc programs. / Currently being done. CBT authoring systems (Quest, TenCore, etc.) have been multimedia (video, graphics, digitized audio) for years. / This is being done in a limited way but will improve as the 2-way interaction is expanded in the future. / Technology is fine, but hands-on work must be part of the system. / The instructional design must plan for interaction. / MAY become involved. Research has shown often in self-paced instruction students skip steps to get done quickly.

9. The theory is good but in practice or reality it might be difficult to prove. (I teach this subject at Purdue and know it's a tough ball game at the university level.) / Not likely within the 5 year time frame. / I am uncertain. The individual's creativity will be limited by the parameters of the Expert System and the information on the data base. / I agree with Gagne and Clark that all media will teach about the same if the design is correct. Expert Systems not necessarily better except in motivation. / Approach is flawed. The teaching system is the proactive element. / The effects described in this item would not be necessarily attributable to the use of optical storage technologies. Numerous design elements of the instruction would be required to produce such effects. / Instructional strategies (e.g. instructional simulations, problem solving, etc.) are more important that the Expert System and the media.

10. This is easily done now. It is not news, even though the bulk of developers are not using it. / Don't need an Expert System to achieve this. / Currently being done with Level III Interactive Video Disc programs. / The instruction can be individualized into one of several paths. Storage space, development time and testing of the program limit the possibilities of instructional options that can be provided to the student. / Not likely to achieve in the next 5 years. / Individualized but not always suited to everyone's learning style. / Expert Systems

are not particularly good for teaching - probably better as a job aid. Also, there are less expensive ways to build job aids, than Expert Systems, that are just as effective.

11. Don't need an Expert System to achieve this. / Currently being done with Level III Interactive Video Disc programs. / It's already happening.

12. This is more likely to have a greater variety of media to meet differences in learning styles. / Don't need an Expert System to achieve this. / Currently being done with Level III Interactive Video Disc programs. /

13. This is being done now. See SHERLOCK, by Alan Lesgold. Frankly, having a relatively static device like a CD-ROM attached would have little (if any) benefit over a good object-oriented graphics package. The graphics could be more responsive over a broader range of variations in "what if" outcomes and better display the results than visuals captured on a CD-ROM. / Would certainly promote discovery learning and problem solving skills. / Not likely within the 5 year time frame. / Not in 5 years. / I really don't see how, given our current programming levels, "what if" questions can be dealt with in the next 5 years. / Answers to "what if" questions aren't going to be very detailed unless the Expert System has a very good model of what is being taught. CD-ROM does not add anything to this difficult problem. / "What if" encourages discovery learning, but might frustrate an administration of formal learning because measurement and evaluation of the learner's achievements would be hard to pin down. / Instructional simulations may be better than Expert Systems - combine them and use the Expert System to evaluate the learner's performance in the simulation.

14. This will take very hard work and would be like the sparse examples of Level IV Interactive Video Disc. / Would certainly promote discovery learning and problem solving skills. / The authoring system will allow. / Not in 5 years. / I really don't see how, given our current programming levels, "what if" questions can be dealt with in the next 5 years. / Instructional simulations may be better than Expert Systems - combine them and use the Expert System to evaluate the learner's performance in the simulation.

15. Of course! / Not likely within the 5 year time frame. / Not likely to achieve in the next 5 years. / Not in 5 years. / Measurement and evaluation of the learner's achievements would be hard to pin down. What criteria of evaluation is to be applied. / I have visions of this at Purdue, pure chaos! Engineering students don't like discovery learning. / The word "adapting" should be replaced by "anticipating the need for." That is the main way computers can be useful in discovery learning.

16. Especially in model based reasoning and complex graphical simulations of complex numerical data. / Similar to the more excellent and elegant extant examples of Level III Interactive Video Disc. / Doesn't express reality better but allows the instruction to reach more subjects with simulations since it has one-to-one instruction. / Not sure that the Expert System would improve the simulation, but could evaluate the student and thereby increase learning.

17. Excellent science programs are already available. / Especially in model based reasoning and complex graphical simulations of complex numerical data. / Similar to the more excellent and elegant extant examples of Level III Interactive Video Disc. / Progress is certain. / Doesn't express reality better but allows the instruction to reach more subjects with simulations since it has one-to-one instruction. / Not sure that the Expert System would improve the simulation, but could evaluate the student and thereby increase learning.

18. This will depend on better and faster unions of Expert Systems with data bases. / Depends on subjects, topics, level of teaching. / The person would only be confused by too much detail and too many examples. The storage size is not the limiting factor, getting the knowledge is the limiting factor. / A large data base doesn't necessarily make an Expert System better. There are still many things that an Expert System can not handle in a reasonable manner.

19. Using computers in prisons to solve literacy problems is a case in point. / Not all adults will like this approach but some will profit greatly. / NOT BETTER. I agree with Gagne and Clark that all media will teach about the same if the design is correct. Expert Systems not necessarily better except in motivation. / Mastery learning of "basic education concepts and skills" does not require expert systems capabilities. / Nothing replaces a person in adult tutoring. / The computer-person one-to-one relationship is not dynamic enough. / I don't believe that CD-ROM or any other optical data storage device will play a significant part in this area.

20. We have already done this. / Very important: for example, using sounds to diagnose maintenance problems. / It is being done now without Expert Systems. / Can be achieved with non-expert system courseware. / Expert Systems are not the key here. / Not sure that an Expert System is required. Once again, CD-ROM and other optical storage devices will not be the key to this benefit: it will be the intelligent (human) use of the media in sound instructional designs. Performance support systems to "remind" students will become a certainty, but they will not require optical storage. / Not sure that "digital graphics" would increase retention. Learners should, or have to, "internalize" learning, but I'm not convinced this is "the" answer.

21. Can be achieved with non-expert system courseware. / Expert Systems are not the key here. / Once again, CD-ROM and other optical storage devices will not be the key to this benefit: it will be the intelligent (human) use of the media in sound instructional designs. Performance support systems to "remind" students will become a certainty, but they will not require optical storage. / Learners should, or have to, "internalize" learning, but I'm not convinced this is "the" answer.

22. This will be true especially in professional consulting services such as medical diagnosis, systems analysis and maintenance, etc. / Absolutely true. Pennsylvania schools use the CD-ROM union catalog to identify materials in libraries all over the state, and then use the same computers to request interlibrary loans. / An Expert System frontend to a data base system to simplify access to the data and information. / This will occur first in the form of Computer Managed Instruction data bases which guide a student through large curricula. / Hypermedia links more often lead to confusion on the part of the student ("Where was I?") than to learning. / Hypermedia not as good as interactive systems such as Ten Core.

23. Yes! / This was accomplished in 1986. / Doing it now! / To a limited degree, this is available now. Systems I have seen need more creativity and refinement. / A powerful Expert System is needed. / Not in 5 years. / Just don't think this can come about in 5 years. /Neither CD-ROM nor other optical data storage technologies contribute to solving this difficult problem.

24. Yes! / This was accomplished in 1986. / Currently being done. / A powerful Expert System is needed. / Not in 5 years.

25. I'm working on this now. / Sounds great. I have read about this type of system but have not seen an application. Is it economically viable? / Not likely within the 5 year time frame. / Seems a little farther off than 1995. / Not likely to achieve in the next 5 years. / Not in 5 years. / Not in 5 years. / Why focus only on only neural networks? There are many other reasoning technologies available; forward chaining, unification, OPS-5 based engines, etc. / Not impossible, but impractical. / It can only adapt to the extent the courseware allows. / No direct impact on learning.

26. Yes, but it is presently beyond the reality of cost/effectiveness. / Maybe, but not likely. / Seems to me it will be very expensive to develop the CAI courseware.

27. Available today. / Portable computers without optical storage are currently being used as job aids, usually a simple, small data base without and Expert System. / Not likely within the 5 year time frame.

28. Currently being done. / Yes, such as a laptop computer with accessories. / Depends on the course. Not everything translates into computereze. / As expressed, this does NOT provide for the capture and use of "live" learner input. / No direct impact on learning.

29. Hypermedia has significant limitations. / I don't see the pay off for distance education. / Breaking down prejudices against distance education and training without a "live" instructor is a problem in implementation.

30. This is already beginning done. See Anderson Consulting efforts in Dallas. / Exists in some forms now, albeit not in abundance. / Available today. / Some insurance companies have "on line" mini-training packages now. / Not achievable in the next 5 years.

31. Available today. / I believe the armed forces has something like this now to keep equipment operating. / Dislike and "distrust" connotations of "just-in-time" training. / Just-in- time is not soon enough.

32. Very definitely - already being done. / Already in use. / Available 5 years ago. / Currently being done, but neither Expert Systems nor optical storage is required.

33. Already in use. / Absolutely true. There is a help feature usually available on electronic communication equipment. / Is dependent upon learning style. / CD-ROM not really necessary.

34. There is too much data out there to memorize. Harvard Medical School stresses using data bases instead of memorizing trivia. / Currently being done, both with and without Expert Systems. / Believe this exists now. / Boo! Hiss! / It is necessary to memorize facts so that when immediately needed they are available. Also, job aides are not always readily available. / Mere presence and use will cause students to learn, regardless. / "Deep and broad" are relative and in comparison to human "depth and breadth" Expert Systems, even big ones, don't measure up. / Difficult to encode all that knowledge. How does the Expert System know what knowledge is needed and when? Also, the Expert System is too much technology. / DVI is not there yet because of compression/decompression time problems. Real time is a must for this environment. / If you don't know everything, then you haven't learned enough.

35. Believe this exists now.

36. If there are sufficient numbers of students/courses. / This would depend on the numbers of persons needing training, the focus of the training and the cost of developing the Expert System. / Yes. Training costs are less if the factor of increased job performance is evaluated. / Reduces retraining, mistakes, and accidents which all translate into dollars. / Not in 5 years. / Historically, this has not been a normal result of either efficiency or effectiveness. / Technology rarely decreases costs as far as the learner is concerned. / Not in 5 years. When costs of equipment and development are considered, few jobs will benefit from decreased costs. / Development cost is high. / This will depend on the continued development of instructional design systems such as Dave Merrill's at Utah State University.

37. Exists now. / Already achieved with non-expert system software. / We do this today. / It will simplify the use of the system only for those who are visual learners. / Maybe this would depend on the learning style of the person. / Depends on the subject and the user's learning style. / All the student sees is the course. A Graphic User Interface or Expert System are not required, in most cases, to simplify the use of the courseware. / Don't need optical disk to do this.

38. Exists now. / Already achieved with non-expert system software. / Available now. / More detail like real life. / Don't need optical disk to do this. / Based on Dwyers studies, more detail or realism does not always achieve greater learning. / Can't eliminate instruction for visual learners. / An Expert System is probably not a factor. The optical storage may allow more raster images but is not necessary for vector graphics (size not effected by resolution).

39. Available now. / Except for "matching the student's learning style" this has already been accomplished in many Interactive Video Disc programs. / May also benefit individuals who cannot read. / This would help certain learning styles but multi-channel delivery is not always more effective, as Dwyer's studies have pointed out.

40. Available now. / Except for "matching the student's learning style" this has already been accomplished in many Interactive Video Disc programs. / This could also improve the learner's retention of the material. / Simultaneous involvement of the senses does not always achieve higher retention.

41. Except for "matching the student's learning style" this has already been accomplished in many Interactive Video Disc programs.

42. Already achieved with non-expert system software. / Expert Systems not necessary to do this. Currently being done without Expert Systems. / Providing education which lends itself to this format is needed. / Existing hardware is not the issue. Hardware will become very inexpensive. / It is cheaper to buy self-contained packages then to put together systems from existing pieces. / Usually difficult and costly to "integrate" the disparate elements as described. / Material must be completely redesigned for interactive use.

43. It's wonderful! / Possible, currently available for stills and text but not for moving video. / This is a very important idea. / Schools in Texas have approved video disk text books for purchase. However, digitizing facilitates the altering of visual images so that the "fact" or reality of the image is no longer that of the original. Intellectual honesty could be the issue of tomorrow. / Not one disc, must have multiples, CD-ROM transmission rate is too slow for one handler on a large network. / I don't see how an Expert System is critical to this problem, or even necessary.

44. Happens now.

45. Though highly desirable and "possible", this result is not likely within the 5 year time frame. / The "best" minds may not always be helpful as a model for non-genius adult learners. / This will sometimes happen but often the "best" minds won't communicate well in the new medium. / "Best minds" will not be involved in training. / Most training isn't at the "best minds" level. / Get practical. / Getting the "best minds" is a money problem, not a technological problem. / This is not a technology question but a marketing one. / The key here will be that "the best minds" sell their time, and it will be required for an entire ROM publishing industry to grow up for this to occur. It is an economic and practical problem, not a technical one. Our "information society" deals mostly in trivial, easily obtainable information. The good, the essential, the valuable information is sold at a high price.

46. Happens now. / Research could be enhanced by using neural networks to discern patterns of learning processes for different categories of students. / No immediate impact. / It will take more than 5 years. / Expert Systems and optical storage are not the key to this lock. They may be nice-to-have tools, but they are no more useful here than any other tools.

47. True now in some "leading edge" Interactive Video disc" applications. / Self esteem will rise even if the student uses a pencil. This has nothing to do with the technology. / Doubtful in most companies, especially those not deeply committed to TQM. / Companies are not very concerned with self- esteem and internal changes of any consequences are very slow. / A bit of a "stretch."

48. This is a great need. Dave Merrill, from Utah, offers some help in this area. / This will depend on the continued development of instructional design systems such as Dave Merrill's at Utah State University. / Expert Systems might be of value in making it easier and faster to design good courseware, but it must be used carefully. / Cost and time are the issues here. / "Pie in the Sky." Courseware development time and cost are still critical factors in multi-media use. / No, it's slow and expensive initially.

49. This is available today. / It depends on the design. / Not in 5 years. / CD-ROM data access/transmission is too slow. The learner will always be aware of the system, if only due to pauses. / Optical data storage has slow access times. An Expert System needs a fast CPU and dynamic RAM to make it "transparent." / Increasing the size and complexity of the Expert System enough to require CD-ROM as it medium means increasing the size of the data base accessed by the Expert System. This will not speed up the Expert System. It will slow it down. / Don't see the value of this.

50. Most adult learners spend more time confronting actual needs rather than possible needs. / Adults need "REAL" vs possible. / It depends on the lesson. / Not likely within the 5 year time frame. / Not if their training is being paid for by their employer. / Too much information, unorganized and not related to tasks or goals could be overwhelming and, therefore, not helpful to a trainee. / Confronting is a turn off to learners.

51. Currently being done with Level III Interactive Video Disc programs. / Already achieved with non-expert system software. / The Expert System could "better regulate" the sequence but this is a sub-issue of "learning style", I believe. / Individualizes learning. / Happens today. / The Expert System would have to be carefully and creatively programed to supply this. / Makes sense.

52. Currently being done with Level III Interactive Video Disc programs. / Already achieved with non-expert system software. / Not on CD-ROM. Need to be able to write to a storage medium. / Happens today. Does not require Expert System or optical technology. / This is a very good application. I have seen this done in CAI or CBT courses. / Would only tell the instructor what the learner did, not what he/she thought. / This is currently being done and neither Expert Systems or CD-ROM is required. Expert Systems might be used to help evaluate the data collected.

53. Already achieved with non-expert system software. / Currently being done with Level III Interactive Video Disc programs. / Maintains motivation and interest. / The instructional design is the key. The technology provides the tools but unless it is designed properly learning won't take place. / This depends on the material, the instructional design and the writer of the courses. / This must be broken down by the various adult education markets. / Can be a disadvantage for those more comfortable with human interaction.

54. Already achieved with non-expert system software. / An Expert System could provide easier access to CD-ROM data bases. / Excellent use for science, math and statistics instruction. / Good for engineers but won't teach migrant workers.

55. The public is not really rushing to buy CD-ROM texts.

56. Individualizes learning. / Modelling of students is normally done in "artificial intelligence" programs, the big brother of Expert Systems. / Don't need Expert Systems or optical technology , just good algorithms.

57. True, now and in the future. / It is not the shell that helps the learner, but the knowledge the instructor places in the shell. / Students could use neural networks to explore permutations that occur for different combinations of factors. / Students would only assume they had reached the limits of the knowledge base. / To what end? What is the goal?

58. This is possible now in advanced computer managed instruction systems. / Not likely within the 5 year time frame.

59. Already being done without the CD-ROM. / Good idea! / If not, it is not an Expert System. The explanation sub-system is part of any Expert System.

60. Currently being done with Level III Interactive Video Disc programs. / Already achieved with non-expert system software. / What does "consistency" mean? It is usually bad for the organization, as a bureaucracy uses it, and that implies bad for the individual. / Individualization is what Expert Systems can provide. / Consistency is not the goal. Adaptability is the goal!

Negligible or No Impact Statements

61. Even if it is possible, it will be too expensive to produce. / The computer is extremely good at teaching affect and values, especially when connected to video media. / Learner inputs can be analyzed as easily as the teaching material itself. / Impact can be great despite limitations. / This varies with subject matter. / It could help with memorization of and practice with simple things like procedures. Not all instruction requires the analysis of nuances. / Not to the "Nth" degree, but close enough to assist learning. / Expert Systems can be useful in other ways than determining characteristics of learners - individuals are not limited to one learning style.

62. Research has shown that often in self-paced instruction students skip steps to get done quickly. / Expert System not needed for this. / Can do this now, don't need and Expert System. / I agree that it could allow students to bypass many parts of the learning. That is the main challenge, to design the system to not allow this. This design is surely possible, but can probably not be fully enforced without a human teacher. / This is totally inconsistent with the characteristics of an "Expert System." / Only a bad Expert System would allow bypassing. / If properly constructed, an Expert System could discern student boredom, based on bypasses, and adjust the learning approach to reactivate interest. / Depends on how good or bad their design is. / The program designer can set up the instruction to freely let the student go anywhere or just receive certain parts, thus, preventing bypassing sections. / This is a design issue, not a technology problem. / This is a computer managed instruction design problem, not a technology problem. Students can sluff classes now. It has nothing to do with the medium of instruction. / The paradigm assumes that the student learns something once and remembers it forever instead of using the system each time to learn what is needed now. / Statistics show that even if students bypass reviews and sections there is still an increase in retention. A confounding result. / Under-motivated students are not going to get much from this anyway.

63. Will be more than 10 years before really wide spread use of large amounts of courseware become available. / They are combined now for a few specific applications. / It already has an impact in some specialized areas. / Systems are there. Acceptance by managers from the "old school" is the problem. As the computer literate persons advance into management positions, more acceptance will occur. / Need to move faster than we are now. / CD-ROM and other optical technologies will be generally available and Expert Systems will use them simple because they are there.

64. Although the technology is available, the production costs, due to the limited pool of developers, will not yield a cost effective product. / Costs and lack of flexibility in modifying or updating has discouraged the use of these systems. / Optical storage is relatively inexpensive - the cost of the courseware is in the design and production (video, graphics, etc.). / Hardware costs are not the limiting factor, courseware development costs are the limiting factor. / Computers and their peripherals come down dramatically in price every year, sometimes every month. / But as the cost of the hardware goes down, the emerging new factor will be the cost of the software. / This is market dependent. / Costs are coming down and in places where cost is not an object (military, big business) they will be the first to adopt. / Whether the lack of impact is the result of a lack of technology or a human unwillingness to use the technology remains to be seen.

APPENDIX N

COMBINING EXPERT SYSTEMS AND OPTICAL DISC STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED ADULT LEARNING

RANKING OF INDIVIDUAL RESPONSES

INSTRUCTIONS
(Group)
12/12/91

Background for this step of the Delphi:

As stated in the previous rounds, this Delphi is attempting to identify and rank the feasibility of potential linkages between optical disk storage (e.g. IVD, CD-ROM, CD-V, etc.) and Expert Systems technologies that may enable computer-assisted instruction to facilitate adult learning in much the same way as the human counterpart.

In offering your judgements in the second round you were asked to consider two questions. First, does the statement describe or imply some advantageous impact on the adult learner? And second, what is the possibility that the technologies described in the statement will be combined in the next five years to produce this impact on adult learners. The researcher has now ranked the second round judgements and collated the supporting comments.

Two forms are enclosed for this round of the Delphi: a Response Form (page 1), and a Comments Form (page 16).

What You Are Asked To Do:

The third round of this Delphi will ask you to offer a judgement for each item on the Response Form, beginning on page 1. This third round judgement should be based on:

1. the original two questions:
    a. Does the statement describe or imply some advantageous impact on the adult learner?
    b. What is the possibility that the technologies described in the statement will be combined in the next five years to produce this impact on adult learners?
2. your original judgement and reasons
3. the group judgement value
4. the supporting comments offered by your fellow experts.

A "KEY" to the response scale is provided at the beginning of the Response Form. You may wish to note your third round judgement on the Comments Form or if you still have your round two judgements, along side of those.

Please return only the completed Response Form to me. If possible, before the Christmas Holidays. If not by 1/13/92.

COMBINING EXPERT SYSTEMS AND OPTICAL DISC STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED ADULT LEARNING

RESPONSE FORM

The first 60 items on this response form have been ranked, based on participant's second round judgements, beginning with those that were felt to be of greatest advantage to the learner and capable of being achieved technologically. The ranking continues through those items felt to be an advantage to the learner, but impossible to achieve technologically. As a group, none of the items were deemed of no advantage to the adult learner.

For this third round, with the **Response Form** and **Comments Form** side-by-side;

1. Review all of the General Comments on page 16 of the Comments Form.

For each item on this Response Form please proceed as follows:

2. Review the item and its group judgement value on the Response Form.
3. Review the corresponding supporting comments on the Comments Form, beginning on page 17. (Item 39 on the Response Form corresponds to item 39 on the Comments Form.)
4. Consider the two original questions:
   a. Does the statement describe or imply some advantageous impact on the adult learner?
   b. What is the possibility that the technologies described in the statement will be combined in the next five years to produce this impact on adult learners?
5. If you kept a record of how you judged the item in the second round compare it to the group value.
6. On the Response form, offer a judgement for this round of the Delphi in the Judgement column using the KEY below to indicate the alternative closest to your third round judgement. Write any additional supporting comments on the lines below the item.

KEY:

6 Advantage for adult learners, Will be achieved technologically.
5 Advantage for adult learners, Possible to achieve technologically.
4 Advantage for adult learners, Impossible to achieve technologically.
3 No advantage for adult learners, Will be achieved technologically.
2 No advantage for adult learners, Possible to achieve technologically.
1 No advantage for adult learners, Impossible to achieve technologically.

EXAMPLE:

The first item on the next page is an example. After following steps 2 - 6 above I decide that my second round judgement of 3 was correct. Reviewing the comments reinforced my belief that Expert Systems are not necessary to teach basic skills. However, I do believe that we will be able to combine these technologies within the next 5 years to do this, if we see an advantage at a later date.

Judgement	Group Judge.	Item	Statement
Example: 6 5 4 3 2 1	4.76	19.	An Expert System combined with any of the optical data storage technologies could better instruct adults in basic education concepts and skills (i.e. reading, writhing, math) by providing more learning devices for the adults. Expert systems are not necessary to teach basic skills.
6 5 4 3 2 1	5.79	39.	An Expert System combined with CD-ROM could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.
6 5 4 3 2 1	5.76	41.	An Expert System combined with any of the optical data storage technologies could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.
6 5 4 3 2 1	5.73	40.	An Expert System combined with interactive video could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.

6 5 4 3 2 1	5.70	32.	An Expert System combined with CD-ROM could produce a limited expert system embedded in the CD-ROM based material to provide help in specific areas of performing a job. For example, a CD-ROM database on appliance repair might include an Expert System to troubleshoot and diagnose problems as well as diagrams and text on the appliances.
6 5 4 3 2 1	5.63	27.	A portable computer with an Expert System and an optical data storage system would allow learning, review of previously learned material, or consultation with the knowledge base to take place anywhere.
6 5 4 3 2 1	5.61	35.	A portable computer with an Expert System and an optical data storage system could provide for on-site, on-demand training and technical expertise and assistance.
6 5 4 3 2 1	5.52	30.	An Expert System combined with any of the optical data storage technologies could create a Performance Support System at the job site. This type of system would benefit the learner by providing access to information when it is needed or convenient. The Performance Support System could review and reinforce previous training, offer new training that would transfer directly to the job, or act as a consultant to solve a problem with the worker at the work site.
6 5 4 3 2 1	5.48	44.	An Expert System combined with any of the optical data storage technologies could provide better "real world" experiences in updating job skills and in cross training for different job skills.

6 5 4 3 2 1	5.45	22.	An Expert System combined with any of the optical data storage technologies and possibly integrated with hypermedia software, could assist or "guide" learners in locating and cross-referencing the information needed from large knowledge bases.
6 5 4 3 2 1	5.44	16.	An Expert System combined with interactive video could provide the adult learner with simulations that better express reality than those we are currently using.
6 5 4 3 2 1	5.39	8.	An Expert System combined with any of the optical data storage technologies could lead to learning that will be more interactive and multi-modal. The student will become actively involved in the learning situation.
6 5 4 3 2 1	5.38	28.	By combining an Expert System on the same medium as any of the optical data storage technologies, the portability of training will be increased. An entire course, stored on the optical medium, could be sent to any remote site with the equipment to use it.
6 5 4 3 2 1	5.37	29.	Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and Expert Systems) offer the potential of/for creating training programs that will make distance education more meaningful, effective, and efficient.

6 5 4 3 2 1	5.36	4.	An Expert System combined with any of the optical data storage technologies could benefit the adult learner by being able to match the instruction to each individual's needs.
6 5 4 3 2 1	5.36	12.	An Expert System combined with any of the optical data storage technologies could benefit the adult learner by providing instruction that is individualized for each learner.
6 5 4 3 2 1	5.36	18.	A CD-ROM or any of the optical data storage technologies could hold a very large knowledge base for the Expert System. The learner could benefit from this combination by having CAI with a greater ability to illustrate the dynamics of a problem and/or more complex problems.
6 5 4 3 2 1	5.34	17.	An Expert System combined with any of the optical data storage technologies could provide the adult learner with simulations that better express reality than those we are currently using.
6 5 4 3 2 1	5.33	11.	An Expert System combined with CD-ROM could benefit the adult learner by providing instruction that is individualized for each learner.

6 5 4 3 2 1	5.33	23.	An Expert System combined with CD-ROM could produce a system that acts as an intelligent evaluator of student's interactions with the system. This type of a system could continually monitor a learner's current knowledge, needs, pace of learning, and learning style and then present the materials necessary to accommodate the learner.
6 5 4 3 2 1	5.30	10.	An Expert System combined with interactive video could benefit the adult learner by providing instruction that is individualized for each learner.
6 5 4 3 2 1	5.30	51.	An Expert System combined with a CD-ROM database could provide regulation of the instructional sequence for those learners needing direction.
6 5 4 3 2 1	5.28	43.	An Expert System combined with digital data, audio and video on optical data storage could allow for relatively easy modifications to not only the text but also the audio and video portions of the instruction, ensuring up to date instructional materials for the learners. This would be especially attractive to companies if the digital material were at a central site, networked to remote learning stations. Modifications to the instruction could then be accomplished on a single optical disc for the entire network.
6 5 4 3 2 1	5.27	24.	An Expert System combined with any of the optical data storage technologies could produce a system that acts as an intelligent evaluator of student's interactions with the system. This type of a system could continually monitor a learner's current knowledge, needs, pace of learning, and learning style and then present the materials necessary to accommodate the learner.

6 5 4 3 2 1	5.27	38.	An Expert System combined with the higher resolution graphics made possible by optical data storage will better serve the visual adult learner by providing more show than tell in the instruction. __________ __________ __________
6 5 4 3 2 1	5.27	52.	An Expert System combined with a CD-ROM database could collect information about the learner's interaction with the coursework and store it (on a hard disk) for the instructor to review as a guide for future modifications to the course. __________ __________ __________
6 5 4 3 2 1	5.24	5.	An Expert System combined with any of the optical data storage technologies, and possibly integrated with hypermedia software, could guide students through individualized training programs. Selection of the program would be based on the student's skill level, learning style and goals. Students would learn at their own pace using methods which best suit their needs. __________ __________ __________
6 5 4 3 2 1	5.22	1.	An Expert System combined with CD-ROM could benefit the adult learner by being able to match the instruction to each individual's style. __________ __________ __________
6 5 4 3 2 1	5.19	33.	An Expert System could be combined with CD-ROM in an instructional setting where data and text are critical, i.e. administrative assistant, but visual images are not important. A Performance Support System in this setting could have Tremendous advantages in assisting students with data entry, retrieval, and manipulation. __________ __________ __________

6 5 4 3 2 1	5.18	2.	Expert System combined with any of the optical data storage technologies could benefit the adult learner by being able to match the instruction to each individual's learning style.
6 5 4 3 2 1	5.18	31.	An Expert System combined with any of the optical data storage technologies could create a Performance Support System at the job site, reducing classroom training time and transferring it to the work site on a just-in-time basis.
6 5 4 3 2 1	5.18	37.	An Expert System combined with any of the optical data storage technologies capable of using visuals as a graphic user interface will simplify the use of the system for learners.
6 5 4 3 2 1	5.16	9.	An Expert System combined with any of the optical data storage technologies could result in learning that would be more interactive, multi-modal and matched to the student's cognitive style. This implies that the learning could be deeper and more intuitive, improving the student's creative processes. Having improved the individual's creativity should optimize long term productivity, especially in a dynamic environment.
6 5 4 3 2 1	5.15	15.	An Expert System might be combined with interactive video or any of the other optical data storage technologies. Actual hands-on materials might also be available, as in the case of a laboratory. By monitoring the student input, this type of system could promote discovery learning by adapting the presentation and instruction to circumstances and results arising from the student's actions.

6 5 4 3 2 1	5.12	14.	An Expert System combined with any of the optical data storage technologies could enable the learner to ask "what if" questions of the knowledge base. This could benefit the learner by making self-directed learning available, allowing the learner to follow his/her interests in the subject.
6 5 4 3 2 1	5.09	13.	An Expert System combined with CD-ROM could enable the learner to ask "what if" questions of the knowledge base. This could benefit the learner by making self-directed learning available, allowing the learner to follow his/her interests in the subject.
6 5 4 3 2 1	5.09	46.	An Expert System combined with any of the optical data storage technologies could provide a means to do empirical research on adult learning processes, therefore, furthering the field of study.
6 5 4 3 2 1	5.06	6.	An Expert System combined with CD-ROM could maintain a high level of motivation and interest in the learner through its ability to monitor the learner and adjust the use of instructional materials.
6 5 4 3 2 1	5.06	42.	Combining existing analog audio/video (cinema, video, videodisc libraries, interactive videodisc) with a microcomputer containing an Expert System could encourage interactive training, as many organizations already have these pieces of hardware in place. This increase in interactive training could benefit the learner by providing more self-paced, competency-based adult education.

6 5 4 3 2 1	5.03	7.	An Expert System combined with any of the optical data storage technologies could maintain a high level of motivation and interest in the learner through its ability to monitor the learner and adjust the use of instructional materials.
6 5 4 3 2 1	4.94	36.	An Expert System combined with any of the optical data storage technologies and integrated with hypermedia software, could result in decreasing the cost of the training process. (Researcher's extrapolation: The benefit to the learner is that a broader training program might be offered for the same budgeted amount.)
6 5 4 3 2 1	4.90	55.	An Expert System combined with a CD-ROM database (eventually CD-read/write) may gain wide public acceptance. the pace at which the public is accepting large text CD-ROM applications hints at this trend.
6 5 4 3 2 1	4.88	54.	An Expert System combined with a CD-ROM database could result in more experimental data being available to the learner.
6 5 4 3 2 1	4.87	56.	An Expert System to model students within CAI could lead to more flexible and responsive CAI.

6 5 4 3 2 1	4.85	34.	CD-ROM or DVI can be used to provide very large databases of "facts" or real world knowledge that will allow expert systems to have very "deep and broad" intelligence. These Expert Systems could provide "job performance aids" that would minimize the importance or need for students to remember or learn factual details of tools, products, and procedures.
6 5 4 3 2 1	4.85	59.	An Expert System combined with a CD-ROM knowledge base could explain and justify what it is doing so the student could acquire the skills of the Expert System as well as the background information to support those skills.
6 5 4 3 2 1	4.84	48.	An Expert System combined with any of the optical data storage technologies that assist in the development of instruction could make it easier and faster to develop quality educational programs.
6 5 4 3 2 1	4.84	53.	An Expert System combined with a CD-ROM database could result in more attractive learning.
6 5 4 3 2 1	4.82	3.	An Expert System combined with CD-ROM could benefit the adult learner by being able to assist in the translation of a student's optimum learning style into other formats so that the learner can develop other modes of learning as well as the preferred style.

6 5 4 3 2 1	4.81	60.	An Expert System combined with any of the optical data storage technologies could provide consistency in the training.
6 5 4 3 2 1	4.76	19.	An Expert System combined with any of the optical data storage technologies could better instruct adults in basic education concepts and skills (i.e. reading, writhing, math) by providing more learning devices for the adults.
6 5 4 3 2 1	4.73	20.	An Expert System combined with interactive video discs and digital graphics could benefit the adult learner by being able to increase the retention of material learned. This might be done by involving more of the human senses in the learning process and allowing for periodic review of previously learned materials through a Performance Support System at the job site.
6 5 4 3 2 1	4.73	58.	An Expert System combined with any of the optical data storage technologies could assist adult learners in planning their curriculum. It could give the learner more control over what they are to learn.
6 5 4 3 2 1	4.67	26.	Expert Systems could be combined with optical data storage and magneto optical memory technologies. Large knowledge bases could be stored on the optical data storage medium while the magneto optical memory provides the higher amounts of RAM the Expert Systems will need. This will result in CAI that will "know" more than present systems and be capable of growing as information is added and it works with the student.

6 5 4 3 2 1	4.67	21.	An Expert System combined with any of the optical data storage technologies could benefit the adult learner by being able to increase the retention of material learned. This might be done by involving more of the human senses in the learning process and allowing for periodic review of previously learned materials through a Performance Support System at the job site.
6 5 4 3 2 1	4.52	25.	An Expert System (based on a neural network) could be combined with any of the optical data storage technologies. An Expert System based on a neural network framework would have the ability to utilize fuzzy logic. This would provide the system with the capacity to adapt, generalize and learn based on previous information and new information as it becomes available. These systems will prove to be much more adaptive than traditional approaches, providing greater flexibility in the training system and a much longer effective life cycle for both the process and the training itself.
6 5 4 3 2 1	4.44	45.	An Expert System combined with any of the optical data storage technologies will lead to the best minds in the various fields of study being tapped to solve problems and train students. Thus, adults will be challenged by the best thinking in the field.
6 5 4 3 2 1	4.42	57.	The adult learner using an Expert System shell combined with a knowledge base from any of the optical data storage technologies would learn a great deal about the boundaries and extent of that knowledge.

6 5 4 3 2 1	4.22	50.	Adult learning will spend more time confronting the possible rather than the actual because of the large knowledge bases available through optical data storage coupled with the Expert System.
6 5 4 3 2 1	4.20	47.	An Expert System combined with any of the optical data storage technologies could lead to greater self-esteem among participants if feedback on these systems results in changes within the company.
6 5 4 3 2 1	4.10	49.	An Expert System combined with any of the optical data storage technologies where the optical disc storage device will "drive" the Expert System; i.e., contain deep elements of the Expert System called upon by the system's heuristics. As such, the Expert System will be virtually transparent to the learner because its breadth and depth can be so expanded by the disc's storage capacity.

Offer a third round judgement for the last four items base on the KEY below.

KEY:
5 Strongly Agree
4 Agree
3 No Opinion
2 Disagree
1 Strongly Disagree

5 4 3 2 1	3.76	64.	An Expert System combined with any of the optical data storage technologies will have minimal impact on adult learners and training until the optical data storage technology is much cheaper, easier to produce and modify, and the cost/benefit value makes it an attractive training option.

5 4 3 2 1	2.73	62.	An Expert System combined with any of the optical data storage technologies could allow for undermotivated students to bypass reviews or less interesting sections resulting in a decrease in retention of the material. ____________________ ____________________ ____________________
5 4 3 2 1	2.72	63.	An Expert System combined with any of the optical data storage technologies will not have a meaningful impact on adult learning in the next 5 years as these technologies will not effectively be combined for instructional purposes within this time period. ____________________ ____________________ ____________________
5 4 3 2 1	2.21	61.	An Expert System combined with any of the optical data storage technologies will have negligible impact on adult learning. Many aspects of learning, the affective domain as an example, cannot be reduced to a level capable of being programmed into a computer. As such, it is believed that Expert Systems will not be capable of capturing or analyzing the nuances and individual characteristics of learners, their styles of learning or their reaction to mediated instruction. ____________________ ____________________ ____________________

Signature: ________________________
(Voluntary)

What Happens Next:

This has been the third and final round of this Delphi. Please return only this Response Form in the enclosed envelope. The researcher will calculate the numerical judgement for each statement and prepare a final report for distribution to all participants who would like a copy. Please see the enclosed form "Request for Final Report".

Again, thank you for your valuable time and judgements.

APPENDIX O

Request for Final Report

If you have signed your Response Form disregard this request. A copy of the final report will be sent to you automatically. For those wishing to remain anonymous, please print your name below and return with your Response Form (I will separate this request from the Response Form immediately) or return in a separate envelope to:

Tim McLaughlin
674 Wayland
East Lansing, MI 48824

____

(Please Print)

Appendix P

Judgements In Response To Round Three

N = 40

* Number of Participants responding to the Likert scale are beneath each statement

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
39. An Expert System combined with CD-ROM could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.	1=0 2=0 3=1 4=0 5=12 6=27	5.6818	5.5556	5.6250
35. A portable computer with an Expert System and an optical data storage system could provide for on-site, on-demand training and technical expertise and assistance.	1=0 2=1 3=0 4=1 5=10 6=28	5.5909	5.6111	5.6000
41. An Expert System combined with any of the optical data storage technologies could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.	1=0 2=0 3=1 4=1 5=11 6=27	5.6364	5.5556	5.6000
28. By combining an Expert System on the same medium as any of the optical data storage technologies, the portability of training will be increased. An entire course, stored on the optical medium, could be sent to any remote site with the equipment to use it.	1=0 2=1 3=1 4=0 5=9 6=28	5.7273	5.4118	5.5897
22. An Expert System combined with any of the optical data storage technologies and possibly integrated with hypermedia software, could assist or "guide" learners in locating and cross-referencing the information needed from large knowledge bases.	1=0 2=0 3=1 4=1 5=12 6=26	5.5000	5.6667	5.5750
32. An Expert System combined with CD-ROM could produce a limited expert system embedded in the CD-ROM based material to provide help in specific areas of performing a job. For example, a CD-ROM database on appliance repair might include an Expert System to troubleshoot and diagnose problems as well as diagrams and text on the appliances.	1=0 2=1 3=2 4=0 5=7 6=30	5.5455	5.6111	5.5750

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
40. An Expert System combined with interactive video could provide learning experiences containing not only text descriptions but audio and video as well. The benefit to the learner as a result of combining these technologies would be the ability to involve more of the human senses in the learning process and to better match the instruction to the student's learning style.	1=0 2=0 3=1 4=1 5=12 6=26	5.5909	5.5556	5.5750
30. An Expert System combined with any of the optical data storage technologies could create a Performance Support System at the job site. This type of system would benefit the learner by providing access to information when it is needed or convenient. The Performance Support System could review and reinforce previous training, offer new training that would transfer directly to the job, or act as a consultant to solve a problem with the worker at the work site.	1=1 2=0 3=0 4=2 5=10 6=27	5.2727	5.8333	5.5250
12. An Expert System combined with any of the optical data storage technologies could benefit the adult learner by providing instruction that is individualized for each learner.	1=0 2=0 3=0 4=2 5=15 6=23	5.5000	5.5556	5.5250
10. An Expert System combined with interactive video could benefit the adult learner by providing instruction that is individualized for each learner.	1=0 2=0 3=0 4=2 5=16 6=22	5.4545	5.5556	5.5000
31. An Expert System combined with any of the optical data storage technologies could create a Performance Support System at the job site, reducing classroom training time and transferring it to the work site on a just-in-time basis.	1=0 2=0 3=2 4=0 5=16 6=22	5.4091	5.5000	5.4500
27. A portable computer with an Expert System and an optical data storage system would allow learning, review of previously learned material, or consultation with the knowledge base to take place anywhere.	1=0 2=2 3=1 4=1 5=9 6=27	5.5455	5.3333	5.4500
51. An Expert System combined with a CD-ROM database could provide regulation of the instructional sequence for those learners needing direction.	1=0 2=0 3=2 4=0 5=16 6=21	5.4545	5.4118	5.4359

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
37. An Expert System combined with any of the optical data storage technologies capable of using visuals as a graphic user interface will simplify the use of the system for learners.	1=0 2=0 3=2 4=2 5=14 6=22	5.3636	5.4444	5.4000
52. An Expert System combined with a CD-ROM database could collect information about the learner's interaction with the coursework and store it (on a hard disk) for the instructor to review as a guide for future modifications to the course.	1=0 2=1 3=3 4=0 5=11 6=25	5.5909	5.1667	5.4000
44. An Expert System combined with any of the optical data storage technologies could provide better "real world" experiences in updating job skills and in cross training for different job skills.	1=0 2=2 3=1 4=1 5=11 6=25	5.4545	5.3333	5.4000
17. An Expert System combined with any of the optical data storage technologies could provide the adult learner with simulations that better express reality than those we are currently using.	1=0 2=0 3=2 4=1 5=15 6=20	5.6000	5.1667	5.3947
4. An Expert System combined with any of the optical data storage technologies could benefit the adult learner by being able to match the instruction to each individual's needs.	1=1 2=0 3=0 4=4 5=12 6=23	5.2727	5.5000	5.3750
11. An Expert System combined with CD-ROM could benefit the adult learner by providing instruction that is individualized for each learner.	1=0 2=1 3=1 4=3 5=13 6=22	5.4091	5.2778	5.3500
16. An Expert System combined with interactive video could provide the adult learner with simulations that better express reality than those we are currently using.	1=1 2=0 3=3 4=0 5=12 6=23	5.5714	5.0556	5.3333
8. An Expert System combined with any of the optical data storage technologies could lead to learning that will be more interactive and multi-modal. The student will become actively involved in the learning situation.	1=0 2=1 3=4 4=1 5=9 6=25	5.4545	5.1667	5.3250

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
1. An Expert System combined with CD-ROM could benefit the adult learner by being able to match the instruction to each individual's style.	1=1 2=0 3=1 4=5 5=10 6=23	5.3182	5.2778	5.3000
43. An Expert System combined with digital data, audio and video on optical data storage could allow for relatively easy modifications to not only the text but also the audio and video portions of the instruction, ensuring up to date instructional materials for the learners. This would be especially attractive to companies if the digital material were at a central site, networked to remote learning stations. Modifications to the instruction could then be accomplished on a single optical disc for the entire network.	1=1 2=1 3=0 4=2 5=15 6=20	5.1429	5.4444	5.2821
5. An Expert System combined with any of the optical data storage technologies, and possibly integrated with hypermedia software, could guide students through individualized training programs. Selection of the program would be based on the student's skill level, learning style and goals. Students would learn at their own pace using methods which best suit their needs.	1=1 2=1 3=2 4=1 5=13 6=22	5.2273	5.2778	5.2500
6. An Expert System combined with CD-ROM could maintain a high level of motivation and interest in the learner through its ability to monitor the learner and adjust the use of instructional materials.	1=0 2=1 3=2 4=3 5=17 6=17	5.0909	5.2778	5.1750
7. An Expert System combined with any of the optical data storage technologies could maintain a high level of motivation and interest in the learner through its ability to monitor the learner and adjust the use of instructional materials.	1=0 2=0 3=3 4=2 5=20 6=15	5.2727	5.0556	5.1750
29. Intelligent hypermedia-based systems (including the integration of hypermedia software, optical disc storage technologies, and Expert Systems) offer the potential of/for creating training programs that will make distance education more meaningful, effective, and efficient.	1=1 2=1 3=2 4=0 5=16 6=17	5.0455	5.3333	5.1622
2. Expert System combined with any of the optical data storage technologies could benefit the adult learner by being able to match the instruction to each individual's learning style.	1=1 2=0 3=1 4=5 5=15 6=17	5.2381	5.0556	5.1538

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
23. An Expert System combined with CD-ROM could produce a system that acts as an intelligent evaluator of student's interactions with the system. This type of a system could continually monitor a learner's current knowledge, needs, pace of learning, and learning style and then present the materials necessary to accommodate the learner.	1=2 2=0 3=1 4=6 5=10 6=21	5.0000	5.2778	5.1250
38. An Expert System combined with the higher resolution graphics made possible by optical data storage will better serve the visual adult learner by providing more show than tell in the instruction.	1=0 2=2 3=5 4=1 5=10 6=22	5.2727	4.9444	5.1250
42. Combining existing analog audio/video (cinema, video, videodisc libraries, interactive videodisc) with a microcomputer containing an Expert System could encourage interactive training, as many organizations already have these pieces of hardware in place. This increase in interactive training could benefit the learner by providing more self-paced, competency-based adult education.	1=1 2=1 3=2 4=2 5=16 6=17	5.2727	4.8824	5.1026
14. An Expert System combined with any of the optical data storage technologies could enable the learner to ask "what if" questions of the knowledge base. This could benefit the learner by making self-directed learning available, allowing the learner to follow his/her interests in the subject.	1=1 2=1 3=1 4=6 5=12 6=19	5.1364	5.0556	5.1000
33. An Expert System could be combined with CD-ROM in an instructional setting where data and text are critical, i.e. administrative assistant, but visual images are not important. A Performance Support System in this setting could have Tremendous advantages in assisting students with data entry, retrieval, and manipulation.	1=0 2=0 3=6 4=2 5=14 6=17	5.2381	4.8889	5.0769
13. An Expert System combined with CD-ROM could enable the learner to ask "what if" questions of the knowledge base. This could benefit the learner by making self-directed learning available, allowing the learner to follow his/her interests in the subject.	1=1 2=1 3=2 4=4 5=14 6=18	5.1818	4.9444	5.0750
53. An Expert System combined with a CD-ROM database could result in more attractive learning.	1=1 2=2 3=3 4=1 5=14 6=17	5.3000	4.6667	5.0000

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
24. An Expert System combined with any of the optical data storage technologies could produce a system that acts as an intelligent evaluator of student's interactions with the system. This type of a system could continually monitor a learner's current knowledge, needs, pace of learning, and learning style and then present the materials necessary to accommodate the learner.	1=2 2=0 3=2 4=5 5=15 6=16	5.0455	4.8889	4.9750
15. An Expert System might be combined with interactive video or any of the other optical data storage technologies. Actual hands-on materials might also be available, as in the case of a laboratory. By monitoring the student input, this type of system could promote discovery learning by adapting the presentation and instruction to circumstances and results arising from the student's actions.	1=2 2=0 3=1 4=6 5=16 6=15	5.0000	4.9444	4.9750
34. CD-ROM or DVI can be used to provide very large databases of "facts" or real world knowledge that will allow expert systems to have very "deep and broad" intelligence. These Expert Systems could provide "job performance aids" that would minimize the importance or need for students to remember or learn factual details of tools, products, and procedures.	1=1 2=1 3=3 4=4 5=14 6=16	4.6868	5.3529	4.9744
60. An Expert System combined with any of the optical data storage technologies could provide consistency in the training.	1=1 2=2 3=3 4=2 5=13 6=17	5.4286	4.4118	4.9737
59. An Expert System combined with a CD-ROM knowledge base could explain and justify what it is doing so the student could acquire the skills of the Expert System as well as the background information to support those skills.	1=0 2=0 3=6 4=4 5=16 6=14	4.9091	5.0000	4.9500
58. An Expert System combined with any of the optical data storage technologies could assist adult learners in planning their curriculum. It could give the learner more control over what they are to learn.	1=0 2=2 3=4 4=2 5=15 6=14	4.7619	5.1875	4.9459
18. A CD-ROM or any of the optical data storage technologies could hold a very large knowledge base for the Expert System. The learner could benefit from this combination by having CAI with a greater ability to illustrate the dynamics of a problem and/or more complex problems.	1=2 2=3 3=1 4=0 5=13 6=17	4.9000	5.0000	4.9444

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
46. An Expert System combined with any of the optical data storage technologies could provide a means to do empirical research on adult learning processes, therefore, furthering the field of study.	1=1 2=2 3=4 4=2 5=14 6=17	4.9545	4.8889	4.9250
56. An Expert System to model students within CAI could lead to more flexible and responsive CAI.	1=0 2=3 3=2 4=4 5=16 6=13	5.0000	4.7647	4.8947
9. An Expert System combined with any of the optical data storage technologies could result in learning that would be more interactive, multi-modal and matched to the student's cognitive style. This implies that the learning could be deeper and more intuitive, improving the student's creative processes. Having improved the individual's creativity should optimize long term productivity, especially in a dynamic environment.	1=1 2=0 3=6 4=6 5=13 6=14	4.9545	4.6111	4.8000
20. An Expert System combined with interactive video discs and digital graphics could benefit the adult learner by being able to increase the retention of material learned. This might be done by involving more of the human senses in the learning process and allowing for periodic review of previously learned materials through a Performance Support System at the job site.	1=1 2=2 3=4 4=3 5=16 6=13	4.7619	4.8333	4.7949
54. An Expert System combined with a CD-ROM database could result in more experimental data being available to the learner.	1=1 2=2 3=6 4=2 5=16 6=13	4.6818	4.7778	4.7250
21. An Expert System combined with any of the optical data storage technologies could benefit the adult learner by being able to increase the retention of material learned. This might be done by involving more of the human senses in the learning process and allowing for periodic review of previously learned materials through a Performance Support System at the job site.	1=1 2=2 3=5 4=4 5=14 6=13	4.6190	4.8333	4.7179
36. An Expert System combined with any of the optical data storage technologies and integrated with hypermedia software, could result in decreasing the cost of the training process. (Researcher's extrapolation: The benefit to the learner is that a broader training program might be offered for the same budgeted amount.)	1=4 2=1 3=0 4=5 5=17 6=12	4.9091	4.4118	4.6923

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
19. An Expert System combined with any of the optical data storage technologies could better instruct adults in basic education concepts and skills (i.e. reading, writhing, math) by providing more learning devices for the adults.	1=1 2=3 3=6 4=2 5=12 6=14	4.8000	4.5000	4.6579
55. An Expert System combined with a CD-ROM database (eventually CD-read/write) may gain wide public acceptance. The pace at which the public is accepting large text CD-ROM applications hints at this trend.	1=2 2=5 3=1 4=1 5=15 6=13	4.8500	4.4118	4.6486
48. An Expert System combined with any of the optical data storage technologies that assist in the development of instruction could make it easier and faster to develop quality educational programs.	1=1 2=3 3=3 4=5 5=17 6=9	4.5500	4.6667	4.6053
50. Adult learning will spend more time confronting the possible rather than the actual because of the large knowledge bases available through optical data storage coupled with the Expert System.	1=3 2=2 3=3 4=4 5=18 6=7	4.5778	4.2778	4.4324
3. An Expert System combined with CD-ROM could benefit the adult learner by being able to assist in the translation of a student's optimum learning style into other formats so that the learner can develop other modes of learning as well as the preferred style.	1=2 2=2 3=6 4=6 5=14 6=9	4.5714	4.2222	4.4103
45. An Expert System combined with any of the optical data storage technologies will lead to the best minds in the various fields of study being tapped to solve problems and train students. Thus, adults will be challenged by the best thinking in the field.	1=2 2=2 3=5 4=8 5=14 6=8	4.4286	4.3333	4.3846
57. The adult learner using an Expert System shell combined with a knowledge base from any of the optical data storage technologies would learn a great deal about the boundaries and extent of that knowledge.	1=2 2=7 3=4 4=3 5=13 6=9	4.3333	4.0000	4.1842

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
26. Expert Systems could be combined with optical data storage and magneto optical memory technologies. Large knowledge bases could be stored on the optical data storage medium while the magneto optical memory provides the higher amounts of RAM the Expert Systems will need. This will result in CAI that will "know" more than present systems and be capable of growing as information is added and it works with the student.	1=3 2=4 3=3 4=6 5=17 6=4	4.2000	4.0588	4.1351
25. An Expert System (based on a neural network) could be combined with any of the optical data storage technologies. An Expert System based on a neural network framework would have the ability to utilize fuzzy logic. This would provide the system with the capacity to adapt, generalize and learn based on previous information and new information as it becomes available. These systems will prove to be much more adaptive than traditional approaches, providing greater flexibility in the training system and a much longer effective life cycle for both the process and the training itself.	1=6 2=2 3=2 4=10 5=11 6=7	4.2381	3.7647	4.0263
49. An Expert System combined with any of the optical data storage technologies where the optical disc storage device will "drive" the Expert System; i.e., contain deep elements of the Expert System called upon by the system's heuristics. As such, the Expert System will be virtually transparent to the learner because its breadth and depth can be so expanded by the disc's storage capacity.	1=6 2=1 3=4 4=9 5=13 6=6	4.1905	3.8333	4.0256
47. An Expert System combined with any of the optical data storage technologies could lead to greater self-esteem among participants if feedback on these systems results in changes within the company.	1=4 2=3 3=5 4=4 5=16 6=3	4.1579	3.7500	3.9714
64. An Expert System combined with any of the optical data storage technologies will have minimal impact on adult learners and training until the optical data storage technology is much cheaper, easier to produce and modify, and the cost/benefit value makes it an attractive training option.	1=4 2=5 3=2 4=18 5=11 6=NA	3.8182	3.5000	3.6750

Ranked Statement	Likert Distribution	HRD Mean	DEV Mean	GROUP Mean
63. An Expert System combined with any of the optical data storage technologies will not have a meaningful impact on adult learning in the next 5 years as these technologies will not effectively be combined for instructional purposes within this time period.	1=6 2=10 3=5 4=11 5=7 6=NA	2.9048	3.2778	3.0769
62. An Expert System combined with any of the optical data storage technologies could allow for undermotivated students to bypass reviews or less interesting sections resulting in a decrease in retention of the material.	1=10 2=13 3=2 4=10 5=5 6=NA	2.7727	2.5556	2.6750
61. An Expert System combined with any of the optical data storage technologies will have negligible impact on adult learning. Many aspects of learning, the affective domain as an example, cannot be reduced to a level capable of being programmed into a computer. As such, it is believed that Expert Systems will not be capable of capturing or analyzing the nuances and individual characteristics of learners, their styles of learning or their reaction to mediated instruction.	1=11 2=21 3=1 4=3 5=4 6=NA	2.3636	2.0000	2.2000

APPENDIX Q

COMBINING EXPERT SYSTEMS AND OPTICAL DISC STORAGE TECHNOLOGIES IN COMPUTER-ASSISTED ADULT LEARNING

ROUND THREE COMMENTS TO SUPPORT JUDGEMENTS

The following pages contain the comments that were offered in support of the Round Two judgements. The comments within an item are presented with those that support the item first, followed by comments that refute the item. A forward slash (/) is used to separate each respondent's comments within an item.

Individual Item Comments:

1. Could allow the individual to select the instruction to meet their needs.

3. Usually the learners adapt the material to fit their own learning style./Too expensive. Adapting learning to cognitive style won't happen to any extent for a number of years because we don't know enough and it is too expensive./Tough job to do!/We don't understand learning.

4. If adequate job or task analysis is done to determine needs./Usually the economics of development prevent multiple versions from being produced./I don't think we will ever know how to recognize individual needs./Not enough knowledge on how to do this.

5. Agree that such a combination of technologies would allow this, but the problem lies in techniques of individualization./Doesn't need an expert system. We're already doing this./This suggests an unrealistic development environment with an inexhaustible supply of money./ Large knowledge bases are still a ways off technically./Not enough research here.

6. Depends on instructional design of the information on the CD-ROM for the motivation part, although the expert system would help./Provided it keeps records on the learner some place./Monitoring and adjusting does not have to be complex, you can just ask the learner, periodically, if he/she wants more or less of "X"./What input device can monitor the learner's motivation and interest? Has someone invented the "Psychological Dipstick Device" (PDD)?/Possible but does not require an expert system or CD-ROM.

7. What input device can monitor the learner's motivation and interest? Has someone invented the "Psychological Dipstick Device" (PDD)?/Possible but does not require an expert system or CD-ROM.

8. This is the objective./May become involved, depending on the motivation./Depends on the instructional strategies used./I would point out that the huge costs of development decreases the likelihood that multiple modalities are used./Nothing special about expert system.

9. Would require a lot of design effort./This is possible , but I am highly skeptical that it will happen. There are few places in education where we enhance creativity./This is great stuff! It's got all the right words, but it's total B.S.

10. Of course.

11. Usually the economics of development prevent multiple versions from being produced.

12. If we identify the variables that account for individual differences./Not enough knowledge on how to do this.

13. CD-ROM not needed./This seems like a scenario that could take advantage of the expert system and optical media combination.

14. Yes./An important direction to facilitate the move from a teaching culture to a learning culture./This seems like a scenario that could take advantage of the expert system and optical media combination./Optical storage not needed for this.

15. Yes. An active system following the student's decisions is what customization of learning can be./ Absolutely right./An important direction to facilitate the move from a teaching culture to a learning culture./Discovery learning works better in Japan than in the USA because of the teaching and learning styles inherent in our schools./Neither expert systems nor interactive video necessarily lead to discovery learning.

16. Maybe not reality but closer a representation./Expert system may not express reality better, though it's possible./I'm putting more hope on digital technologies than on analog.

17. Yes./Some are already doing this./Already being done./Don't need expert system./"Better" than those we are currently using, probable not. We can already do more and better with technology than we actually do.

18. Yes! This is very important. This is why we need Gigabytes of data... to simulate the world./The availability of the storage will encourage developers to include more stuff./Large knowledge bases are still a ways off technically./The size of the database is not the real issue for learning, it is the organization of information into concepts./Too much complexity.

19. Might be good for writing, but not for reading or math. This is overkill for basic skills.

20. Other, less glamorous variables, such as time on task ought to be considered./Don't need an expert system./ The involvement of more senses does not, by itself, necessarily improve learning, as Travers and others have found over the past 30 years.

21. Don't need an expert system.

22. Yes!/Why include an expert system?/Think hypermedia is more likely to be useful in this setting than expert system.

23. Yes. In fact there are always two experts systems: one teaching, the other capturing information to know how the student works best. This is a major concept./ Substantial potential, but the teaching culture will inhibit its broad usage./Needs work on the education and learning research side./This is very labor intensive. Many hours to develop. With the U.S. headed for fiscally troubled times, I don't anticipate funding for this type of activity will be available.

24. A tall order.

25. Not in 5 years./Not in 5 years./Not in 5 years./ Possible, but a long way off.

26. We'll both be dead before this happens regularly./ Neither expert systems nor any form of data storage or memory will make this happen.

27. The CD-I discman is a great example of this. CD's with TV screen and logic that fit in the hand and cost $700.00 are available today./Should be gaining some acceptance in some fields where the added cost of the optical drive and a portable is worth it.

28. I don't believe that this is a major issue, but should certainly be provided as an option.

29. Great potential here./Implementation difficult/For this to aid in distance education in 5 years, the equipment would have to be more widely available then I predict it will be./ Networking is a key here. IAV will eventually phase out in favor of digital media./ Hyper media and distance learning are buzz words that are not well defined. TV distance learning is not very effective, an interactive medium may be more effective, depending on the quality of the courseware.

30. Yes./Already achieved./It's there./The performance support system will also enable the worker to send comments back to the engineer./Doubtful/There's a limit to the learning impact of higher and higher resolution. A picture is worth a 1000 words; a picture with twice as much resolution is not necessarily worth 2000 words.

31. Yes!/Definitely agree.

32. Already done, why are you asking?/This is done all the time./Current application./Current applications are quite limited. Attractive to business so quite likely to happen in varying forms./Sure, but how are you going to get people to use it and keep it up-to-date?

33. Yes!/This is fairly straight forward given current technology.

34. Einstein said he never memorized anything he could look up./In one sense, this is a trivial application. In another sense, it can be very impactful as a "memory expander"./What happens to problem solving and reasoning abilities in the students?

35. Assistance is very important.

36. Traditionally, technology becomes cheaper and better rapidly./Of greater and greater benefit as we move from teaching to learning environments./Depends on the number of trainers, shelf-life of the materials, need to travel, and other factors that vary widely from job to job./The cost won't be coming down for at least 10 years./Not going to decrease cost./It will take a while for the decreases to show given the cost of the equipment and curriculum development.

37. Yes./Only for some learners./Optical system is not required for this, a computer based visual interface would serve just as well./Don't think either an expert system or optical media necessarily result in easy to use interface.

38. Very useful , if not critical, to certain applications like medical and technical training./Since a storyboard teaches as well as a finished medium, better illustrations do not equate with better learning./Expert system is irrelevant to this setting.

39. Provides a greater variety of learning alternatives which might match learning styles./Available now. CD-ROM is necessary as any storage media would work as well or better./Will be achieved if an expert system is a necessary adjunct./What about touch, smell and taste?

40. If we had a "smart expert system" it could alter itself to suit learning styles./Available now. However, expert systems aren't particularly effective because it is difficult to develop good knowledge data bases even for well defined processes, and learning style is not a well defined process.

41. Available now. Learning styles are not well understood. The same person has different learning styles for different topics or skills.

42. Currently being done, but usually not with good results because the various parts don't work well together, not all are interactive./The existing libraries are difficult to use for instruction. Repurposing is more illusory than we are led to believe./Better at this level to start fresh./Far too much hassle trying to retrofit. Adding an expert system to existing materials doesn't really help, you need an integrated system from the very beginning./ This is an inefficient and often ineffective approach./In general, new hardware and software is needed to do this.

43. One of the few good ideas that is not blatantly obvious./We computer people should be able to figure out the networking of video once it is digital./Video is not easily modified./Graphics via networks are slow for the foreseeable future./Modification would not require an optical disc at all. Single copy optical is too expensive.

44. Current application./Selected jobs only, "real world" is questionable for most jobs.

45. Yes. This is very important./This would be fun, too./Good in theory, difficult in practice./Bull/No more so than with others.

46. A number of examples of such applications exist now./ Good use for combining these two technologies.

47. Any feedback that is positive will help self-esteem./ This seems a bit far fetched.

48. Only in certain type of educational programs./Only in the long run./This has been the dream for many years, but there is more to development than that./Despite work in automated instructional development, doesn't seem that this is very likely in the near future.

49. Get real!

50. Only during the training program./Will require changing the traditional instructor led session. We won't see this in 5 years./Totally disagree. Adult learners are looking for real solutions not possible solutions.

51. Could be done but not a good idea in most cases.

52. Yes, Yes, Yes./Everyone pays lip service to this, but no one does it./Doesn't need an expert system. We're already doing this./Doubt that we know enough about learning for this to be of value./Don't need an expert system or CD-ROM to do this.

53. Possible.

54. Yes, within specialized networks./Possible, but online databases are more likely to achieve this./Such data will be of limited use./For a few defined jobs.

55. 10 years minimum./Don't think this is likely in near future and don't think it helps training that much.

56. If used appropriately, this could lead away from instruction controlled by the instructor or computer to learning by the learner./Anything more than a superficial model of the student will require gains in cognitive science.

57. Yes, this does happen./An important application./The human mind establishes this with any media or collection./Depends on the learner./The few who build the systems are the ones who are most likely to learn this.

58. Good idea./Possible.

59. This can happen./Limited to rather well defined skills, very difficult to develop knowledge data bases for less well defined skills./Will not be widespread in 5 years./Learn to "reason" like a computer software package, great!

60. Yes, provided "consistency" means consistency of high quality./It's a given./Providing a minimum level of facts or information might be good./Certainly possible, but depends more on training management./ Consistency is not the goal of an expert system. The purpose is to adapt. You can have consistency without and expert system./Point of an expert system is adjustment and variety, not consistency.

61. We don't understand learning styles so it is rather difficult to develop an expert system that does./It can begin to get closer, it does not have to be perfect to do a better job. Humans are good examples./It can be done. We have build such a system for the control of landing the space shuttle and it works./This is nonsense. It is our tools, now our intelligent tools, that help us become increasingly human, if we but use them to that end.

62. Not if it was an "expert" and had some "smarts"./A good system will not allow bypassing./Expert system would not allow this./System shouldn't allow this if it's designed properly./Not much expertise in a system that allows this./No more so than an undermotivated student fails to retain other material./Improper use of an expert system.

63. Probably will not have a meaningful impact because they are not required. Courseware design and quality are much more important./Change is slow, unless there is a critical issue where a powerful constituency can push it along./It will take a new generation of trainers and developers who know how to uses this technology, maybe 10-20 years./ Any progress would be meaningful./Not in education, but in business training./Not totally, but parts may be implemented./ Except in specialized settings./Very few students will learn from such systems within 5 years.

64. This is destined to happen. The savings over stand-up instructors is immense./Optical storage has no direct effect on learning, its only value is storage and low cost may mean it will be used if its performance is improved. An expert systems may have an effect, but not by itself. The major technology that effects learning is instructional technology, and it must be applied to develop courseware that is effective./Cost of the optical data storage is not the problem, the

utility of the expert system is the limiting factor./Cost of the technology is not the issue, it's the know-how and willingness to use it./And it's accepted in academe./In all but the largest of organizations, costs are limiting./The lack of knowledge about expertise more powerfully limits the field.

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