THE EFFECTS OF OPTIMIZATION ON COGNITIVE SKILL ACQUISITION FROM INTELLIGENT DECISION AIDS

By

GEORGIA ANN SMEDLEY

Bachelor of Arts
Mesa State College
Grand Junction, Colorado
1976

Master of Science Accounting
University of Arkansas
Fayetteville, Arkansas
1992

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Thesis Adviser

Dean of the Graduate College

PREFACE

This study examined how cognitive skills could be acquired through the use of intelligent decision aids (IDA). Guided by Anderson's 1993 Adaptive Character of Thought – Rational (ACT-R) theory, IDAs were designed to provide subjects with differing sets of prompts thought to effectively increase learning. Subjects were faced with the task of assessing the adequacy of internal controls in a payroll environment. Prompts provided to subjects in a laboratory experiment included explanations of the level and characteristics of individual internal controls, questions asking subjects to consider similarities among internal controls, and instructions to change a given control and consider the effect of that change on overall control adequacy. Pretest and posttest measures were taken of the 155 subjects who completed the experiment, these measures served as the basis for analysis. Initial analysis showed a failure of these prompts to illicit theorized outcomes. However, post hoc analysis of subjects who demonstrated an intention to learn yielded findings that provide support for inclusion of some of these prompts in IDA development. While the prompts that asked subjects to consider similarities were not effective, both explanations and instructions to consider the effects of changes were shown to be successful in aiding subjects to make improved decisions about the adequacy of internal controls.

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CHAPTER I

THE RESEARCH PROBLEM

Introduction

This research study focuses on the use of intelligent decision aids (IDA) as agents in knowledge transfer. IDAs are generally rule-based decision aids that are deemed helpful in situations where (1) the decision-task domain is well-defined, (2) qualitative as opposed to quantitative reasoning is employed, and (3) the task is semi-structured. Because the practice of accounting is also often rule-based, well-defined, and somewhat structured, accounting tasks are often useful for studying IDAs. In fact, 16% of the IDAs developed for business are accounting applications (Tyran and George, 1993). Such IDAs include: Purpool, an IDA that assists in business combination decisions; Lessee, an aid to lease treatments; Cashvalue and Financial Advisor, capitol project planning aids; and Taxman, ExperTAX, and Taxadvisor, tax planning and compilation tools (Chandra and Palvia, 1993).

In addition to being a decision-making tool, an IDA also holds the potential to be an on-the-job tutor, one that allows a user to learn the decision-making tactics of the IDA. An IDA's knowledge base is generally comprised of a series of IF - THEN rules through which the system's inference engine searches to arrive at a decision. IDAs can be developed in such a way that the user may receive from the system not only the system's conclusions but also the rules followed to arrive at those conclusions. Moreover, IDAs can be developed to provide the user with explanations of the rules employed by the system and many other types of feedback. Because IDAs can be designed to have the capacity to divulge rules and logical inferences, and because IDAs may be written to provide such feedback as explanations, thought-provoking queries, and a number of interactive routines, IDAs are often considered to be valuable training devices (Awad, 1998).

Given that industry demands for IDAs exist, and given that there are claims that IDAs can be constructed in such a way that they can serve as tutors as well as support the decision process, the question of how these aids can be best constructed to assist in the learning process arises. The current study addresses this question.

This chapter is organized in the following manner. A section summarizing a prevalent knowledge acquisition theory (i.e. Anderson's 1993 Adaptive Character of Thought (ACT)), which is applied in this study is presented first followed by a section which reviews applications of this theory in the IDA literature. Next, this chapter will present the research questions to be examined here and the importance of these questions in light of the theory and prior research. Finally, this chapter will present a section that outlines the organization of the remainder of this study.

Adaptive Character of Thought

ACT (Anderson, 1993) is the most frequently referenced cognitive theory in the

IDA literature. This theory states that there are two major phases through which a learner must pass in order to develop strong cognitive skills. These phases are (1) an accumulation of "chunks" of retrievable facts within the declarative memory and (2) a system of fine-tuned production rules within the procedural memory.

All facts about a new learning situation are stored in declarative memory. To streamline the retrieval process, the human brain groups a few related facts together as chunks. While all facts are stored in declarative memory, not all of these facts are retrievable; instead, learners are only able to remember chunks that have a sufficient amount of strength attached to them, chunks that are salient, and/or chunks that are closely associated with other chunks that the learner can recall. The learner's first task, therefore, is to increase the probability of recall of a chunk in declarative memory that pertains to a new learning situation. One way of doing this is to increase the relative strength of a salient chunk.

The strength of a chunk in declarative memory is a function of the number of times that chunk has been retrieved. The more frequent the retrieval, the stronger the chunk. One method of increasing the strength of a memory chunk is to provide the learner with elaborations or explanations about the facts that comprise a chunk of memory. These explanations cause the learner to review (and hence recall) the fact. Another advantage of these explanations is that they may be stored in the same memory chunk as the initial fact or in a new and associated memory chunk. Therefore, explanations can increase a chunk's retrieval frequency and explanations can increase a chunk's level of association.

Anderson (1993) claims that the demonstration of the ability to perform any task that requires thought is dependent upon the development of a set of production rules. Production rules are defined to be condition - action pairs that are built from declarative facts. A set of production rules will provide a chain that leads the learner from an initial question to an eventual conclusion.

Anderson (1993) further claims that this set of productions rules must be fine tuned or optimized before true learning may be said to have taken place. There are, therefore, four techniques a learner employs to optimize production rules. Two techniques, modularity and asymmetry, relate to characteristics of the rules themselves. Modularity implies that rules may be added or subtracted from the set itself. Asymmetry implies that rules are followed in a condition - action sequence rather than an action - condition sequence.

The other two optimization techniques, abstraction and goal structuring, require effort on the part of the learner. Often similarities exist among the condition sides of several production rules. Anderson (1993) states that the learner will form a more efficient set of production rules when he/she first recognizes these similarities and then reformats several rules into one rule based upon these similarities. This is a process of generalization referred to as abstraction. A danger exists to the learner, however. Not all rules with similar conditions require the same actions, and the learner must be able to differentiate among competing action requirements. The process of recognizing different needed actions when conditions are similar is called goal structuring. There is a give-and-take relationship between abstraction and goal structuring. Abstraction seeks to limit the number of rules that may be considered while goal structuring provides an ample richness of choice among rules so all necessary goal states may be derived. The next section examines how this theory has been tested in the IDA literature.

ACT and the IDA Literature

A number of studies have examined the effects of explanations supplied by an IDA on learning. These studies have yielded varied results. Pei and Reneau (1990) found that explanations positively affect recall only when the mental model of a user matched the IDA's mode of presentation. Similarly, Pei et al. (1994) showed a positive effect for matched-modality explanations on recall. Mascha (2001) found that explanations helped IDA users make better decisions.

In contrast, Murphy (1990) and Steinbart and Accola (1994) found no benefits for explanations on either recall or problem solving. Eining (1988) and Eining and Dorr (1991) found that while IDA users outperformed non-IDA users on measures of problem-solving speed and accuracy, explanations did not help improve this performance. Odom and Dorr (1995) found that as the richness of elaborations increased, recall ability actually decreased and problem-solving ability was unaffected.

ACT suggests that explanations offer the learner an opportunity to strengthen declarative memory chunks, thus facilitating recall of facts. This is important for two reasons. First, a fact that cannot be recalled is useless and declarative-stage learning is hindered. Second, procedural-stage production rules are constructed with declarative-stage facts. A fact that cannot be retrieved is also a fact that cannot be used in the rule-building process. A clearer understanding of the utility of explanations is necessary.

A number of studies examined factors other than, or in addition to, explanations that were believed to affect learning through the use of an IDA. For example, Pei et al. (1994) also considered the effects of prompting on recall and problem solving. Prompts requiring thought about the truth of a fact, the rational of a step, or the effect of an alternative positively affected both recall and problem-solving ability. While not explicitly stated, a prompt requiring consideration of an alternative could have been a test of goal structuring. Unfortunately, whether one or all of the prompt types led to learning was not known, therefore, nothing is discernable about the effects of manipulating goal structuring alone.

Hornik and Ruf (1997) employed a technique causing IDA users to reflect on the similarities between a current problem and previously solved problems. This led to increased learning. While this manipulation seems to be one designed to increase abstraction among IDA users, whether improvement was due to abstraction or learning by analogy is not clear.

Purpose of the Study

This brief review of the literature suggests that learning may indeed occur through IDA usage, but questions about the causes and extent of this learning remain. One question concerns the effects of explanations on recall. Because some of these studies support Anderson's (1993) theory that explanations can increase chunk strength and others fail to provide support, the effects of explanations on recall need to be examined more thoroughly.

Another question concerns the effects of abstraction and goal structuring on cognitive skill acquisition via IDA usage. Neither of these optimizing techniques have been explicitly tested in an IDA context. While Anderson (1993) suggests that these techniques are an important part of learning, whether these techniques are inherent to the learner or if they may be externally stimulated is not known. Further, whether an IDA can effectively provide this stimulation to the learner is not known.

Answers to these questions have important implications for novice users of IDAs. Decision aids can serve as a natural storehouse of expertise and, they may also have the potential to help train novices. If novices fail to develop new expertise through their interactions with an IDA, a learning opportunity may be lost. This could be especially critical in knowledge-based professions such as auditing.

Auditors have an ethical responsibility not to subordinate their professional judgment. In an IDA setting, the results derived from the aid must be evaluated and deemed to be in keeping with the accountant's professional judgement (Sutton et al. 1995). This is an impossible task if the user has not developed expertise. Therefore, novice auditors who rely on IDAs must obtain the decision-making expertise embedded in the IDA. The tutorial capacities of IDAs may provide the necessary bridge to expertise for these novices.

Barr and Sharda (1997) found that the typical novice user of a decision aid tends to merely rely on the system's decision rather than question that decision and investigate how the decision was made. More experienced users of decision aids, on the other hand, question the decision and try to determine the basis on which the decision was made. One implication of novice reliance on an IDA is the subordination of professional judgment. The current study offers some insight into the feedback novices require to acquire expertise and overcome decision aid over reliance.

Carlson et al. (1997) suggested that one roadblock to the implementation of IDAs as tutors in business applications is the inability of the system to match user requirements. The current study provides some information that may help IDA developers understand the nature of the requirements a learner needs from the IDA.

Organization of the Paper

This chapter has provided an overview of the theory underlying this study along with a brief examination of the pertinent literature and a statement of the purpose of the study. The next chapter will provide a more detailed literature review. The review of the IDA literature includes a broad examination of decision aid studies from decision quality, reliance, learning, and cognitive load perspectives. Emphasis in this review will be placed on the learning perspective and will include information from both the cognitive sciences and decision aid disciplines.

Chapter three will present an amplification of the Anderson (1993) theory that has been summarized here. This chapter includes the contextual development of the theory, the theory's constructs, and the application of these constructs to decision aids. In addition, the hypotheses to be tested will be formally stated in the third chapter.

The fourth chapter details the research methodology. Examination of the research questions involved a laboratory experiment in which senior-level accounting students were randomly assigned to one of four decision aids. The experimental task involved the assessment of the adequacy of internal controls in a payroll environment. All subjects were provided prompts designed to facilitate recall of the level and characteristics of the internal controls. Further, one half of the subjects received prompts that were designed to stimulate abstraction and one half of the subjects received prompts that were designed to stimulate goal structuring. Declarative- and procedural-stage measures were taken at pretest, subjects used their assigned IDA to assess control adequacy for two experimental sessions, and then posttest measures of declarative- and procedural-stage knowledge were taken. The task, subjects, variables, procedure, and models for analysis are the subjects of chapter four.

Chapter five presents the results of this study. Initial examination of this study's findings demonstrate a failure to find evidence supporting the predicted results. However, post hoc investigation reveals that when subjects are divided between incidental and intentional learners, the intentional learners derived benefits from prompts that stimulated goal structuring. Further, abstraction prompts appeared to be counterproductive.

A sixth chapter concludes the documentation of the study. Chapter six summarizes the findings reported in chapter five, presents the known limitations to this study, and suggests some additional areas for future research.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Cognitive skill acquisition may be defined as gaining "the ability to solve problems in intellectual tasks where success is determined more by subjects' knowledge than their physical prowess" (VanLehn, 1996). Research in cognitive skill acquisition questions how people learn to solve knowledge intensive problems. Such research examines how novices gain expertise. The use of decision aids, especially intelligent decision aids (IDA), as agents of cognitive skill acquisition is one such research area that has been examined. This research has stemmed, in part, from the parallels between theories in knowledge acquisition and decision aid architecture.

Decision aids include "all forms of information systems and technologies designed to assist one or more decision makers in making decisions or choosing a course of action in an episodic situation that requires judgment" (Scott, 1984). Decision aids may be defined as interactive computer-based systems which help decision makers solve structured, semi-structured, or unstructured problems (Turban, 1988).

In their synthesis of decision aids in accounting research, Brown and Eining (1996) provided a framework for understanding the divergent avenues of decision aid research in accounting. These authors extracted four basic types of decision aid characteristics that influence the behavior of decision makers: decision aid features, decision-maker characteristics, decision task features, and the decision environment. Decision aid features include display modes, explanatory capabilities, guidance, and computational abilities. Decision-maker characteristics are the unique characteristics of the decision maker that may influence decision-making behavior. Task features relate to the level of complexity, ambiguity, or relative stability of a task. Features of the decision environment include outside pressures, incentives, and accountability. These characteristics that influence behavior in general should also impact knowledge acquisition from a decision aid – the particular area of interest in this study.

An overview of the pertinent literature concerning skill acquisition through decision aids may be undertaken in one of three ways: by category, characteristics, or theoretical stream (Rose, 2000). Rose (2000) suggested an analysis of the extant literature by the theoretical streams of decision quality, decision aid reliance, and knowledge acquisition. While all three approaches should examine the same literature, the latter approach has been employed here for the same reason sited in Rose (2000), this approach highlights what is known and what is not known about the effects of decision aids on behavior – specifically cognitive skill acquisition.

As a point of clarity for the discussion in this chapter, the types of decision aids are first defined and then categorized to aid in understanding the array of research that has been previously reported. There are basically three types of decision aids: (1) simple or deterministic aids, (2) decision support systems, (3) intelligent decision support systems, and (4) expert systems. Deterministic aids may or may not be computerized. These aids include any tool that provides judgment aid in an algorithmic manner. As such, deterministic aids are best employed in a very structured decision-making environment. A decision support system is "a computer-based system that helps decision makers confront semi-structured problems through direct interaction with data and analysis models" (Burn and Caldwell, 1990). A decision support system is based on limited and specialized knowledge and is best used in situations that are reasonably defined, have a moderate degree of uncertainty, and require only a moderate level of expertise. Both intelligent decision support systems and expert systems provide decision recommendations in semi-structured or unstructured decision environments that are narrowly defined (Ashton and Ashton, 1995). The differences between the two lies in their design. Intelligent decision support systems are model-based (for example, neural networks) while expert systems are analytically based. Together, intelligent decision aids and expert systems may be referred to as intelligent decision aids (Silverman, 1994).

The remainder of this chapter shall examine decision aid studies. These studies will be topically organized by decision quality, decision aid reliance, and knowledge acquisition. Finally, a section that summarizes the extant work in knowledge acquisition through interaction with decision aids will be presented. This section will focus on what is known and what is not known in this area, thus setting up the need and value of the current study.

Decision Aids and Decision Quality

Advantages of using a decision aid include comparability and consistency of decisions among users (see Rose, 2001 for a discussion of the perceived benefits associated with using a decision aid). IDAs embed human expertise; therefore, a properly designed decision aid should provide the user with the decision-making finesse of an expert (Awad, 1996). An implication of this statement is that the use of well-designed decision aids should produce decisions of superior quality. While decisions may be comparable and consistent among decision aid users, evidence suggests that a claim of decision superiority cannot be supported. One explanation is provided by the theory of technology dominance (Arnold and Sutton, 1998). This theory stipulates that when the expertise of the user of a decision aid is inferior to the expertise embedded in that decision aid, decision quality may suffer. Arnold and Sutton (1998) also consider: (1) when a decision maker will decide to rely on a decision aid; (2) when that user's decision might be dominated by the decision aid; and (3) whether this dominance will lead toward a de-skilling of expertise. While this theory has implications for both decision quality and decision aid reliance, empirical evidence concerning this theory is largely of a quality nature. This section presents an examination of studies concerned with the decision quality of users of IDAs and relies on the theory of technology dominance for understanding of the results of these studies.

Butler (1985) conducted a study to determine whether the use of a decision aid could reduce the bias inherent in human decision processing. Bias in this study was the tendency of an individual to fix on one or more aspects of risk to the exclusion of other, often more important but overlooked or forgotten, aspects of risk. The decision aid was shown to be effective in redirecting auditors' attention to more salient risk factors, thus improving their decision quality. The subjects in this study were auditors who had an average of 2.6 years of experience, therefore, the subjects' level of expertise may have matched that of the expertise found in the decision aid.

Timmermans and Vlek (1994) also found support for increased decision quality through decision aid use in a personnel selection task. The personnel selection task involved determining the best candidate for an assistant professor position and a project manager position. Subjects were students who presumably had a lower level of expertise than did the IDA. While these novices outperformed non-decision aid users in tasks of low to moderate complexity, decision aid users in a more complex task made poorer hiring decisions than did the non-decision aid users. An implication of these results is that as the difference in expertise increases between a novice and a decision aid, the quality of the novice's decision will decrease.

Kotterman, Davis, and Remus (1994) found that while decision aid users in a production-planning task decision had greater confidence in their decisions, their decision quality was significantly less than for the control group. Subjects in the Kotterman et al. (1994) study were MBA students from an operations research class rather than working experts. Again evidence indicates that a mismatch exists between the user and the aid and that this mismatch may negatively affect decision aid effectiveness.

While individuals who have their own expertise may employ decision aids, these individuals may not agree with the outcome of the decision aid process. In this case, even if the decision aid produces a superior decision, that decision may be questioned and even ignored in the decision process. Will (1992) conducted a field examination of an expert system with oil and gas engineers. Fourteen engineers made decisions without expert system guidance and 14 used an expert system. The quality of decisions did not differ between the groups, but the expert system group expressed a greater degree of confidence in their decisions. Because there was no decision-quality difference between the two groups of experts, Will (1992) concluded that novices might benefit more from expert system use than would experts, especially since the decision aid users (in spite of their confidence in the decision made) expressed discomfort in the decision process. This conclusion is without empirical support and contradicts the theory of technology dominance.

One aspect of decision aid use is that the aid might perform routine functions and provide the user with more cognitive freedom to consider non-routine implications of a decision task. Todd and Benbasat (1992) examined this issue. Instead of finding an increase in decision quality among decision aid users who could then use additional information, decision aid users were determined to minimize their overall effort.

In an examination of insolvency specialists, Arnold et al. (2000) found that IDAs were most beneficial to individuals possessing greater expertise. An implication of this work was that decision aids might be a better complement to expertise than a substitute for expertise. Masselli et al. (2000) used tax preparation software to determine the effects of this decision aid on tax preparation decisions. Tax preparation software typically employs "audit flags" which are embedded intelligent agents. The authors examined the impact these "audit flags" had on the determination of tax liability among tax novices and tax experts. Results indicated that novices took a conservative approach when faced with an audit flag and produced returns that included a higher tax liability than did subjects with greater experience. Again, these results indicate that decision aids might complement expertise more than substitute for it. Noga and Arnold (2002) examined the determined tax liability of subjects in a 2 x 2 factorial design. The two factors were expertise and use of a decision aid. Findings show that the decision aid effectively reduced the determined tax liability for both experts and novices but that experts benefited more from the decision aid than did novices. Once more support was provided for the theory of technology dominance.

The studies cited here have a common thread. When experts use IDAs, decision quality does not appear to be negatively impacted; when novices use IDAs to make relatively simple decisions, decision quality does not appear to be negatively impacted. But when a mismatch between the user and the aid exists – specifically, when a novice uses an aid to produce a decision beyond the novice's sphere of ability – decision quality may suffer. While IDAs are employed with a goal of producing consistent and comparable decisions, these aids must be matched to user expertise when used in an actual decision-making environment. An alternative approach may be to use more sophisticated aids as a training tool for novices.

Decision Aids and Decision Aid Reliance

A decision aid is of little practical or learning value if the advice provided by the aid is ignored. Further, any purported advantage of knowledge transfer from using a decision aid may be effectively negated through over reliance on decision aids. Both of these issues are considered in this section.

If a decision aid produces, in general, an optimal decision, why might that decision be ignored? Will (1992) provided some insight into this question when he determined a higher degree of disagreement and discomfort existed with an aided decision among experts. In Will's experiment, experts were not given the choice of acceptance.

Boatsman, Moeckel, and Pei (1997) employed a management fraud decision aid and found that audit seniors failed to rely on the decision aid in their final planning decisions. A number of factors were sited for this lack of reliance: (1) Self-possessed knowledgeable decision makers have more confidence in their own decision making skills. (2) Increased performance pressure will increase non-reliance on a decision aid. (3) No decision aid is perfect. If future consequences can result from decision aid reliance, an expert may mitigate those consequences if self-possessed knowledge contradicts the aid.

Eining, Jones and Loebbecke (1997) employed (1) a decision aid that solicited input from auditors in a management fraud decision task, (2) a decision aid that merely provided a solution, and (3) a checklist. Results of the experiment were that soliciting input increased the chance that an auditor would utilize the aid and, thereby, make more optimal decisions than would those for whom input was not solicited. Similarly, Whitecotton and Butler (1998) conducted an experiment wherein half of the subjects were allowed to select information for a bond rating prediction and the other half were provided optimal information by the decision aid. Both groups then received a decision aid's prediction based on optimal formulation of the selected data. While the subjects who were allowed to select information produced decisions that were sub-optimal, these subjects were more willing to accept the decision than were those who had no input in the process. When the goal is to get a decision maker to use a system, allowing input that results in a sub-optimal outcome may be beneficial. This is especially true when, as Whitecotton and Butler (1998) found, the sub-optimal decisions are better than decisions that would have been made without the decision aid.

Barr and Sharda (1997) examined the literature on decision quality through decision aid use and determined that most studies found an increase in decision quality. An understanding of why quality increased became their central question. In a longitudinal investigation which included adding to and taking away decision aids, Barr and Sharda (1997) found that while decision quality increased with use of a decision aid, the apex of quality decisions was not attained when the aid was removed. They concluded that decision makers, and especially novice ones, relied on the decision aid without understanding the basis of the aid's decisions. Similarly, Glover, Prawitt, and Spilker (1997) also found that novices used decision aids in a mechanistic and non-participatory manner.

Taken together with the evidence stated in the previous section, novices seem to make sub-optimal decisions when they use decision aids that are not matched well in terms of expertise. Further, novices tend to over rely on decision aids. Because of these adverse findings, the question of when novices should use decision aids becomes critical. Are IDAs tools that should be left out of the hands of novices to prevent over-reliance on a tool that helps the novice potentially make poorer-quality decisions? Conversely, should well-designed IDAs be supplied to novices to enable them to substitute for experts? Or is the answer somewhere in the middle. Might IDAs that are matched well with user ability and have the capacity to train be the preferred answer to the question of novice use of IDAs? The capacity to use decision aids as a training tool will be explored next.

Decision Aids and Knowledge Acquisition

Rose and Wolfe (2000) suggest two expected accounting benefits for knowledge acquisition through the use of decision aids: (1) Aids are not always available to accountants even though decisions must be made. (2) As accountants rise to managerial positions, their decisions must be made based upon their professional knowledge. Accountants must use their professional knowledge to evaluate staff decisions that are based on decision aids. Therefore, gaining expertise as one progresses from staff accountant to manager is critical. One of the possible benefits of using an IDA is that the decision aid can be a training tool and, that a user can actually gain expertise through his/her interaction with the aid. An examination of how expertise may be gained via decision aids follows. This section has three subsections: an examination of studies based on theories of cognition, research based of the theory of cognitive load, and a summary of the implications and limitations of the extant research.

Theories of Cognitive Skill Acquisition

Cognitive psychologists consider production system architecture to be the framework through which human cognition may be understood (Anderson, 2000). While Anderson is not the sole theorist in skill acquisition (see Fitts, 1976 and Craik and Lockhart, 1972), Anderson's work has emerged as the dominant theory in cognitive skill acquisition. Further, this body of work (Anderson, 1976; Anderson, 1983; and Anderson 1993) has served as the basis for much of the literature concerning cognitive skill acquisition via decision aid interaction. To retain a commonality of semantics and to parallel the stages of cognitive skill acquisition explicated in the decision aid literature, this section briefly describes Anderson's 1993 theory and reveals some of the extensions of that theory as they apply to the acquisition of cognitive skills through the use of decision aids. Anderson's theory will be examined in greater detail in chapter three.

The basic premise of ACT-R (Anderson's 1993 theory is an acronym for Adaptive Character of Thought – Rational) is that cognitive skills are built upon, obtained through the acquisition of, and realized by production rules. Production rules, in turn, are IF - THEN (condition - action) pairs (Anderson, 1993). Because the ability to perform a mental task or solve a problem is contingent upon having a set of IF - THEN rules that lead to the ultimate solution, ACT-R theorizes how production rules are acquired.

Anderson (1993) purports three distinct memories within the human mind: (1) a short-term or working memory; (2) a long-term declarative memory; and (3) a long-term procedural memory. Among the three memories, only working memory is limited. Estimates on the number of items that may be concurrently held in working memory vary from as few as five to as many as nine (Awad, 1996). Because neither declarative or procedural memories seem to have storage limits, the inability to recall items from either long-term memory is attributed to retrieval errors (Anderson, 1993). A discussion of each of these memories follows.

Working Memory.

An analogy between a computer's random access memory (RAM) and working memory exists. Both have a memory limit and both hold the information currently receiving focus. Within the working memory, information under consideration could be one or more of four different types. It could be factual information about a new situation, or it could be factual information retrieved from declarative memory. Conversely, it could be a new problem that requires a solution or it could be a production rule retrieved from procedural memory (Anderson, 1993).

Sweller et al. (1990) and Sweller (1993) considered the implications of the size limitations of working memory on learning. Sweller et al. (1990) observed a traditional approach for instruction in mathematics and engineering which involved a presentation of mutually referring information. This approach to problem solving resulted in misdirected attention and cognitive overload. Sweller (1993) examined the effects of solving a large number of conventional problems on learning. He found a significant and negative correlation existed between learning and solving numerous problems. Working memory limitations were stated as the determinant factor of limitation in both of these studies.

Declarative Memory

Anderson (1993) makes the case for the existence of two distinctly different long-term memories (i.e., declarative and procedural) based on studies conducted with individuals suffering from amnesia. Amnesiacs were found to be able to demonstrate procedural skills but were unable to retrieve declarative knowledge (Corkin, 1968; Cohen and Squire, 1980).

"Declarative knowledge is factual knowledge that people can report or describe" (Anderson, 1993, p. 18). Declarative knowledge is a direct encoding of the environment. As such, declarative knowledge can be taught and expressed in words. The basic unit of knowledge in declarative memory is called a chunk. Chunks have a limited number of components (perhaps three; i.e. apple, red, sweet), perform different roles (propositional, semantic, and relational), and may be organized in a hierarchical manner (chunks of chunks) (Anderson, 1993).

New factual knowledge is considered by working memory, transferred to declarative memory and stored in chunks. All information that leaves working memory remains and can be recalled or reactivated through a spreading activation process (Anderson, 1993). Spreading activation is the level of activation assigned to a chunk and is based on an estimation of the "base-level of activation of a memory structure and the activation that spreads to the memory structure from elements in the current context." (Anderson, 1993, pp. 50-51).

Anderson and Matessa (1997) measured subjects' abilities to accurately recall serial lists. This study tested the spreading activation process formulated in ACT-R (Anderson, 1993). Results of this study showed: (1) As a list got longer, activation was divided among more chunks. (2) As a list got longer, activation suffered a decay. (3) As a list got longer, more positional confusion resulted. (4) As a list got longer, acoustic confusion increased. (5) Successful recall of longer lists required more intermediate success. Anderson and Matessa (1997) provided empirical support for the necessity of spreading activation among chunks in the successful retrieval of declarative memory units.

Studies investigating the encoding process have focused on the effects of elaborations. Elaborations are additions of statements to chunks that provide the chunks with greater meaning. Stein et al. (1982a) found that learners demonstrated more effective recall if they elaborated upon declarative-stage facts. Consider the statement "the tall man bought crackers." If the learner's responsibility was to remember that the cracker buyer was tall, an elaboration of " . . . from the top shelf" effectively helped in correct recall. However, Stein et al. (1982b) found that not all subjects were equal in their ability to generate meaningful elaborations. For example, one subject elaborated that the tall man bought crackers because he was hungry. While the elaboration was not untrue, it did little to help the subject remember that the man who bought crackers was tall. Franks et al. (1982) found that less successful learners required explicit elaborations whereas more successful learners required only implicit elaborations for effective recall. An implication of this stream of research is that the provision of explicit elaborations may help a learner encode declarative information in a manner that increases the level of activation spread to a memory item.

Pressley et al. (1987) examined the effects of elaborations on intentional learners and incidental learners. In that study, intentional learners were those subjects who had been informed that a test would follow the presentation of a number of sentences; incidental learners were not informed of a test. In addition, prompts that asked the subject to consider the logic of each sentence were given to half of the intentional learners and half of the incidental learners. Results showed that a prompt was not effective for the group who intended to take a test; however, it did increase the incidental learners' abilities to recall facts.

Chi et al. (1989) conducted a study to determine the effect of developing elaborations on understanding. In that study, students were asked to study examples of already-solved problems prior to undertaking problem-solving activities. Protocols of their study were also recorded. Some students merely read the study problems, others uttered self-explanations as they worked through the example problems. Subsequently evaluated problem-solving skills showed that students who offered more self-explanations also exhibited greater problem-solving ability. It was believed that providing self-explanations required greater attention from the learner and a higher level of learner involvement in the learning process. In terms of Anderson's (1993) theory, those who offered self-explanations were more likely to establish true and retrievable chunks during the declarative stage. Moreover, incidental learners may need to be prompted to provide self-explanations.

Declarative Memory and Decision Aids. In an accounting context, Pei and Reneau (1990) studied the effect a user's mental model had on knowledge transfer via expert system usage. Two methods of instruction in internal control evaluation were employed to impart mental models. The first method presented controls as they occur within a process or cycle (i.e. input, process, and output (IPO)). The second method presented controls as a hierarchy (i.e. prevention, detection, and correction (PDC)). The IPO approach introduced prevention, detection, and correction controls as they occur within a cycle; the PDC approach introduced controls as a hierarchy and then presented the hierarchy within each step through a cycle.

Pei and Reneau (1990) devised two expert systems that presented internal controls in either an IPO or a PDC order. Half of the IPO-trained subjects were assigned to an IPO system and the other half to a PDC system. A similar assignment was made of the PDC-trained subjects. Findings showed that when a subject's mental model (method of instruction) was congruent with the expert system's order of presentation, the subject was more likely to recall rules and, until the task became too complex, to join rules together.

From a cognitive psychology perspective, matching mental models with expert system design affects encoding, a declarative stage activity. To successfully encode and compile, the learner must have a mental model that is congruent with the presentation format of the expert system.

Murphy (1990) presented subjects with three decision aids in an attempt to determine which aid best affected learning as measured by a subject's ability to (1) recall

SFAS 91 rules, (2) recall and apply these rules and (3) to apply these rules correctly to a new and unaided situation. The three decision aids included a manual system and two expert systems. The manual system was a surrogate that presented the rules, in narrative form, which were embedded in the SFAS 91 expert systems. Subjects used a self-directed search to obtain pertinent information from the manual decision aid. Expert system subjects were given one of two expert systems, one with explanations and one without explanations.

The first two measures, recall and application, in Murphy (1990) correspond to the declarative stage. The third measure, rule application in a new situation, corresponds with Anderson's (1993) procedural stage.

In one-day long experiment, Murphy (1990) found that manual system users outperformed users of both types of expert systems in their ability to (1) recall SFAS 91 rules and (2) recall SFAS 91 rules and determine if a loan transaction correctly applied these rules. No significant difference existed among the three groups' abilities to correctly apply rules to a new situation. Further, no significant differences existed between expert system users who did or did not use an expert system with explanations.

Steinbart and Accola (1994) manipulated the type of explanation provided by an expert system and the degree of expert-system-user involvement to observe the effects of these factors on knowledge transfer. Cognitive psychology theories predict that when a learner receives meaningful explanations about a fact, that fact will be more likely to be correctly encoded (Pressley et al. 1987; Stein et al. 1984). In addition, as the richness of an explanation increases, the learner will be more likely to link a new fact to prior knowledge, thus facilitating recall (Anderson 1993). Steinbart and Accola (1994) employed two levels of explanation in their study, rule-traced explanation and justification. Rule-traced explanations merely stated the IF - THEN rules that "fired" Justification provided an explanation of why a rule was significant.

Research in psychology also shows that the more actively involved a learner is, the more that learner will learn (Bransford et al. 1982; Franks et al. 1982; Stein et al. 1982a; and Stein et al. 1982b). Involvement connotes time and effort in a cognitive task. The amount of time spent attending to a fact should increase the probability that the fact will be recalled, a declarative stage activity. Anderson (1985) showed a learner will be more successful solving a third problem if he attempted to solve the previous two problems rather than merely viewed the previous problems as examples with solutions. To promote involvement, Steinbart and Accola (1994) required half of their subjects to explicitly type responses to two questions: (1) What was the link between the listed threat and specific control objectives? (2) What is the seriousness of the listed threat?

The effects of manipulating explanations were measured by the subjects' abilities to recall control procedures and to identify threats (declarative-stage measures). The effect of manipulating involvement was measured by a comprehensive essay response (a procedural-stage measure). Results indicate that neither of the manipulations significantly affected the declarative-stage measures. Involvement, however, significantly and negatively affected user satisfaction.

Odom and Dorr (1995) manipulated the type and placement of explanations in an attempt to find the effect an explanation has on knowledge transfer through expert system usage. Explanations in this study were provided by the expert system and not generated by the user. As in the work of Bransford et al. (1982), Franks et al. (1982), Stein et al. (1982a), and Stein et al. (1982b), the authors here believed that the precision of an explanation should have an effect on the development of declarative knowledge. Moreover, the authors believed that providing examples in an explanation should affect procedural knowledge. Results showed that precise explanations with examples actually negatively affected declarative-stage knowledge and had no significant affect on procedural-stage knowledge.

The amount of feedback given to a learner was also tested in Odom and Dorr (1995). Half of the subjects in this study received explanations at each step in expert system usage, the other half received explanations only at the end of an expert system application. Results showed that neither the type nor placement of feedback significantly affected either declarative- or procedural-stage knowledge. As with Pei et al. (1994), the optimal level of feedback remains a question.

Procedural Memory.

"Procedural knowledge is knowledge people can only manifest in their performance" (Anderson, 1993, p. 18). Procedural knowledge is the ability to accomplish a task that requires, on some level, thought. Anderson (1993) suggests that procedural knowledge can only be acquired through example or analogy, it can neither be acquired through direct instruction nor directly communicated.

Learning is a process of adapting to new situations and our ability to learn is rooted in human evolution. Prehistoric human, for example, did not have the ability to tell another prehistoric human how to start a fire. If the second human were to learn from the first human, he learned by observing an example of the first human's fire-lighting technique. This is an example of learning by example. Similarly, early humans may have known that the root of a specific plant with large green and purple leaves was edible. A given human could have come across a similar looking plant, remembered the qualities of the first and, by analogy, determined that the second plant could also be edible. This is an example of learning by analogy.

Anderson and Fincham (1994) conducted experiments that demonstrated subjects could obtain valid production rules by studying examples. In these experiments subjects first memorized examples of uniquely paired numbers, for example 24 m 33 and 68 n 75. After the memorization phase, the subjects were able to map unique pairings to a new set of numbers. For example given the two memorized strings stated above, subjects were shown the partial strings of 61 m _ and 47 n _ . Subjects were able to provide 70 and 54 by determining the rules embedded in the memorized strings[1]

Caplan and Schooler (1990) conducted an experiment wherein subjects were expected to learn to use computerized painting software (Fullpaint). In their study, Caplan and Schooler presented training instructions in two orders, organized and random. Further, one half of the subjects received an analogical model of the software features

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24 m 33 implied the first digit in the second number exceeded the first digit in the first number by one and the second digit in the second number was one less than the second digit in the first number. Using this rule, identified by the character "m", 61 m 70 was correct.

(for example, stencils represented two-dimensional drawing features) and the other half received no form of analogy. They found that analogies were beneficial for solving less complicated tasks and organized training instructions were of benefit in solving more complex tasks. Anderson (1993) explains that while production rules cannot be directly taught, the presentation of production rules acts as a form of example through which a learner can produce production rules. The Caplan and Schooler (1990) experiment demonstrate the benefits of both example and analogy in learning.

Pirolli and Anderson (1985) examined the role of examples in a programming task. They found that novices rely on examples in their initial solution attempts. Further, they found learning success increased as the number of examples increased.

The basic unit of knowledge in procedural memory is a production or production rule (Anderson, 1993). As was previously stated, productions are IF - THEN (condition - action) pairs and cognitive skills are realized by production rules (Anderson, 1993). The set of productions required to perform a cognitive skill is called a production system and a production system is operated through a pattern matching and conflict resolution cycle (Anderson, 1993).

Basically, a declarative fact exists in working memory that requires a solution. Productions are retrieved from procedural memory and the condition sides of those productions are examined to determine whether any condition exists in procedural memory that matches the declarative fact in working memory – pattern matching. If only one match exists, the action side of that production fires. However, the possibility exists that more than one match can be found. In this situation, competing productions are examined to determine which action should be fired – conflict resolution (Anderson, 1993).

Productions have four aspects or characteristics that allow productions to be optimized for use. Unlike declarative chunks, productions have a modular characteristic that allows them to be added and deleted independently of other productions. Production systems (hence skills) can grow or adapt by the addition or deletion of productions. Productions have an abstraction aspect that allows a degree of generalization among productions. This means that a specific stimulus need not exist for pattern matching, instead, productions can be abstracted to match varying stimuli. It is, however, necessary to be able to respond differently to the same generalized stimuli in order to adapt. Therefore, productions also have a goal-structuring aspect that provides for different responses given similar conditions. Finally, productions lack symmetry between their condition and action sides. The implication of this characteristic is that rules are considered in a condition-action order rather than vice versa (Anderson, 1993).

Limited evidence exists to support these optimization characteristics. Anderson and Fincham (1994) demonstrated the asymmetric qualities of production rules. In this study, subjects were given inputs and asked to calculate outputs and vice versa. Inputs compared to the condition side of a production rule and outputs compared to the action side. While they were eventually able to calculate inputs given outputs, subjects did so at a significantly slower rate than with the reverse task.

As with information in declarative memory, procedural knowledge is not forgotten. However, searching through all productions for all possible matches would be cognitively exhaustive and ineffective. Therefore, a buildup and decay of productions exists that parallels the process in declarative knowledge retrieval. Anderson (1993) calls this process procedural-rule tuning. Like the spreading activation process associated with declarative memory, procedural-rule tuning is a statistical estimation process that assigns a production precedence based upon the strength of the rule (i.e. how useful the rule has been in the past), the probability that the rule will produce the intended effect, and the perceived cost (cognitive effort) that will result from the execution of the rule (Anderson, 1993).

Procedural Memory and Decision Aids. Fedorowicz, Oz, and Berger (1992) examined the financial risk analysis ability of novices. College seniors and graduate students served as subjects in an experiment to determine whether financial risk assessment decisions might improve through the use of an expert system developed by CitiCorp. This system provided no feedback to the users other than an expert assessment of overall risk and an assessment of component risk. Not only did expert system users outperform non-expert system users, the performance of these expert system users was found to improve not only during their use of an expert system, but also after the expert system was withdrawn.

Eining and Dorr (1991) (also see Eining, 1988) conducted a study over a five-week period to assess how well subjects learned to evaluate the control environment in payroll. In their study, subjects were divided among four treatment groups: a control group that received no decision aid, a group that received a manual questionnaire that was similar to a directed decision aid used in practice, and two groups that worked with expert systems to direct their assessment of internal controls. The expert system used by one group offered no explanation for its control assessment while the second displayed the rules that "fired" to reach an assessment of internal controls (Eining, 1988; Eining and Dorr, 1991).

The authors hypothesized that subjects receiving a decision aid would increase their speed and accuracy in decision making, a procedural-stage measure of having learned. Further, the authors believed that expert system users would outperform non-expert system users and that the group that received explanations would outperform all other groups. All subjects were required to make decisions without the benefit of a decision aid during the first and fifth weeks of the experiment. Changes in these decisions provided the data for analysis.

Results of analysis showed that the expert system groups made significantly better assessments of controls than did the other two groups, that expert system users made decisions significantly faster than did the control group, and that there was no significant difference between the two expert system groups for either speed or accuracy.

Pei et al. (1994) suggested that alternative designs of expert systems could affect the quantity of knowledge transferred to users. To this end, they designed systems that manipulated prompting and judgment strategy. Prompting was an attempt to require the reader to think about why a fact was true, the rationale underlying each step in a process, or to explicitly examine the effect of alternatives (Lewis and Anderson 1985). Prompting, in this study, may be seen as an attempt to strengthen declarative chunks and attend to specific elements in examples.

Manipulation of judgment strategy was an attempt to determine whether the order in which rules were presented, compared to the users' mental models, affected skill acquisition (as done in Pei and Reneau, 1990). Judgment strategy was operationalized in the design of two expert systems. One expert system presented rules as they would occur in an evaluation of controls in a cycle (input, processing, and output). The second expert system presented rules as they would occur when evaluating a system for preventive, detective, and corrective controls.

Subjects were tested for both declarative stage knowledge and procedural stage knowledge via three tests: a pretest given after two sessions of lecture, a posttest given at the conclusion of one experimental session, and a second posttest given one week following the expert system session. Analysis of the first posttest showed that (1) judgment strategy significantly affected the subjects' abilities to classify controls (a declarative-stage measure), (2) prompting significantly affected the subjects' abilities to recall the functions of controls (a declarative-stage measure), and (3) both judgment strategy and prompting affected the subjects' abilities to solve context-specific problems (a procedural-stage measure). Analysis of the second posttest showed that prompting significantly affected the subjects' abilities to classify controls, an interaction between judgment strategy and prompting affected recall, and both judgment strategy and prompting affected the subjects' abilities to solve context-specific problems.

Hornik and Ruf (1997) also manipulated the type of explanation given a subject in an attempt to determine the effect of explanation type on knowledge transfer from the use of an expert system. In this experiment, subjects evaluated internal controls in a payroll environment. One expert system provided only the expert's evaluation of the control environment (low, medium, or high), a second provided the experts' evaluation and the rules followed to arrive at that evaluation, and a third provided the evaluation, the rules followed, and requested the user view a log of previously-solved problems. By requiring the subjects to review a log of previously-solved problems, the authors were attempting to make subjects attend to the similarities between the current problem and problems they had already seen, learning by analogy to previously solved problems. Subsequent analysis showed that users of the expert system that required a reflection of previously-solved problems performed significantly better in a posttest of unaided-problem solving.

Mascha (2001) conducted a study that examined the effects of task complexity and feedback types on procedural knowledge acquisition from an expert system. Task complexity was set at two levels: simple and complex. Feedback type was set at three levels: no feedback, rule-based feedback, and detailed-text-with-example feedback. Mascha found that subjects who evaluated complex control assessment cases demonstrated a greater degree of procedural skills than did subjects who evaluated simple control assessment cases. Further, Mascha found that subjects receiving either type of feedback performed better than those who received no feedback. Finally, Mascha found an interactive effect of complexity and feedback, but the interactive effect was counter intuitive. While it was predicted that task simplicity would combine with rule-based feedback to produce a higher degree of procedural skill demonstration, this combination actually produced a lower level of procedural skill acquisition.

Theory of Cognitive Load

Rose (1998), in his dissertation, hypothesized that efforts to provide instructive prompts within decision aids had the effect of increasing the load on the user's working memory to the end that both learning and the decision task were adversely effected. This study found: (1) as cognitive load increased, schema acquisition decreased; (2) as effort increased, schema acquisition increased; (3) users with greater ability obtain more schema as effort increases; (4) problem-solving speed is a determinant of effort duration; (5) problem-solving ability effects schema acquisition; (6) cognitive load effects subjects of all abilities; and (7) cognitive load does not impact the amount of time spent learning. Rose used his finding to help explain the disparate findings of the effects of decision aids on knowledge acquisition. Further, Rose explained the lack of congruity between learning theory and effects of decision aids on learning as a function of cognitive overload.

Summary of Theories of Learning

An examination of the literature regarding declarative memory knowledge structures shows a mixture of results. It is this effect of strength on level of activation that lead psychological researchers (Stein et al., 1982a and 1982b; Bransford et al., 1982; and Frank et al., 1982) and decision aid researchers (Murphy, 1990; Eining and Dorr, 1991; Steinbart and Accola, 1994; Pei et al., 1994; Odom and Dorr, 1995; and Hornik and Ruf, 1997) to evaluate the effects of elaboration type and placement on learning.

Elaborations or explanations have been used to increase the strength of a memory structure and may be measured directly by the ability to retrieve a declarative fact. Of the decision aid studies stated above, only Murphy (1990), Steinbart and Accola (1994), Pei et al. (1994), and Odom and Dorr (1995) provided a declarative-stage measure of the effectiveness of elaborations. The findings from these four studies are evenly divided on these effects. Murphy (1990) and Steinbart and Accola (1994) found their manipulations of elaborations were not effective in promoting declarative-stage learning. The opposite was true with Pei et al. (1994) and Odom and Dorr (1995). This discrepancy in results begs reexamination.

Facts, examples, and analogies, according to Anderson (1993) provide learners with the declarative chunks necessary to begin learning. These declarative chunks must be turned into production rules if the learner is to become proficient. Moreover, production rules need to be optimized to increase their efficiency. Well-formed production rules are demonstrated to the word via a demonstration of the ability to perform a cognitive task. Of the studies stated, Fedorowicz, Oz, and Berger (1992), Eining (1988), Eining and Dorr (1991), Murphy (1990), Pei et al. (1994), Odom and Dorr (1995), Hornik and Ruf (1997), and Mascha (2001) provide a procedural measure of learning – demonstration of the ability to perform a cognitive task.

For the most part, studies that compared knowledge acquisition among expert system users and manual system users (Fedorowicz, Oz, and Berger, 1992; Eining, 1988; Eining and Dorr, 1991; Murphy, 1990; and Mascha, 2001), found the use of an expert system to be more beneficial than the use of a manual system. Only Murphy (1990) found contrary results. The first conclusion suggested is that simple use of a decision aid that was developed as a learning tool may promote learning. Facts, examples, and analogies were not explicitly manipulated in any of these studies, but facts, examples, and analogies are the building blocks of Anderson's (1993) theory of cognition. All other things being equal, an expert system user may be more likely to extract facts about a learning situation, view tasks as sets of examples, and form their own analogies than are non-expert system users.

Explanation types were manipulated without significant procedural knowledge effect in Eining (1988), Eining and Dorr (1991), Murphy (1990), Odom and Dorr (1995), and Mascha (2001). The preponderance of this evidence is understandable in light of Anderson's (1993) theory. Explanations are most effective in strengthening declarative memory structures and these memory structures are fact based. While declarative knowledge is turned into procedural knowledge, factors extraneous to declarative structure strength are associated with this knowledge evolution. These factors include examples and analogies, which may be supplied by the learner, and which may confound determination of the effects of explanations on knowledge acquisition.

Pei et al. (1994), Odom and Dorr (1995), Hornik and Ruf (1997), and Mascha (2001) manipulated examples and analogies. Pei et al. (1994) found an interactive effect of examples and judgment strategy on long-term procedural knowledge. Odom and Dorr (1995) found that feedback with examples did not significantly promote skill acquisition over other types of feedback. Similarly, Mascha (2001) found detailed examples did not significantly differ from rule-based feedback in promoting end-stage learning. Hornik and

Ruf (1997) found that prompting for analogies increased procedural knowledge. These results suggest that the type of examples provided makes little difference but do not suggest that examples are not helpful to learners. Moreover, providing analogies within an IDA appears to be beneficial. Nothing in this literature refers to the optimization of production rules.

According to Anderson (1993), abstraction is an optimization technique that should increase the learner's ability to perform pattern matching. Similarly, goal structuring is an optimization technique that should increase the learner's ability to perform conflict resolution. While the effects of facts, examples, and analogies on cognitive skill acquisition have been examined in the decision aid literature, the effects of manipulating the optimization techniques of abstraction and goal structuring on knowledge acquisition via IDA use have not been examined.

The next chapter formally presents Anderson's ACT-R theory, including detail on the theorized effects of abstraction and goal structuring on optimizing production rules. Hypotheses concerning the effects of explanations and optimization on learning are also presented.

CHAPTER III

THEORY AND HYPOTHESES DEVELOPMENT

Introduction

Cognitive psychologists have long sought to understand how the human brain processes information. Questions of how people absorb information, transform information, and learn to perform new tasks capture the attention of these scientists. In the 1970's cognitive psychologists embraced new computer science methodologies of artificial intelligence (AI) in their quest to find answers to many of their questions. With the emergence of programs that mimicked human activity came a format in which cognitive psychologists could implement their models of human thought and learning (Cohen and Feigenbaum, 1982).

Newell and Simon (1972) developed the general problem solver (GPS). This early AI system contained a core of knowledge about a task environment which the system could query to develop solutions to task-independent questions. Perhaps the greatest success of the GPS was the subsequent work it initiated (Anderson, 1993). From the GPS model came two production system prototypes: OPS and ACTE. OPS, the given name of a programming language, was developed by Forgy (1984) as an expert system programming language. ACTE was the basis upon which Anderson has built his theory of human cognition (Anderson, 1993).

Adaptive Character of Thought

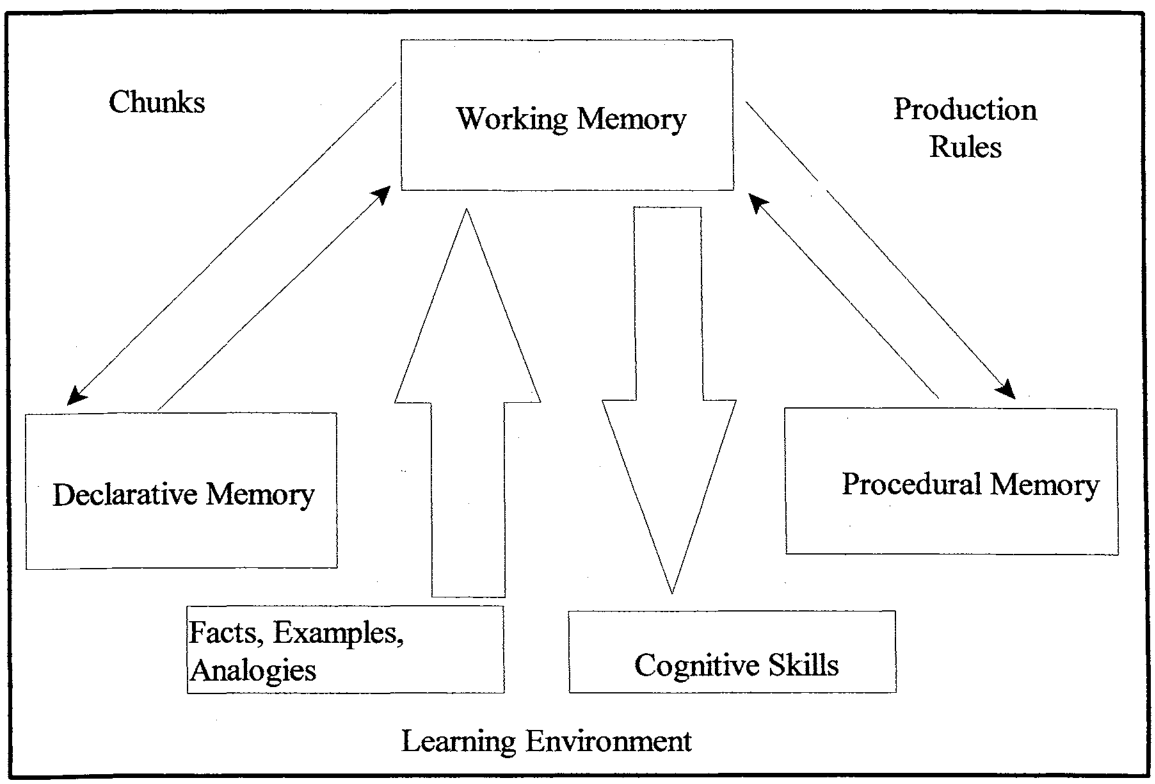
Anderson's general theory of cognition is called Adaptive Character of Thought (ACT). This theory has undergone a number of refinements, each refinement producing a slightly new theory name: ACTE – Adaptive Character of Thought Electronic (Anderson, 1976), ACT* – Adaptive Character of Thought Star (Anderson, 1983), and ACT-R – Adaptive Character of Thought – Rational (Anderson, 1993). Given the similarities among these acronyms, it is not surprising to find that the literature is inconsistent in citing Anderson's theories, indeed, the names attributed to Anderson's theories include almost any set of words that can form the acronym ACT. The discussion in this chapter focuses on Anderson's most recent iteration of ACT – ACT-R (Anderson, 1993).

Anderson's (1993) ACT-R theory of cognitive skill acquisition proposes the existence of three distinct memories, defines the relationships among these memories and the learning environments, and introduces several factors that impact these memories. A discussion of ACT-R and a set of hypotheses derived from the ACT-R theory follow.

Figure I presents an overview of the three memories within a learning environment. The environment supplies, to working memory, facts about a new learning task. In addition, a learner may obtain from that environment (in working memory) facts about a new learning task, examples of the task solution, and analogies to similar tasks. New facts and steps implied from examples and analogies are stored, as chunks, in declarative memory. Because reconstructing the declarative steps of examples and analogies is cognitively expensive, the learner may alternatively store examples and analogies as a set of production rules in procedural memory. When a new goal state (problem) is presented to working memory, the learner will attempt to retrieve facts, example steps, and/or analogy steps from declarative memory and/or the learner will attempt to match production rules from procedural memory to the new goal state. Once a new goal state is successfully matched the production rule fires, and a solution is able to be demonstrated to the environment.

FIGURE I

AN OVERVIEW OF THE LEARNING ENVIRONMENT



As an example of this process, suppose the problem posed to working memory is to find a solution to 4 + 6. Further, suppose the individual was familiar with addition problems. A declarative fact that "4 + 6 = 10" may be stored in declarative memory. The learner could probe declarative memory until that solution is obtained by retrieving chunk after chunk from declarative memory until a match of "4 + 6" is found. Alternatively, the learner could probe procedural memory for a set of rules that could derive the solution. The distinction between these two memory searches is that the first supplies a "what" answer, the second supplies a "how" answer. Given that both memories are available to the learner, the search chosen will depend upon the learner's implicit perception of cost and success of a search.

Now suppose the learner was not familiar with addition problems. There are a number of ways in which the learner could discover a solution to this new problem. The learner could read an addition table, working methodically through "0 + 0 = 0; 0 + 1 = 1; 0 + 2 = 2; etc." until a match is found. Obviously, this approach would be quite time consuming and would result in the storage of many declarative facts in declarative memory. Further, a subsequent search through a mental addition table would be necessary in order to solve this problem in the future. If the learner has reason to suspect this problem may have to be solved in the future, a more efficient method is desired.

Two more efficient methods are available to the learner: examples and analogies, both of which may be obtained from the environment. Examples of previously-solved addition problems may be examined by the learner (i.e. 3 + 5 = 8). These examples will provide the learner with the repeated steps necessary to perform addition problems.

Analogies might also prove helpful to the learner. For example, learning that if a baker had already placed four cups of flour in the bowl and then added six cups of flour, he/she would have ten total cups of flour in the bowl, provides an additive analogy that once again provides the learner with solution steps.

Steps provided by examples and analogies may be stored as declarative facts. When the learner is required to perform a new addition problem, these steps can be retrieved from declarative memory. However, if the problem is somewhat complex, the steps must be repeated numerous times. Once again the learner might desire a more efficient method. Efficiency requires that these steps be converted to a set of rules that apply to all addition problems. These rules embody the "how" of addition as opposed to a set of "what" results from additive steps.

Declarative Stage Knowledge

The ability to retrieve a chunk from declarative memory to working memory is contingent upon the level of activation ascribed to that chunk. A chunk (or declarative memory structure) must be retrievable if it is to be used for a direct solution or in the formulation of production rules. Anderson (1993) formally states the level of activation as:

$$A_i = B_i + \sum_j W_j S_{ji} \qquad \text{(Equation 3.1)}$$

Where:

A_i = a specific memory structure's level of activation
B_i = the base level or strength of a memory structure
W_j = the salience or validity of memory structure j
S_{ji} = the strength of association between memory structure j and i

According to this formula, the level of activation (the probability of retrieval) of a chunk in declarative memory is contingent upon base strength, validity, and relevance. Strength (B_i) is determined by the number of times a chunk has been retrieved in the past. Frequency of retrieval indicates utility of a memory structure, a memory structure that has proven useful in the past will be more likely to be considered useful in the future. While strength indicates the probability that a memory structure will be directly retrieved, the possibility exists that a memory structure will be retrieved because an associated memory structure has been retrieved. Strength of association (S_{ji}) is a measure of relationship between memory structures j and i. A memory structure that has proven to be associated with another memory structure in previous problems may be perceived as valuable in future problems, especially if the first memory structure was useful. Salience (W_j) refers to the usefulness ascribed to the first element (j).[1]

Logically, an increase in the strength of a chunk and/or its level of association with another relevant chunk will increase the possibility that the first chunk can be retrieved from declarative memory. Therefore, two approaches can be used to increase a chunk's level of activation: (1) increase the strength and/or association of a related relevant chunk or (2) increase the strength of the chunk itself. A memory chunk may hold several facts and the composition of each chunk is individual specific. One individual may store two related facts in the same chunk while another will employ two

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1 Anderson (1983) referred to this process as "spreading activation." In the 1983 version the salience of element j was not considered. Anderson (1993) includes salience and ascribes W_j with a value from 0 to 1. The value of this factor is that associated but irrelevant memory structures are ignored.

separate chunks for those two facts. Because of the individual, internal, and non-observable manner of storing facts, testing the first approach is problematic and perhaps almost impossible. IDA researchers have focused on the second approach by attempting to increase the relative strength of a chunk through embedded agents that offer additional facts about a desired chunk of information. The first hypothesis here follows this approach by employing similar agents that provide the learner with chunk-enriching information.

H_1: There will be no difference in the ability to retrieve declarative chunks before and after activities designed to increase chunk strength.

A related question is whether all individuals will demonstrate the **same** ability to retrieve declarative chunks. Anderson (1993) infers that chunk strength is directly related to the number of times a chunk has been retrieved. Therefore, an individual's ability to retrieve a chunk is only dependent upon past retrieval success and is independent of all other things. Activities designed to strengthen memory chunks should have an equal effect on all individuals. This leads to the second hypothesis to be considered in this study.

H_2: There will be no difference in declarative chunk retrieval ability between groups of individuals engaging in identical strengthening activities.

ACT-R is a general theory of learning and is not addressed to learning in any specific context. IDAs have been used for their perceived ability to facilitate declarative-knowledge acquisition. Typically, training has been the result of different types of feedback provided by the IDA. One type of feedback and IDA can provide is a set of explanations that provide additional meaning to declarative-stage information.

Procedural Stage Knowledge

Given a goal state (a problem that requires a solution) in working memory, a learner will draw on both chunks and production rules to satisfy the goal. The previous discussion involved the level of activation attached to declarative memory chunks and described the hierarchy of the process of searching through declarative-memory chunks. A discussion of the search through procedural-memory production rules remains.

Production rules are defined as pairs of IF - THEN statements. Each production rule must have both an if (condition) and a then (action) clause to meet this definition. Anderson (1993) claims that all cognitive skills are obtained by developing a system or set of production rules. This production system provides the learner with the ability to accomplish a task. While chunks are facts that may be vocalized, a production system provides the "how" of task solution that cannot be explicitly stated.

A search through procedural memory may yield one or more production rules for which there is a match between the goal state and the condition side of the rule or rules. Anderson (1993) calls this process "pattern matching." The search process will not consider every rule in procedural memory as this would be a cognitively exhaustive search. Instead, only production rules with sufficient strength will be considered in the pattern matching search. Anderson (1993) defines the strength of a production in terms of the learner's implicit perception of a production rule's success and cost. Production-rule success will be discussed first followed by a discussion of production-rule cost.

The probability of success of a production (P) is stated: $P = qr / (1 - (1 - q) f)$ (Equation 3.2)

Where:

$q = (\alpha + m) / (\alpha + \beta + m + n)$ (Equation 3.3)

And:

m = the number of times a production rule has lead to a success in the past

n = the number of times a production rule has lead to a failure in the past

α and β = are parameters describing prior probability of success

$r = (\alpha + m) / (\alpha + \beta + m + n)$ (Equation 3.4)

And:

m = the number of times a goal is eventually achieved

n = the number of times a goal is not eventually achieved

α and β = are parameters describing prior probability of success

f = deterioration in prospects if a production fails

Equation 3.3 is an evaluation of how successful a production rule has been in solving prior problems. A production rule that has been useful in the past will be perceived as being more useful in the future. Hence, q is a measure of the probability that a production rule will achieve the desired effect.

Equation 3.4 is an evaluation of the probability that the goal will eventually be obtained given the current production rule is successful. Hence, r is a measure of the probability of goal satisfaction.

Equation 3.2 combines the results of Equation 3.3 and Equation 3.4. The relative success assigned to a production rule is a function of both how successful that rule has been in the past and how many times the rule helped to obtain a goal. A final element considered in the estimation of production rule's success is failure rate. The more time failure is encountered in the consideration of production rules, the less likely the learner will consider an additional production rule to be successful.

While success is a measure of prior accomplishment, cost is a measure of effort required to reach an eventual solution. Anderson (1993) provides the following to estimate the total cost (C) of firing a production : $C = a + b$ (Equation 3.5)

Where:
a = the cost of performing a production
b = the cost of further action after this production has performed

The cost of firing a production (Equation 3.5) is simply an estimation of total effort demanded of the learner. Total effort is a measure of the effort required to perform the action clause of the current production rule plus the effort that will be required to perform the action clause of all subsequent production rules. Taken together, the strength assigned to a production rule will increase as success increases and decrease as cost increases.

Production rule strength is nothing more than the chance that a given rule will be retrieved to see if it matches a goal in working memory. Retrieval of a production is of little value if the action suggested by the production rule fails to successfully match the action required by the goal state. In other words, the condition side of the production rule matches the condition in working memory but produces the wrong answer. For example, suppose the goal state was for the learner to find a way to warm a room. A possible production rule might suggest that if it is cold, one needs to light a fire. If no fire place exists in the cold room, the action of a correctly-matching production rule would be inappropriate. Therefore, a successful learner must be able to select from the set of productions that employ a correct pattern match, only the production rules that also meet the action sought in the goal state. Anderson (1993) calls the process of choosing among possible productions "conflict resolution."

Anderson (1993) further suggests that production rules can be optimized to increase their utility. Optimization of production rules is a trade off between the range of applicability of a rule (pattern matching) and its efficiency of application (conflict resolution). Productions have two characteristics that promote optimization: they are both modular and asymmetric. Modularity implies that one may add to and delete from a set of productions required for skill accomplishment; it also implies that skills can be developed by acquiring new productions and strengthening existing productions. The asymmetric quality of productions requires a distinction between the condition and action sides of a production and requires that a condition be first satisfied before an action is considered, thus making the total consideration process more efficient. Abstraction and goal structuring are two additional aspects of production optimization.

The concept of abstraction is grounded in the condition-and-response work of Guttman and Klaish (1956). Guttman and Klaish used pigeons that were trained to peck a key when presented with a light of a particular wavelength, then the wavelength was subtly altered to determine how much difference could be made before the pigeons failed to recognize the light color as one that required a key-pecking action. One result of the Guttman and Klaish work was that conditions were found to be generalizable (Anderson, 2000).

When the condition side of a production rule is stored in a very explicit form, the process of comparing the production condition to the goal condition is quite exacting and computationally expensive. Anderson (1993) contends that if the condition side of a production rule can be reformed in a more general manner, pattern-matching expense can be mitigated. Anderson (1993) calls the process of making productions more general in nature abstraction. Anderson (1993) perceives abstraction as an inherent characteristic of a production rule.

One obvious advantage of abstraction is that the cost of retrieving, comparing, and firing a production will be reduced. As was stated earlier, reduced cost increases the relative strength of a production rule. A less obvious advantage of abstraction involves production rule success. The success of a production rule will increase as number of times that production rule matches a goal condition increases. A generally stated production rule condition is more likely to match more goal conditions. Therefore, a generalized production rule will match more frequently and will be more successful than one that is not generalized. Further, the strength of that rule will increase. The fine-tuning process of abstraction increases the relative strength of a production rule by decreasing cost and increasing success. A stronger production rule is more likely to be considered in subsequent tasks. In synthesizing these various aspects and predictions noted in the above discussion, the theory in this area can be reduced to the inference that abstraction can be used to improve pattern matching. Hornik and Ruf (1997) indirectly considered the possible benefits of abstraction by requesting that IDA users reflect on previously solved problems. The intent in this study was to cause learners to form generalities, but learners likely relied as much on learning by analogy as on abstraction.

Therefore, an abstraction activity of directly comparing similar production rules is suggested. This leads to a third testable hypothesis:

> **H_3:** There will be no difference in pattern-matching abilities between individuals who engage in abstraction activities and individuals who do not engage in abstraction activities.

Only production rules that match a goal condition can be considered and fired in the process of solving a problem. Because cognitive skill acquisition is dependent upon obtaining a set of valid productions, it is reasonable to assume that improved pattern matching will yield a more successful production system. If pattern matching can be improved through abstraction, it is also reasonable to expect that abstraction can also lead to improvement in cognitive skill performance.

> **H_4:** There will be no difference in cognitive skill demonstration between individuals who engage in abstraction activities and individuals who do not engage in abstraction activities.

Anderson (1993) suggests that abstraction is a necessary activity but does not discuss whether abstraction is internally generated and/or externally stimulated. However, prompting has been demonstrated as a somewhat successful means of promoting declarative chunk strength. A logical progression, in an IDA context, is that prompting may also induce a strengthening among procedural memory productions.

A production rule not only contains a condition side, it also contains an action side. While many production rules can match an internal condition, a critical element of adaptation to new learning situations is the ability to distinguish among the best-matching productions by evaluating the actions suggested by those productions. As with abstraction, the learner's goal is to strengthen productions that not only match, but also produce the correct result because it is costly to fire a production rule that yields an incorrect result. When a learning situation involves slightly different outcomes, a critical action is that the learner must fire the production rule that is best matched to the different outcomes. The process of forming production rules that encompass differing outcomes is called "goal structuring" (Anderson, 1993).

Goal structuring is also rooted in condition-response literature. Jenkins and Harrison (1960) considered pigeons that were to receive a reward if they pecked an object when a particular frequency of sound was introduced. After initial training the sound frequency was varied to elicit a generalization process. It was determined that the pigeons began to peck at the introduction of all sound frequencies. When rewards were only offered for responses within a frequency range, the pigeons began to differentiate between their pecking responses and the sound frequency.

Anderson (1993) infers that goal structuring can be manipulated to increase the possibility of correctly matching different outcomes. Pei et al. (1994) asked IDA users to consider a number of factors including how outcomes could differ as production rules differed. This study did not measure the effect of this goal structuring activity separately from the other factors, but this approach did serve as a basis for introducing goal structuring activities in an IDA context. The question of the effect of goal structuring activities can be tested under the following hypothesis:

> **H_5:** There will be no difference in responding to different outcomes among individuals who engage in goal structuring activities and individuals who do not engage in goal structuring activities.

Demonstration of cognitive skill acquisition is dependent upon the acquisition of an appropriate set of production rules. This set must contain production rules that differ as outcomes differ. Therefore, production rules must be goal structured to demonstrate cognitive skills. This leads to the sixth hypothesis.

H_6: There will be no difference in cognitive skill demonstration between individuals who engage in goal structuring activities and individuals who do not engage in goal structuring activities.

Anderson (1993) also suggests the necessity of goal structuring without providing a prescribed mechanism for promoting procedural learning. As with abstraction, a potential means of promoting goal structuring in an IDA environment is to provide the learner with a prompt to simulate this activity.

When a production rule has been successfully abstracted and goal structured, that rule should be more successful than a rule that has not been similarly optimized, and successful rules gain strength to the end they will be retrieved. A learner must develop these successful rules. A learner must form generalities among rules and be able to distinguish among these generalized rules. Given the almost antagonistic nature of the two optimization techniques, there must exist a trade-off. Anderson (1993) does not provide a basis concerning the relative necessity of abstraction versus goal structuring. Instead, both types of production rule optimizations are considered imperative. Therefore, abstraction and goal structuring must interact to provide a combined effect on rule strengthening. The interaction between the two is considered in the next hypothesis.

H_7: Difference in cognitive skill performance for both levels of abstraction is consistent over all levels of goal structuring.

Successful problem solving is, according to Anderson (1993), a function of practice. With practice, problem-solving time is expected to decrease because necessary chunks will have sufficient activation levels and production rules will be sufficiently strengthened. Problem-solving speed may be defined as the time required to retrieve all necessary productions and the time required of each production is stated as:

$$T_p = \sum Be^{-b(Ai = Sp)} \text{ for all i}$$

Where:

T_p = The time it will take to match chunk A_i and production rule S_p
A_i = The level of activation of a memory chunk i (Equation 3.1)
S_p = The strength of production p (Equations 3.2 and 3.5)
B and b are constants

The strength of a given production rule is increased, in part, by optimization. It follows then that both abstraction and goal structuring activities will produce stronger rules thereby decreasing the time required to retrieve those rules.

H_8: Difference is problem-solving speed for both levels of abstraction is consistent over all levels of goal structuring.

Summary

Anderson (1993) presented a theory on cognitive skill acquisition. This theory proposed the necessity of developing chunks of declarative (factual) memory items that can be retrieved by the learner. While a skill may be performed in a step-by-step manner based solely on declarative chunks, this process is both cumbersome and cognitively taxing. Anderson (1993), therefore, proposed that a true demonstration of a cognitive skill required a transformation of declarative chunks into procedural production rules. Further, these production rules required optimization. Anderson (1993) further clarified the difference between declarative learning and procedural learning as a "what to do" versus "how to do it" approach.

Because chunks are the building block of production rules, they must be developed first and they must be of sufficient strength that the learner can retrieve them. This chapter presented two hypotheses concerning declarative chunk strength. The next chapter will present an experiment in which these two hypotheses can be tested.

Cognitive skill acquisition requires that the learner develop a production system – a set of production rules that leads the learner from the initial question to the ultimate solution. The production rules are condition-action pairs that require some fine tuning that will also make them strong enough to be called upon and used. Anderson (1993) calls the fine-tuning process optimization and suggests two optimization techniques that should promote production-rule strength. Abstraction is one optimization technique that causes the learner to form a few generalized condition-side statements from many statements. Goal structuring is an optimization technique that differentiates the action-side of the production rule. Anderson (1993) theorizes that both optimization activities are necessary and that the two are interactive. While the relationships between abstraction and goal structuring and learning are hypothesized here, the following chapter also presents a method of testing these relationships.

A final postulate presented in Anderson (1993) concerns the relationship between problem-solving speed and production-rule optimization. Generally, a speed up in problem solving is expected as rules are optimized. Again, this hypothesized relationship will be tested in an experiment described in the subsequent chapter.

CHAPTER IV

METHODOLOGY

Introduction

An overview of the literature concerning cognitive skill acquisition from intelligent decision aids (IDA) revealed two significant issues. The first issue was that there were mixed results for the effect of explanations on declarative-stage knowledge. The second issue was that the separate and joint effects of abstraction and goal structuring on procedural-stage knowledge have not been examined. The current study reexamined the effects of explanations. This was done with the use of prompts that provided subjects with explanations about a number of internal controls. More importantly, the current study examined the separate and joint effects of abstraction and goal structuring on procedural-stage knowledge acquisition from IDA usage. IDA prompts were employed to provide a focus on some similarities and differences among a number of internal controls. The study was conducted in a laboratory experiment environment.

The following sections will be presented in this chapter. The first section will describe the task employed to test the effects of explanations, abstraction, and goal structuring on cognitive skill acquisition through the use of an IDA. Section two will identify the subjects involved in the task and will present an analysis of subject demographic information. A third section will provide a discussion of the dependent and independent variables as well as how these variables were operationalized. The fourth section will describe the procedure employed to test the hypotheses presented in the previous chapter. This section will include a discussion of the experimental procedure, a pilot test from which the experiment benefitted, and participation incentives. The final section will present model statements for each of the analyses to be performed. In addition, this section will present predicted outcomes of the analyses.

Task

This study was concerned with learning through IDA interaction. Therefore, a learning task was needed in order to study whether an IDA could aid the user in developing a cognitive skill. In addition, the task for this study had to be one that was realistic, one with which subjects had some familiarity, and one that could be accomplished in a reasonable time. The assessment of the adequacy of internal controls in a payroll environment using an IDA met all of these requirements and was, therefore, selected as the experimental task.

Staff auditors routinely employ decision aids in their initial determination of the adequacy of internal controls (Eining, 1988; Eining and Dorr, 1991). These decision aids, which can be as simple as a manual checklist and as complex as an IDA, are used to record the presence or absence of specific internal controls. An initial judgment of control adequacy is made based on the combination of controls. With a checklist, this judgment generally results from a form-directed question and response search. With an IDA, this judgment relies on a knowledge-base and inference engine search. Because IDAs are used in practice to assess the adequacy of internal controls, such a system was desirable for this study.

The evaluation of internal controls in a payroll environment was an appealing subject for IDA design for two reasons. First, payroll is a system that is familiar to the majority of subjects in this study. Second, payroll represents a relatively capsulized process that employs a series of consistent and well-defined rules. These rules are both straight-forward to model in an IDA and can be learned within the time constraints of a laboratory experiment.

To assess the separate and joint effects of abstraction and goal structuring, four IDAs were developed. The first IDA served as a control system, the second presented abstraction prompts, the third presented goal structuring prompts, and the fourth presented both abstraction and goal structuring prompts. In addition to finding the effects of abstraction and goal structuring, this study also sought to understand the effects of explanations on declarative-stage knowledge acquisition. Therefore, each of the four IDAs provided explanations (for both the level and functional characteristic) for each of the controls considered by the system.

Visual Basic 6.0[1] was selected as the IDA development tool for several reasons.

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[1] *Visual Basic* is a registered trademark of Microsoft Corporation, Redmond, Washington.

Visual Basic is a Rapid Application Development (RAD)[2] tool, that features Agent OCX (OLE Control Extension) that is employed extensively in contemporary system design. As such, *Visual Basic* is a current standard in the development of IDAs (The Haley Enterprise, Inc., 1996). *Visual Basic* also produces an interface that has a "*Windows* look and feel" that allows a user, comfortable in a *Windows* environment, to utilize the software without first becoming acquainted with a new operating system (Lynch, 1995). Finally, from a practical perspective, the computer labs used in this experiment provided *Visual Basic* for each subject. The advantage here was that each experimental version of the IDA could be packaged and run from a single diskette or downloaded from a server without adding additional software or hardware locks to the lab computers.

Two internal auditors from Oklahoma State University specializing in payroll audits reviewed the logic and decision trees used to construct the IDAs for this study. Their review and suggestions enhanced the system development and provide some external validity for the IDA developed exclusively for the present study. Both the decision trees and the *Visual Basic* code are included in Appendix C and D.

Subjects

Students enrolled in Accounting Information Systems at The University of Nevada, Las Vegas served as volunteer subjects for this experiment. Novice auditors who use IDAs in their appraisal of internal controls comprised the external population of

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[2] RAD is a method of systems development that combines prototyping and joint application development.

interest. Accounting Information Systems is a senior-level class at The University of Nevada, Las Vegas, as such, these enrollees were considered to be good surrogates for entry-level auditors (see Gordon et al., 1987 and McMillan, 1994). These students, many of whom were currently serving internships, possess approximately the same educational and experiential background as would novice auditors.

An extensive pilot test was conducted prior to the actual experiment and was used to refine the instruments. During the pilot study, 86 junior, senior and graduate students at Oklahoma State University acted as subjects (Oklahoma State University Institutional Review Board approval is provided in Appendix E). These subjects were volunteers who were either enrolled in one of several different courses that provided course credit for participation or who participated out of interest in the study.

The use of human subjects at The University of Nevada, Las Vegas required the approval of the Office of Sponsored Programs (OSP). Further, subjects had to be clearly informed that they were taking part in a research study as well as the type and extent of the tasks they would have to perform. A copy of the OSP approval form has been included in Appendix E. While subjects were not told the actual hypotheses being tested nor the differences among the experimental groups to which they were assigned, they were verbally informed that this was a research study designed to investigate how IDAs could increase learning. In addition, subjects were required to provide their consent for inclusion in the experiment on an Informed Consent form. This document explicitly stated the risks and benefits expected from the experiment, the voluntary nature of the experiment, class credit that could accrue from participation in the experiment, alternate methods of earning equivalent credit, and the confidential nature of reporting experimental results. A copy of that form is also included in Appendix E. Further, computerized screens (included in Appendix A) reiterated much of this information.

One hundred fifty nine subjects began this experiment and 155 usable responses were obtained. An *a priori* assessment of sample size lead to the following conclusions. Stevens (1996) suggested a minimum of 15 observations per independent variable to ensure a 50% chance of detecting differences when they existed in a multiple-dependent-variable examination. This study examined 6 dependent variables, so a minimum of 90 subjects was required. Sample size for univariate analysis (as suggested by Hicks, 1993) was determined based on variances and parameter shifts found in Eining and Dorr (1991). Holding $a = 0.05$ and $\beta = 0.10$, a minimum sample size of 80 was determined to be sufficient. One hundred and fifty-five subjects, therefore, should be sufficient for the analysis conducted in this study.

Responses from four subjects were not used in the analysis. Diskettes used to collect responses from two subjects were not readable due to defects in the diskettes. One subject dropped the course in which the experiment was conducted prior to the conclusion of the experiment, thus no posttest information was obtained from that subject. One subject suffered a back injury which required medication and eventual surgery. While this subject was encouraged to participate for class credit and the potential of learning, this subject's responses were omitted because the medication might decrease the validity of the responses.

Randomization Checks

Subjects were randomly assigned to experimental groups based on the toss of two coins. A HH combination indicated assignment to the control group, a HT combination indicated assignment to the experimental group that received abstraction prompts, a TH combination indicated assignment to the experimental group that received goal structuring prompts, and a TT combination indicated assignment to the experimental group that received both abstraction and goal structuring prompts. Demographic data were collected from all subjects at pretest. These data included age, GPA, gender, number of semester hours completed, auditing experience (had taken auditing previously, was currently taking auditing, would take auditing in the future), comfort level using computers (0 = I am comfortable using word processing, spreadsheet, and internet software; 1 = I use word processing, spreadsheet, and internet software but am not very comfortable; 2 = I am comfortable using word processing, spreadsheet, internet, and programming software; 3 = I use word processing, spreadsheet, internet, and programming software but am not very comfortable), computer use (personal, work, school) and prior expert system use. Data for the subjects who completed the experiment are presented in Table I. Note that the acronym WSP in the Median Use Level row of Table I connotes computer use for work, school, and personal purposes.

TABLE I

SUBJECT DEMOGRAPHIC INFORMATION

Response Variable	Group 1	Group 2	Group 3	Group 4
Females	20	25	22	23
Males	19	14	17	15
Total	39	39	39	38
Average Age	27.82	25.44	28.41	29.53
Average GPA	3.27	3.34	3.35	3.35
Average Completed Hours	117.72	116.10	124.54	115.05
Median Audit Experience	Previously Enrolled	Previously Enrolled	Future Enrollment	Future Enrollment
Median Comfort Level	0	0	0	0
Median Use Level	WSP	WSP	WSP	WSP
Median Expert System	None	None	None	None

Consideration should be given to the implications of the median responses reported in Table I. More subjects in groups one and two had enrolled in auditing in a previous semester than were enrolled in auditing concurrent with the experiment or than were planning to take auditing in the future. In contrast, more subjects in groups three and four planned to take auditing in the future than the other two enrollment options. The median response for level of comfort using computers for all groups was an indication of comfort using word processing, spreadsheet, and internet software. The median indication of computer use for all groups was for work, school, and personal use. No groups had an indication of expert system use.

Because gender, auditing enrollment, and computer use were nominal, a test of independence was performed to determine whether these subject characteristics differed among group assignment. A contingency table was prepared for gender, auditing enrollment, and computer use; a Pearson Chi Squared test was performed. A Pearson

Chi Squared is a test of difference between two proportions which, when significant, indicates general association. Results of this analysis, which show no statistical association between group assignment and class enrollment or gender, are presented in Table II.

TABLE II

CHI-SQUARED ANALYSIS OF SUBJECT GROUP ASSIGNMENT

Source	DF	Pearson X^2	p-value
Gender	3	1.459	0.971
Taken Auditing	6	10.436	0.107
Expert System Use	3	3.838	0.280

Despite the fact that the median response for when auditing was scheduled within a subject's course of study differed between group assignment, this difference was not found to be significant ($p = 0.107$). Nor were there significant differences between groups for gender or prior expert system use.

Subject age, GPA, hours completed, level of comfort using computers, and degree of computer use had ordinal characteristics and were ranked accordingly. An analysis of variance on these ranked factors by group assignment was performed with results as shown in Table III:

TABLE III

ANOVAs TO COMPARE SUBJECT GROUPS FOR EACH RESPONSE VARIABLE

Response Variable	DF	Type I SS	Mean Square	F-Value	p-value	Levene's Test p-value
Age	3	345.731279	115.2437595	2.09	0.1043	0.1043
GPA	3	1.805238	0.060174	0.41	0.7456	0.4724
Hours	3	1608.09182	536.030607	0.85	0.4691	0.1896
Computer Comfort	3	4.735950	1.57864989	0.44	0.5067	0.9343
Computer Use	3	1.813330	0.604443	0.54	0.6555	0.2034

Analysis of variance on these ordinal demographic information factors reveals that none are significantly different due to group assignment. Taken together with the results presented in Table I, the four groups do not appear to differ by subject age, GPA, hours completed, computer comfort or use, gender, or auditing enrollment status. The randomization technique employed appear to be successful, and none of these factors need be employed as covariates in subsequent analysis.

Hicks (1993, p. 69) lists assumptions of an analysis of variance as:

1. The process is in control, that is, it is repeatable.
2. The population distribution being sampled is normal.
3. The variance of the errors within all *k* levels of the factor is homogeneous.

This experiment is repeatable. An assumption of normality is generally considered to be met when the sample size exceeds 30. In this case, the sample size is equal to 155. One method of determining whether the variances are homogeneous is Levene's Test for Equal Variances. With the Levene's Test, variances are assumed to be equal if the associated p-value is greater than 0.05. These tests were performed for each of the demographic variables used in the ANOVA and p-values are reported in Table III.

Results show that all variances may be assumed to be equal.

Variable Definitions

This investigation employed both independent and dependent variables. Because the literature presented mixed results concerning the constructs of explanations and their influence on declarative-stage learning and little evidence concerning the effects of abstraction and goal structuring on procedural-stage learning, these three constraints were the independent variables of concern in the current study. Since no demographic factors were found to differ significantly between groups, posttest measures of declarative- and procedural-stage learning, together with their pretest covariates were considered to be dependent variables. Discussion of both types of variables follows.

Independent Variables

Three independent variables were employed in this study: explanations, abstraction, and goal structuring. Explanations were presented as statements of control level and functional characteristic. For example, subjects were asked, for each scenario, who authorized hiring. The response choices were Personnel, Payroll, and Supervisor. When a subject selected the hiring agent for that scenario, a message box appeared stating, "This is an authorization control designed to prevent unauthorized personnel from being paid."

Explanations were provided for only five or six of the 22 questions posed with each scenario and were alternated among the eight scenarios. Thus an explanation for each control was presented twice during each of the two experimental sessions. Intermittent prompting, as given here, has been shown to be beneficial (Pei et al., 1994) because learners tend to disregard prompts that are presented at each step.

Abstraction was operationalized via a prompt that asked subjects to consider how the current control was similar to a control previously considered. For example, subjects were first asked who authorized hiring and then who approved overtime. When selecting the agent who approved overtime, a message box appeared asking how this control was similar to the hiring authorization function. Abstraction prompts were provided three times for each scenario.

To discriminate among differences, subjects had to first be presented with a control evaluation, make a change in one rule, and determine how that change would affect a subsequent evaluation. Therefore, subjects in the groups for which goal structuring was manipulated (i.e., Group 3 and Group 4) were first asked to enter the control environment depicted in a scenario and request the decision aid's evaluation of the adequacy of the controls. They were then asked to click on a "Make a Change" button. This button activated a screen that requested the subject to change his/her response for a particular question to something else and then to make another request for the IDA's evaluation of the adequacy of controls. For example, if the scenario said that the supervisor authorized hiring, the control evaluation was probably less than high (determination of control adequacy in each scenario involved several controls, therefore an exact evaluation cannot be stated here). If the subject changed the hiring agent to personnel, the subsequent control evaluation probably increased. Prompts for changes occurred three times in each scenario.

Dependent Variables

Anderson (1993) distinguished declarative-stage knowledge from procedural-stage knowledge by stipulating the first as "what to do" knowledge comprised of facts (chunks) and the second as "how to do it" knowledge comprised of production rules. Given these distinct forms of knowledge, the following discussion of dependent variables will group these variables by the knowledge stage to which they relate.

Declarative-Stage Knowledge

Declarative-stage knowledge is comprised of chunks or facts the learner has obtained from his/her environment. The ability to access these chunks is dependent upon the relative strength assigned to each chunk. One means of increasing a chunk's strength is for the learner to reference it multiple times. The IDAs utilized here employed rules used in the evaluation of the adequacy of internal controls. These rules embodied the controls themselves and the controls could be stated factually. Each control had both a level and a functional characteristic. Levels included prevention, detection and, correction. Functional characteristics included authorization, separation of responsibility, accounting records, access, and independent verification. For example the internal control of storing unused checks in a locked area exemplifies a preventive control that limits access to an asset. The ability to recall these facts is an integral part of learning to understand how internal controls work together in an internal control environment. A measure of a subject's ability to recall these facts about a control is to present a control and ask the subject to define the level and functional characteristic of that internal control. This was done for 10 different internal controls at both the pretest and posttest. This measure is referred to as **recall** in the remainder of this paper.

Procedural-Stage Knowledge

Procedural-stage knowledge is based upon a production system – a set of production rules necessary to demonstrate the ability to perform a cognitive skill. Anderson (1993) stresses that the relative strength and usefulness of each production rule is dependent upon how well that rule has been optimized. Anderson (1993) also asserts that well-optimized sets of production rules will allow the learner to better demonstrate cognitive skills and do so more quickly than non-optimized sets of production rules. The implication here is that a cognitive skill must be measured in terms of correctness and speed. For the current study, the cognitive skill in question is the ability to make accurate assessments of the adequacy of controls in a payroll environment. This assessment can be measured in terms of correctness and speed at which that assessment was made. A further implication is that assessment correctness and speed are dependent upon production-rule optimization.

IDAs that provided abstraction and/or goal structuring prompts were employed to help subjects optimize production rules. If subjects truly learned through their interaction with an IDA, then they should have been able to make a more accurate unaided assessments of the adequacy of internal controls after IDA. The global measurements of control assessment accuracy and control assessment speed were used in Eining (1988) and Eining and Dorr (1991) and are appealing as constructs here because they reflect the end stage of expertise acquisition. These measures will be referred to as the **control accuracy score** and **speed**, respectively.

A set of global measures, however, may not adequately capture the effects of abstraction and goal structuring. More direct measures of these activities are also warranted. Unfortunately, the literature did not provide pretested measures for these activities. The following measurements flowed instead from the experimental manipulations of abstraction and goal structuring.

Abstraction is a process of finding similarities among productions and then combining several similar productions into one production. If subjects successfully abstracted the rules in a control assessment task, they should have correctly determined when two or more controls were similar. One means of measuring the separate effect of abstraction was the score a subject received on a matching instrument where a subject was asked to choose from a set of controls, the one control that best paralleled another given control. The instrument was a matching quiz, and the number of correct matches on the quiz is referred to as a **match score**.

A prompt to stimulate this process has been shown to be necessary (Stein et al., 1982a; Stein et al., 1982b). Hornik and Ruf (1997) used examples of previously solved problems by having the user refer to a log. Such action is possible only for certain types of IDAs with log-viewing capabilities and it is not a usable alternative in all IDAs. Pei et al. (1994) used a system that displayed 27 rules. A prompt to consider the meaning of these rules appeared after the third and 19th rules. While Pei et al. (1994) did not directly manipulate abstraction or goal structuring with their prompting scheme, their scheme produced significant learning. In addition, their scheme was adaptable in most IDAs.

The frequency with which prompts should be provided is not known. Pressley et al. (1988), in a non-computerized setting, found benefits for prompting for each item to be learned. Gal and Steinbart (1992) raised the possibility that prompting at each rule in a computer-based system could actually cause the user to respond mechanically, thus decreasing true interactive behavior. Pei et al. (1994) found a significant benefit by presenting four prompts within a series of 27 rules. The study reported in this study relied on the Pei et al. (1994) findings and presented a proportional number of prompts, three[3].

Similarities in controls lie along two lines. Different controls are similar if they both fit into one of the control-level categories: preventive, detective, or corrective. Two controls are also similar if they both fit one of the following control function categories: (1) proper authorization of transactions, (2) separation of responsibilities, (3) design and use of adequate accounting records, (4) asset access limitation, and (5) independent verification. Consequently, abstraction prompts include asking the user to observe that two controls fall within the same functional category or perform the same level of protection (prevention, detection, and correction). All other things equal, it was expected that IDA users who received abstraction prompts would exhibit greater

[3] $4/27 \approx 3/22$

procedural-stage knowledge, as measured by the match score, than those who did not receive this prompt.

Goal structuring is a process of determining the effects of differences between competing productions. If subjects effectively accomplished goal structuring, they should have been able to determine the effect of a rule change on a control adequacy assessment. One means of measuring the separate effect of goal structuring was the score a subject received on a rule-change instrument. This instrument presented a control assessment along with a rule that was used in making that assessment. Subjects were then asked to determine the effect on control adequacy that resulted from a change in one control. The instrument was a quiz concerning changes and the number of correct determinations for the effect of each change and is referred to as the **change score**.

Using the prompting scheme stated above, goal structuring was also presented at two levels: present and absent. After viewing the system's conclusion, subjects were asked to change one or more of the input items and consider the effect of that change on the new system conclusion. The result of such an action allows the user to see both a correct and an incorrect application of a production and the total effect of that production on the conclusion. This study employed this type of system to measure the effect of goal structuring on knowledge transfer from an IDA.

Experimental Procedure

The experimental design employed is a 2 x 2 factorial arrangement of treatments in a randomized design. A 2 x 2 design implies two factors, each at two levels. The two factors in this study were abstraction and goal structuring, each factor was presented at two levels each – present and absent.

This study was conducted in two phases. A pilot was conducted during the Spring 1999 semester at Oklahoma State University. As will be explained in this chapter, this pilot study aided in identifying several control problems. The second phase of the study served as the basis for analysis. After addressing the control problems revealed in the first phase and making appropriate modifications to the study, the actual experiment was run over three semesters at the University of Nevada, Las Vegas. Discussion will first surround the actual experiment and then the pilot study.

The Pilot Study

The pilot study involved five sessions spanning a five-week period with one session held each week. The first session of the pilot study served as an orientation session as well as the collection period for demographic and pretest data. Subjects were randomly assigned to one of four treatment groups (i.e., one of the four IDAs) prior to the initial session. During each of the three experimental sessions (sessions two, three, and four), subjects were presented with eight different (i.e., 24 in total) scenarios. The final session served as a posttest and debriefing session.

Each experimental session was scheduled at various times throughout each week to accommodate subject schedules. Of the 83 subjects who completed the pilot study, 11 failed to attend one regularly scheduled session. Four subjects, for example, were allowed to join the test during the second week. These four participated in two sessions during the second week. Five subjects failed to attend one session each. The subjects were contacted by telephone and were rescheduled for a different session time. Two subjects missed the final session and were rescheduled for the following week.

Because this pilot study was not conducted during any regular group meeting time, the experimenter arranged seven meeting times for each session each week. To increase attendance, each subject was e-mailed or called each week to remind him/her of his/her scheduled meeting time. Further, if a subject failed to attend a session, the experimenter contacted that subject to arrange a make-up session. Only three subjects failed to complete the pilot study. In each case, withdrawal from the study followed withdrawal from the course from which the subject was recruited.

The pilot study provided an opportunity to identify several weaknesses in both the software and the experimental procedure. Identification of problems through the pilot study allowed the experimenter to make necessary corrections to improve the experimental environment. A discussion of these corrections follows.

During the second session of the pilot test it was discovered that subjects could click on the "continue" button at the bottom of each scenario input screen and continue to a second screen without completing work on the first screen. The impact of this shortcoming was that subjects could complete the experimental phase of this study without being exposed to the training manipulation. Prior to the third session, the program code was modified. Additional code was included to require each question to be answered sequentially and for all questions to be answered prior to screen advancement. This modified code was employed in subsequent testing.

While subjects in the pilot study had all taken a course in accounting information systems, this course could have been taken at any time and from several instructors. The problem that could stem from subjects' prior instruction from a variety of instructors concerned the mode of instruction. Pei and Reneau (1990) found that mental models need to match the presentation order of an IDA for users to be most successful in learning from the decision aid. The decision aid in this study employed a prevention, detection, and correction (PDC) approach that may or may not have matched the models of prior instruction. In the actual experiment, all subjects were presented with a PDC instructional model that matched the IDA model.

Demographic information was obtained from all pilot test subjects. This information included subject classification (i.e., junior, senior, graduate, or other), class enrollment (i.e., Auditing, EDP Auditing, Cost Accounting, or other), age (i.e., 18-21, 22-25, 26-29, or 30 or over), gender, GPA (i.e., Below 2.0, 2.0-2.4, 2.5-2.9, 3.0-3.4, or 3.5-4.0), prior expert system use, and level of comfort using computers (i.e., Very Comfortable, Comfortable, Neutral, Uncomfortable, or Very Uncomfortable). The purpose of this information was to determine whether the randomization technique employed was successful or whether any of these factors should be employed as covariates in subsequent analysis. A number of shortcomings existed with the factors and response categories presented. Subject classification, for example, proved to be somewhat ambiguous for the Oklahoma State University students. Oklahoma State University offers a traditional four-year accounting degree as well as a 3-2 degree that leads to a Master's degree. Some subjects enrolled in the 3-2 program considered themselves to be graduate students even though they had not completed a minimum of 120 hours. A more exact measure of "number of hours completed" was subsequently used in the study described in the actual experiment.

Responses to the question of age were presented in range form, one range being "30 or over." This broad category was not sensitive to the wide disbursement of possible numbers that existed with ages greater than thirty. The demographic instrument was adjusted to request subjects provide age in years rather than via ranges.

A final point of confusion with demographic information solicitation concerned GPA. Students at Oklahoma State University receive several differently computed GPAs. While the GPA a subject had earned toward matriculation was expected, the type of GPA each subject reported was uncertain. The alternatives included the GPA a subject expected to earn during the current semester, the GPA earned in a major field of study, and upper division GPA. The demographic instrument was adjusted to provided exact instruction as to the GPA requested. In addition, GPA was solicited as a number rather than a range.

The final session served several purposes. In this session, posttest data was received, data for manipulation checks were provided, and debriefing was performed. Another problem was discovered with this final session of the pilot study, manipulation checks were not sensitive enough to be useful. The following changes were made and used in the actual study. (1) "The project was a good learning experience" was changed to " My knowledge of internal controls improved because of this project." (2) The length of time was changed from five to four weeks on one question. (3) "My ability to recognize similarities among internal controls improved through this project" was added. (4) "Projects like this should become a part of every accounting course" was changed to "I believe all accounting courses should require projects that use the computer." And (5) "I tried as hard as I could to gain knowledge from this project" was added.

Experimental Study

The experiment that provided data for analysis involved four sessions spanning a four-week period with one session held each week. No information existed to suggest an optimal number of experimental repetitions, and scheduling constraints made a shorter period necessary. The experiment was replicated with groups in each of three consecutive semesters.

The first session served as an orientation session as well as the collection period for demographic and pretest data. During the first session, each subject provided demographic information through a computerized interface. Further, each subject was tested on his/her knowledge of internal controls by his/her responses to a series of questions. These questions were designed to measure the subjects' ability to recall control levels and functional characteristics, to recognize similarities and differences among controls, and to accurately assess the adequacy of controls in five different internal control scenarios. In addition, a measure of problem-solving speed was recorded based upon the five internal control scenarios. The results of the pretest data served as a base-line for subsequent learning.

Sessions two and three served as the experimental sessions in which subjects were randomly assigned to one of four treatment groups (i.e., one of the four IDAs). During each of the two experimental sessions, subjects were presented with eight different (i.e., 16 in total) scenarios. Subjects were asked to respond to 22 questions within each scenario. The responses to these questions provided the IDA with the input necessary for the system to evaluate the adequacy of the internal control structure for each scenario. Subjects were then asked to request the IDAs' evaluations and to read those evaluations along with the rules the system evoked.

In addition to the systems' evaluations of control adequacy, all subjects received cues concerning the level and functional characteristic of each internal control. Further, all subjects, except those in the control group, received prompts designed to stimulate abstraction and/or goal structuring. The nature of these cues and prompts will be explored in a subsequent section.

To increase the chance that subjects would complete each scenario, fully respond to all questions, attend to the cues, and respond to the prompts, several steps were taken. The responses to each scenario were recorded on individual diskettes. The system was coded to ensure that each of the 22 questions concerning each scenario had been answered before a subject could advance to a new screen and start a new scenario. The software was written so that subjects had to respond to each question sequentially. For example, if the first question was left blank and a subject attempted to respond to the second question, a message box appeared saying, "You must respond to Question #1 before you may proceed," and the answer to the second question was rejected. Cues and prompts were presented in message boxes that were cleared only by clicking an OK button. While this last measure did not guarantee subject attention to the content of the message box, it did at least require the subject to look at the message box. In addition, the experimenter roamed the classroom during all sessions.

The final session served as a posttest and debriefing session. As with the first session, subjects were presented with questions designed to measure their ability to recall control levels and functional characteristics, to recognize similarities and differences among controls, and to accurately assess the adequacy of controls in five different internal control scenarios. A measure of problem-solving speed was recorded. The posttest data reflected the results of subject responses without the aid of an IDA and served as a measure of learning. Finally, a set of questions to illicit subject feedback was presented. Appendix A contains simulations of each of the interface screens used during the pretest, experimental, and posttest sessions.

Incentives and Motivation

Subjects in this pilot test were motivated to participate in two ways - via class credit and through a monetary incentive. Providing class credit for participation was not considered to be an adequate means of motivating subjects to perform at their highest level. In the workplace, such a level of performance is stimulated through monetary incentives. Bolle (1990), recognized that the monetary incentives offered in many studies seemed unrealistically low and limited expected subject motivation and experimental abstraction. Bolle utilized a lottery system wherein one subject received the entire budgeted experimental remuneration. Bolle found, that while the expected value of the remuneration was equal to a low payoff, subjects were more inclined to participate given one chance to win a substantial amount. Bolle's premise was incorporated into the incentive structure of the pilot study. Subjects were informed that one person from each of the four experimental groups would win $100 based on his/her responses throughout the experiment. Subjects were not told which responses would be considered but that their best efforts throughout the experiment should be provided.

While a monetary incentive might be helpful in stimulating a higher level of participation, one could not be offered for the actual experiment. The experimenter was also the instructor of the classes from which subjects were drawn. Because of this duel status, a monetary incentive was not offered. Discussion with University of Nevada, Las Vegas officials yielded a concern that a monetary incentive could compromise the appearance of the instructor's objectivity. Instead, only class credit was offered to subjects in the actual experiment. Therefore, an incentive to earn up to 50 points (approximately 8.3% of the total available points) was the only participation incentive.

All subjects were aware that they were being observed, the experimenter could visually ascertain that some degree of attention was being paid to the task, and subject questions could be asked and answered. In addition, subjects were informed that the credit to be received for participation would be based upon responses that were recorded throughout the experiment, to earn full credit, a subject needed to do his/her best on all parts of the experiment.

Predictions and Models

Declarative-stage knowledge, as measured by accuracy in rule recall, was expected to increase for all subjects through IDA interaction. Further, the treatment effects stated below should not have affected any of the experiment groups' abilities to recall. The model used to evaluate this prediction is:

$$Recall2_{ijk} = \mu + \beta(Recall1_{ijk} - \overline{Recall1}) + ABS_i + GS_j + ABS_i \times GS_j + \epsilon_{ijk}$$

where:

$Recall2_{ijk}$ = The posttest recall score for the *k*th observation (*k* = 1 . . n) on the *i*th abstraction treatment (*i* = 1 or 2) and the *j*th goal structuring treatment (*j* = 1 or 2).

μ = The effect common to the whole experiment.

β = The slope coefficient between Recall2 and Recall1 over all data.

$Recall1_{ijk} - \overline{Recall1}$ = The adjustment for covariation between the pretest measure and the treatment.

ABS_i = The effect of the *i*th treatment (*i* = 1 or 2) - whether abstraction is introduced or not.

GS_j = The effect of the *j*th treatment (*j* = 1 or 2) - whether goal structuring is introduced or not.

ϵ_{ijk} = The random error present in the *k*th observation on the *i*th and *j*th treatments.

This model is an analysis of covariance. The reasoning for using an analysis of covariance as opposed to an analysis of variance is discussed in detail in the next chapter. A simple explanation of the model is provided here. Recall2 is the posttest recall score for each subject. The model implies that the value for each posttest score is dependent upon each subject's pretest score (Recall1) – adjusted for the average pretest Recall score for all subjects -- and group assignment (i.e., the group receiving abstraction prompts, goal structuring prompts, neither, or both). Group assignment is captured by ABS (presence or absence of abstraction prompts), GS (presence or absence of goal structuring prompts) and the interaction of ABS and GS.

The procedural-stage activities of abstraction and goal structuring were also considered here. In this experiment, abstraction was presented at two levels: present and absent, as was goal structuring. These optimization techniques were predicted to enhance cognitive skill acquisition. Cognitive skill acquisition could be measured by the global variables of control accuracy score and speed. Based on theoretical predictions, abstraction should be positively correlated with match score and goal structuring should be positively correlated with change score.

The multivariate and univariate models employed in the analysis of these predictions were as follow: A multivariate model that evaluated whether abstraction or goal structuring or a combination of the two affected a subject's ability to accurately recall the level and/or characteristic of a control, match similar controls, find the effect of a change in controls, assess the adequacy of internal controls in a payroll environment, and the speed at which a subject completes the control assessment tasks is stated as:

Recall/Match/Change/Scenario/Speed = $\mathbf{X\beta} + \mathbf{Z\alpha} + \epsilon$

where:

Recall/Match/Change/Scenario/Speed= An 155 x 6 matrix of the ten internal control level response totals, ten internal control characteristic response totals, ten match response totals, ten change response totals, five scenario scores and speed measure, all taken at the posttest for each subject.

$\mathbf{X}$ = An 155 x 4 identity matrix.

β = A 4 x 6 matrix designating the experimental treatment by which each of the 6 response measures were influenced. There are two levels of each treatment: (2 x 2 = 4).

$\mathbf{X\beta}$ = The treatment partition of variance.

$\mathbf{Z}$ = An n x 6 matrix of the six pretest response measures of each subject.

α = 6 x 6 matrix having the slope coefficients (α_1 to α_5) on the diagonal and zeros elsewhere.

$\mathbf{Z\alpha}$ = The covariant partition of variance.

ϵ = An 155 x 6 matrix of the error. The transpose of each 6 x 1 row of ϵ has a 6 x 6 covariant matrix.

This model represents an analysis of covariance with multiple dependent variables and is stated using the matrices that are employed in the analysis. The six dependent variables are the posttest measures of recall (both the level and characteristic of an internal control), match, change, control accuracy, and speed. Each of these dependent variables is assumed to be reflective of both an individual's six pretest scores and the individual's group assignment.

The univariate models to assess the effects of abstraction and/or goal structuring on the ability to match similar controls, distinguish the effect of control changes, and assess control accuracy score are:

$Match2_{ijk} = \mu + \beta(Match1_{ijk} - \overline{Match1}) + ABSi + GS_j + ABS_i \times GS_j + \epsilon_{ijk}$

where:

$Match2_{ijk}$ = The match score for the *k*th observation ($k = 1 \ldots n$) on the *i*th abstraction treatment ($i = 1$ or 2) and the *j*th discrimination treatment ($j = 1$ or 2).

μ = The effect common to the whole experiment.

β = The slope coefficient between the pretest and posttest Match Score over all data.

$Match1_{jk} - \overline{Match1}$ = The adjustment for covariation between the pretest measure and the treatment.

ABS_i = The effect of the *i*th treatment ($i = 1$ or 2) - whether abstraction is introduced or not.

GS_j = The effect of the *j*th treatment ($j = 1$ or 2) - whether goal structuring is introduced or not.

ϵ_{ijk} = The random error present in the *k*th observation on the *i*th and *j*th treatments.

This model is also an analysis of covariance (ANCOVA) and the remarks made for the previous ANCOVA pertain here as well. Instead of Recall, however, this model implies that the posttest Match Score (Match2) is dependent upon both the pretest Match Score (Match1) (adjusted for the average of all pretest Match Scores) and an individual's group assignment. The groups provided with abstraction prompts were expected to earn higher average Match Scores than the groups not receiving abstraction prompts.

$\text{Change2}_{ijk} = \mu + \beta(\text{Change1}_{ijk} - \text{Change1}) + \text{ABSi} + \text{GS}_j + \text{ABS}_i \times \text{GS}_j + \epsilon_{ijk}$

where:

Change2_{ijk} = The change score for the *k*th observation ($k = 1 \ldots n$) on the *i*th abstraction treatment ($i = 1$ or 2) and the *j*th discrimination treatment ($j = 1$ or 2).

μ = The effect common to the whole experiment.

β = The slope coefficient between the pretest and posttest Change Score over all data.

Change1_{jk} - Change1 = The adjustment for covariation between the pretest measure and the treatment.

ABS_i = The effect of the *i*th treatment ($i = 1$ or 2) - whether abstraction is introduced or not.

GS_j = The effect of the *j*th treatment ($j = 1$ or 2) - whether goal structuring is introduced or not.

ϵ_{ijk} = The random error present in the *k*th observation on the *i*th and *j*th treatments.

This model is also an ANCOVA that implies an individual's posttest Change Score (Change2) is dependent upon his/her pretest Change Score (Change1) adjusted for the average pretest Change Score and the individual's group assignment. The groups receiving goal structuring prompts were expected to earn higher average change scores than the other groups.

Control Accuracy $Score2_{ijk} = \mu + \beta$(Control Accuracy $Score1_{ijk}$ - Control Accuracy $Score1$) + ABSi+ $GS_j + ABS_i \times GS_j + \epsilon_{ijk}$

where:

Control Accuracy $Score2_{ijk}$ = The control accuracy score for the *k*th observation ($k = 1 \ldots n$) on the *i*th abstraction treatment ($i = 1$ or 2) and the *j*th discrimination treatment ($j = 1$ or 2).

μ = The effect common to the whole experiment.

β = The slope coefficient between the pretest and posttest Control Accuracy Score over all data.

Control Accuracy $Score1_{jk}$ - Control Accuracy Score1 = The adjustment for covariation between the pretest measure and the treatment.

ABS_i = The effect of the *i*th treatment ($i = 1$ or 2) - whether abstraction is introduced or not.

GS_j = The effect of the *j*th treatment ($j = 1$ or 2) - whether goal structuring is introduced or not.

ϵ_{ijk} = The random error present in the *k*th observation on the *i*th and *j*th treatments.

This ANCOVA implies a relationship similar to the previous ANCOVA's. Here, the posttest Control Accuracy Score (Control Accuracy Score2) is dependent upon the pretest Control Accuracy Score and group assignment. The groups receiving abstraction and/or goal structuring prompts were expected to earn higher average control accuracy scores than the control group. Further, the group receiving both types of prompts were expected to earn higher average control accuracy scores than any of the other groups.

The model used to assess the effects of abstraction and/or goal structuring on speed is :

$$Speed2_{ijk} = \mu + \beta\,(Speed1_{ijk} - \overline{Speed1}\,) + ABS_i + GS_j + ABS_i \times GS_j + \epsilon_{ijk}$$

where:

$Speed2_{ijk}$ = The average time for the *k*th observation ($k = 1 \ldots n$) on the *i*th abstraction treatment ($i = 1$ or 2) and the *j*th goal structuring treatment ($k = 1$ or 2).

μ = The effect common to the whole experiment.

β = The slope coefficient between Speed1 and Speed2 over all data.

$Speed1_{ijk} - \overline{Speed1}$ = The adjustment for covariation between the pretest measure and the treatment.

ABS_i = The effect of the *i*th treatment ($i = 1$ or 2) - whether abstraction is introduced or not.

GS_j = The effect of the *j*th treatment ($j = 1$ or 2) - whether goal structuring is introduced or not.

ϵ_{ijk} = The random error present in the *k*th observation on the *i*th and *j*th treatments.

This model captures the effects of both the pretest measure of problem-solving speed (Speed1) and group assignment on the posttest measure of problem-solving speed (Speed2). The group receiving both abstraction and goal structuring prompts were expected to have a significantly lower problem-solving speed at posttest than the other groups.

Summary

To test the effects of explanations, abstraction, and goal structuring, 155 subjects used one of four different IDAs over a two-week period. Prior to IDA use and after IDA use, measures were taken of subject ability to recall the levels and functional characteristics of several internal controls. In addition, measures were taken for subject ability to find similarities and differences among internal controls, ability to accurately access internal control adequacy, and problem-solving speed. The decision aids introduced prompts that provided descriptive information about specific internal controls, requested subjects to consider similarities among internal controls, and requested specific changes to an internal control scenario. Because explanations, abstraction, and goal structuring are all theorized to be instrumental in the demonstration of a cognitive skill, the prompts provided by the IDAs were expected to cause an increase in the measures taken from subjects from pretest to posttest.

Chapter two highlighted the need to investigate the effects of explanations, abstraction, and goal structuring on learning through the use of IDAs. Chapter three laid out the theory that drove the hypotheses concerning the effects of explanations, abstraction, and goal structuring on learning through the use of IDAs. This chapter has developed the task, experimental design, and models to be employed to test these hypotheses as well as the outcomes predicted. The next chapter will provide the results of these tests.

CHAPTER V

RESULTS

Introduction

Anderson (1993) asserted that a learner must first accumulate facts about a new situation. These facts are stored as chunks in declarative memory and are more likely to be recalled as they gain strength. One means of strengthening chunks is to provide the learner with explanations about the facts. Prior research has provided mixed results for the effects of explanations provided by intelligent decision aids (IDA) on declarative-stage recall. Anderson (1993) further suggested that procedural-stage production rules could be optimized via abstraction and goal structuring. The advantage of these two optimization techniques is that optimized production rules become both more successful and less costly. Little can be found in the literature that provides evidence on whether an IDA can help the learner optimize production rules.

The current study presents an examination of the effects of explanations on a learner's ability to recall declarative-stage facts. One reason this recall ability is important to the learner is that production rules are formed from chunks, and production rules are the means by which a learner can demonstrate the acquisition of a cognitive skill. While Anderson (1993) claimed that optimization is important, he did not provide any guidance as to whether any of the optimization techniques are internally or externally derived. The current study may shed some light on the nature of abstraction and goal structuring. Further, the current study examines whether an IDA can be devised to help the learner obtain optimized production rules.

All three mechanisms (explanations, abstraction, and goal structuring) were used in a series of prompts provided to users of IDAs in the experiment conducted here. Explanations concerning the level and characteristic of a number of internal controls were provided to 155 subjects. These subjects had the task of determining the adequacy of internal controls in a payroll environment and were provided with one of four IDAs to help them complete the task. While all subjects received explanation prompts, the total group was divided among four different IDAs. One group received prompts designed to stimulate both abstraction and goal structuring, one group received prompts for just abstraction, one for just goal structuring, and the final group received neither of these optimization prompts. Information was collected at pretest and posttest to determine whether any of these prompts were effective in promoting learning. This chapter presents the results of this examination.

Multiple- and univariate-analysis of covariance models were computed for each of the dependent variables (recall – of the level or characteristic of an internal control, match score, change score, control accuracy score, and problem-solving speed). These models provided statistical tests for the hypotheses generated in chapter three. The multiple analysis of covariance (MANCOVAs) provides an indication of overall significance. That is, whether explanations, abstraction, and/or goal structuring significantly affected at least one of the dependent variables. Only marginal multivariate significance was found. Subsequent univariate analysis of covariance (ANCOVA), however, revealed no significant effect of explanations on recall, and abstraction and/or goal structuring on the match score, change score, control accuracy score, or speed.

The overall lack of significant findings requires a more in-depth examination of the results of the experiment described in the previous chapter. This examination shall explore the statistical tests employed, the results of the analysis, and the relationship of these results to the specific hypothesis tested. In addition, discussion of the findings and subsequent analysis is presented.

Statistical Tests

This section will proceed as follows: First, the multivariate procedure will be presented and then the results of univariate tests will be examined. The univariate tests include ANCOVAs for recall ability, the ability to find similarities among internal controls, the ability to determine the effects of differing internal controls, the ability to accurately assess internal control adequacy, and the speed at which control adequacy assessments were made.

Six pretest and posttest measures were obtained for each subject in this experiment. These measures included each subject's ability to correctly recall internal control levels and functional characteristics, his/her ability to match similar controls, his/her ability to determine the effect a change might have on assessment of control accuracy, his/her ability to correctly assess the adequacy of internal controls, and how quickly he/she made that assessment. An increase of any of these measures from pretest to posttest represents an indication of learning. As a control for potential differences in the treatment groups, an analysis of covariance was performed. Such an analysis treated the pretest scores as a covariant with the treatment. Cook and Campbell (1979) and Hicks (1993) both suggested a preference for MANCOVA over MANOVA when each subject is measured at pretest and posttest. The advantage of using this technique is that one is not limited to running an experiment on only those pupils who have approximately the same pretest scores or matching pupils with the same pretest scores and randomly assigning them to control and experimental groups. Covariance analysis has the effect of providing 'handicaps' as if each student had the same pretest scores while actually letting the pretest scores vary along with the gains (Hicks, p. 388).

Steel and Torrie (1980) suggest that MANCOVA is appropriate when the observed variation in the dependent variable is partly attributable to variation in an independent variable. "The use of covariance removes, by regression, certain effects that cannot be or have not been controlled effectively by experimental design" (Steel and Torrie, 1980, p. 402).

The strongest approach for analyzing related multiple dependent variables was to conduct one test that encompassed all the dependent variables (Stevens, 1996). A univariate assessment with $\alpha = 0.05$ yields a 0.05 probability of failing to reject a spurious result. Conducting the same univariate test six times for the variables used here would have produced a Bonferonni $\alpha \leq 0.30$ (i.e., a 0.30 probability of rejecting a true hypothesis[1].) One method of controlling *alpha* when several dependent variables are present is to conduct one analysis that involves all the dependent variables. If that analysis proves to be significant at the $\alpha = 0.05$ level, then it can be implied that significance exists for at least one of the dependent variables and the researcher can examine each dependent variable univariately to determine which variable(s) is significant without losing control of the tests. This study examined six measures of learning (i.e., six dependent variables).

As Table I -- in the previous chapter -- indicated, cell sizes for analyses were not equal. Thirty nine subjects were assigned to three of the experimental groups and only 38 were assigned to the fourth. Therefore, all analysis of covariance were conducted using the General Linear Models procedure in *SAS version 6.12*[2]. This procedure uses the harmonic mean rather than the arithmetic mean for analyses.

The MANCOVA

Hair et al. (1995, p 274) provided the following framework for a multivariate analysis of covariance. Multivariate analysis of covariance (MANCOVA) is a simple extension of the principles of ANCOVA to multivariate analysis; that is, MANCOVA can be viewed as MANOVA of the regression residuals (i.e., variance in the dependent variables not explained by the covariates.) Two-step analyses were performed. A

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[1] A Bonferonni inequality is approximated by the number of dependent variables times *alpha*. Here $\alpha = 0.05$ and there are six dependent variables.

[2] *SAS* is a registered trademark of SAS Institute, Inc., Cary, NY.

multiple regression in which each of the six pretest measures were regressed on the six posttest measures and the six posttest residuals of this regression were outputted. Then a MANOVA using these residuals as dependent variables and the treatment factors as independent variables provided statistics for analysis. This model was developed in the previous chapter and is stated here in two parts, the first represents the regression model and the second the MANOVA model.

$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}\boldsymbol{\alpha} + \varepsilon$ (The Regression Model)

where:

$\mathbf{Y}$ = an 155 x 6 matrix of posttest control adequacy scores.

$\mathbf{X}$ = an 155 x 4 design matrix.

β = a 4 x 6 matrix defining each subject's treatment group by which the posttest scores were influenced.

$\mathbf{Z}$ = an 155 x 6 matrix of the 6 pretest scores for each subject.

α = a 6 x 6 matrix with the slope coefficients for the pretest scores on the diagonal and zeros elsewhere.

ε = an 155 x 6 matrix of error.

$\mathbf{R} = \mathbf{X}\boldsymbol{\beta} + \varepsilon$ (The MANOVA)

where:

$\mathbf{R}$ = an 155 x 6 matrix of the residuals for each of the 46 posttest measures.

$\mathbf{X}$ = an 155 x 4 design matrix.

β = a 4 x 6 matrix defining the treatment group by which the posttest scores were influenced.

ε = an 155 x 6 matrix of error.

Wilks' λ is a measure of the effect the independent variables had on the dependent variables. The Wilks' λ F-statistic was 0.941768 with a p-value of 0.11 and is, at best, only marginally significant. Nonetheless, given the complexity of the model, it was assumed that the marginal significance found in this MANCOVA was sufficient to warrant examination of the univariate tests directed specifically at each of the hypotheses. The following are MANCOVA assumptions (Stevens, 1996):

1. The observations are independent.
2. The observations on the dependent variables follow a multivariate normal distribution.
3. The population covariance matrices for the six dependent variables are equal.

A lack of independence among observations can result from a group setting where an entire group is affected by common experiences. These experiences can include but are not limited to confusing instructions and room noise. Hair et al. (1995) suggest employing a form of covariant analysis to account for dependence. The above analysis was an analysis of covariance.

Hair et al. (1995) and Stevens (1996) state that a test for multivariate normality does not exist. Moreover, both authors suggest that violations of this assumption are inconsequential when, as with ANOVA, a sample size exceeds 30. Accordingly, no tests of normality were conducted.

The final assumption, homogeneity of covariance matrices, was tested via a Chi-square analysis. Test results of Chi-square = 73.3012 and p-value = 0.1760 support a conclusion that the population variances for the groups may be considered to be approximately equal. Hair et al. (1995) and Stevens (1996) also note that MANCOVA is conditionally robust to this assumption. If group sizes are equal or approximately equal, the condition for robustness is met. Approximately equal groups are those where the largest is not more that 1.5 times the smallest. In this study, the largest group size was 39 and the smallest group size was 38.

Recall

The ability to retrieve declarative-memory chunks (Recall) is a foundation of learning. Recall was operationalized as the subjects' ability to correctly determine both the level (prevention, detection, or correction) and characteristic (access, accounting records, authorization, separation of function, or independent verification) of a given internal control. Subjects were given ten internal controls and asked, for each control, to provide the control's functional level and characteristic. For example, the first control element was "using an internal auditor to investigate payroll complaints." The level choices were: Prevention, Detection, and Correction. The functional characteristic choices were : Access, Accounting Records, Authorization, Independent Verification, and Separation of Function. The correct responses were Independent Verification and Correction (a replication of the computer interface is provided in Appendix A). The *Visual Basic* program was coded to collect the total number of correct responses. This total ranged from a possibility of zero to 20. The recall exercise was presented at pretest and posttest.

The first two hypotheses concerned the effects of explanatory prompting on recall and are restated as:

H_1: There will be no difference in the ability to retrieve declarative chunks before and after activities designed to increase chunk strength.

H_2: There will be no difference in declarative chunk retrieval ability between groups of individuals engaging in identical strengthening activities.

The first hypothesis, in the alternate form, predicted that recall scores would increase from pretest to posttest. The second hypothesis, in null form predicted there would be no difference in posttest recall scores due to group assignment. Table IV presents the pretest and posttest mean recall scores for each group. Table V presents the means and the results of a T-test of differences between the means.

TABLE IV

GROUP RECALL MEANS

	Group 1	Group 2	Group 3	Group 4
Pretest Recall Scores	16.2307	15.5385	15.1538	16.3421
Posttest Recall Scores	14.9744	15.2308	15.3077	15.3947

TABLE V

RECALL MEANS AND T-SCORE

Variable	Mean	Std Dev	Std Error	T-Score	p-value
Pretest Recall Scores	15.8129	2.1405	0.1719		
Posttest Recall Scores	15.2258	2.2808	0.1832		
Paired Difference	-0.5871	2.1435	0.1722	-3.4100	0.0008

For two groups, group one and group two, average recall scores actually decreased from pretest to posttest while groups three and four showed an increase. Table V reveals pretest and posttest recall means and their differences for all subjects. These results indicate that recall scores decreased, on average, 0.5871 from pretest to posttest and that this decrease was significant. However, this was a one-tailed T-test with a predicted positive value. Therefore, the p-value must be reversed for correct interpretation (i.e. p-value = 1.0 - 0.0008 = 0.9992). The conclusion is that the message boxes (explanations) were not an effective method of helping all subjects recall control characteristics and the level of these controls. Results of an analysis of covariance for recall scores are presented in Table VI. The assumptions for ANCOVA (as stated in the previous chapter) were met for this examination.

TABLE VI

ANCOVA FOR RECALL SCORES

Source	DF	Type I SS	Type I MS	F-Value	p-value	Levene's p-value
Recall Pretest	1	226.2539	226.2539	61.15	0.0001	
Abstraction	1	0.0428	0.0428	0.01	0.9145	
Goal structuring	1	2.2242	2.2242	1.14	0.2870	
Abstraction x Goal structuring	1	15.6151	15.6151	4.22	0.0417	0.7693
$R^2 = 0.307249$						

As Table VI indicates, there is a significant difference ($p = 0.0417$) in the mean posttest recall scores for at least one of the experimental groups. Specifically, the mean posttest recall score for group four (the group receiving prompts for abstraction and goal structuring) was significantly higher than the mean posttest recall score for group one (the group that did not receive any abstraction or goal structuring prompts). The predicted outcomes for both hypotheses one and two did not occur. The explanations provided did not help all subjects to recall better (fail to reject hypothesis one) and there was a difference in average recall scores based on group assignment (reject hypothesis two). Two possible explanations exist. The first is based upon the fact that the group receiving both abstraction and goal structuring prompts outperformed the other groups in their ability to recall declarative facts. Declarative facts form the basis for production rules that the optimization techniques seek to improve. The extra drilling on these production rules encouraged by the abstraction and goal structuring prompts may have helped subjects strengthen the chunks in which the declarative facts reside. A second possible explanation is that all subjects, on average, ignored the explanations provided. Only the procedural-stage prompts were attended to, prompts that the poorest performing group (group one) did not receive.

In light of the mixed results for the effect of explanations found in prior work, some discussion is in order. The effect of explanations has been tested on a set of variables that forms a continuum from declarative-stage measures to procedural-stage variables. Murphy (1990) employed a declarative-stage variable and found that his explanations were not effective. Steinbart and Accola (1994) found that the type of explanation did not matter. Odom and Dorr (1995) found that explanations which were accompanied by examples had an interactive effect with placement on declarative-stage knowledge. Explanations alone had no effect. Pei et al. (1994) found a positive effect for explanations on their declarative-stage variable. Eining (1988) and Eining and Dorr (1991) found no effect for explanations on procedural-stage variables.

Murphy (1990) and Steinbart and Accola (1994) had findings that differed from the other researchers who investigated the effect of explanations on declarative-stage knowledge. However, IDA users who received explanations in Murphy (1990) had a higher, but not significantly higher, average score on his declarative-stage measure than did IDA users who did not receive explanations. Steinbart and Accola (1994) found their simple explanation was just as effective as a more complex one. The findings here fail to support these other findings.

Anderson (1993) established a connection between explanations and declarative-stage knowledge. Because Eining (1988) and Eining and Dorr (1991) looked for a procedural-stage relationship, their lack of significant findings actually support Anderson's (1993) theory.

The present study found that explanations did not cause increased recall scores for all subjects. This study also found that when both abstraction and goal structuring prompts were combined with explanations, higher recall scores did result. These findings lend support to the findings of Odom and Dorr (1995). Explanations alone do not seem to affect declarative-stage learning; instead, a combination of explanations with procedural-stage variables is necessary. The preponderance of evidence suggests that explanations, even the simple ones used here and in Steinbart and Accola (1994), can be beneficial in increasing declarative-stage knowledge, provided other information is also given.

Match Score

The match score was operationalized as the total number of matching questions each subject answered correctly. At both the pretest and the posttest, all subjects were presented with a ten-question matching quiz. The intent of the quiz was to find how well subjects could identify similarities among rules. Finding similarities is a necessary step toward abstraction.

Subjects were given a control and asked to choose from a list of controls the one control that was most like the given control. For example, one given control was having a supervisor approve overtime. The parallel control choices were: "Having payroll post earnings to individual accounts," "Having a paymaster distribute paychecks," "Comparing the job cards to the time cards," and "Having personnel authorize overtime." The correct choice was the last one because both the given control and the optimal choice are authorization controls that are designed to prevent errors.

The experiment program code was written to determine correct responses and to tabulate the number of correct answers for each subject. The average pretest and posttest scores for each group are presented in Table VII. Group one was the control group, group two had abstraction prompts, group three had goal structuring prompts, and group four had both types of prompts.

TABLE VII

GROUP MATCH SCORE MEANS

	Group 1	Group 2	Group 3	Group 4
Pretest Match Score	5.9488	6.1282	5.2308	6.2105
Posttest Match Score	6.2308	5.9231	5.3077	6.4211

By recognizing similarities among internal controls, subjects were matching condition-side patterns among production rules. The third hypothesis, which is restated here, provided a testing structure for the effects of abstraction on a subject's ability to match similar internal controls.

H_3: There will be no difference in pattern-matching abilities between individuals who engage in abstraction activities and individuals who do not engage in abstraction activities.

The third hypothesis, in the alternate form, postulated that the experimental groups that received abstraction prompts would outperform the other groups in their abilities to determine the correct association among controls. Table VII provides initial evidence that the predicted direction of change is not satisfied. The only group to decline in average match scores from pretest to posttest was group two – the group receiving only abstraction prompts. Further, the average posttest match scores for groups one and three – the two groups that did not receive abstraction prompts – increased. An ANCOVA was performed to test the third hypothesis and the results are presented in Table VIII.

TABLE VIII

ANCOVA FOR MATCH SCORE

Source	DF	Type I SS	Type I MS	F-Value	p-value	Levene's p-value
Pretest Match Score	1	36.6657	36.6657	23.09	0.0001	
Abstraction	1	2.2065	2.2065	1.39	0.2403	
Goal structuring	1	4.5521	4.5521	2.88	0.0915	
Abstraction x Goal structuring	1	0.5953	0.5953	0.37	0.5413	0.5838
$R^2 = 0.156085$						

Analysis shows a lack of significance and a failure to reject the null hypothesis that no difference exists in the average match scores among the four groups. It was predicted that this hypothesis would be rejected, but it seems that the abstraction prompts, or lack thereof, actually performed in antithesis of the theorized direction.

Change Score

The change score was operationalized as the total number of questions concerning the effect of a change each subject answered correctly. At both the pretest and the posttest, all subjects were presented with a ten-question change quiz. The intent of this quiz was to find how well subjects could identify the change in control adequacy resulting from differing rules. Finding differences among rules is a necessary step toward goal structuring.

Subjects were given a control adequacy assessment that resulted from one of several control conditions. They were then told that the control condition had changed and were asked to determine whether their new control adequacy assessment would increase, decrease, or remain the same. For example, if the adequacy of internal controls was determined to be high because it was believed that blank checks were tightly controlled and then it was determined that those checks were not tightly safeguarded, the subjects' new determination of control adequacy should have decreased.

The experiment program was written to determine correct responses and to tabulate the number of correct answers for each subject. The average pretest and posttest scores for each group are presented in Table IX.

TABLE IX

GROUP CHANGE SCORE MEANS

	Group 1	Group 2	Group 3	Group 4
Pretest Change Score	5.2821	5.0770	5.3077	5.1842
Posttest Change Score	6.1026	5.8462	5.9231	5.9474

Being able to recognize the effects of changes in internal controls is analogous to responding to differing outcomes. The theorized relationship between goal structuring and recognizing differing internal controls is given in hypothesis five:

H_5: There will be no difference in responding to different outcomes among individuals who engage in goal-structuring activities and individuals who do not engage in goal structuring activities.

The fifth hypothesis, in its alternate form, predicted that groups that received goal structuring prompts (groups three and four) would have higher average change scores than would groups that did not receive goal structuring prompts. An evaluation of the means presented in Table IX shows that on average all groups improved their mean change score from pretest to posttest. An ANCOVA was also performed to test this hypothesis. Results are presented in Table X.

TABLE X

ANCOVA FOR CHANGE SCORE

Source	DF	Type I SS	Type I MS	F-Value	p-value	Levene's p-value
Pretest Change Score	1	9.64419	9.64419	7.46	0.0071	
Abstraction	1	0.32632	0.32632	0.25	0.6160	
Goal structuring	1	0.09697	0.09697	0.08	0.7846	
Abstraction x Goal structuring	1	0.69784	0.69784	0.54	0.4637	0.0723
$R^2 = 0.052595$						

Results of this ANCOVA show that while all groups increased their average scores on the change quiz from pretest to posttest, the change was not significantly different between any of the groups. The only conclusion that may be drawn here is that the use of the IDA was sufficient to increase all subject's abilities (on average) to recognize the effects of differing internal controls on their evaluation of internal controls. The prompts provided to stimulate improvement did not seem to make a difference in this measure.

The fourth and sixth hypotheses predicted the effects of abstraction and goal structuring on the global learning measure in this experiment. These hypotheses are restated here:

H_4: There will be no difference in cognitive skill demonstration between individuals who engage in abstraction activities and individuals who do not engage in abstraction activities.

H_6: There will be no difference in cognitive skill demonstration between individuals who engage in goal-structuring activities and individuals who do not engage in goal-structuring activities.

Hypothesis four predicts, in the alternate form, that the groups provided with abstraction prompts (groups two and four) would earn higher average control accuracy scores than would groups not receiving these prompts. The sixth hypothesis predicts, in the alternate form, that the groups provided with goal structuring prompts (groups three and four) would earn higher average control accuracy scores than groups not receiving these prompts. Table XI provides the average control accuracy posttest scores for each group along with the significance of the paired comparisons made between all groups. The group means along with any significant differences may be used to assess the predictions made in hypotheses four and six.

TABLE XI

PAIRWISE COMPARISONS (LSD P-VALUES) OF CONTROL ACCURACY SCORE MEANS

	Group 1	Group 2	Group 3	Group 4
Posttest Control Accuracy Score Means	3.63936400	3.35006843	3.51840316	3.42616874
Group 1	.....	0.2304	0.2300	0.3793
Group 2	0.2304	.....	0.4850	0.7534
Group 3	0.6154	0.4850	.....	0.7035
Group 4	0.3793	0.7534	0.7035	.....

The first finding of note from this analysis is that the group which received none of the prompts thought to increase learning – group one – had the highest average control accuracy score. The second point of note is that none of the pairwise comparisons were significant. While group one had the higher average score, this average was not significantly higher than any of the other scores. An ANCOVA was run on control accuracy scores. Results of this ANCOVA, which are presented in Table XII, show no significance for abstraction and/or goal structuring on control accuracy scores. The conclusion is that neither abstraction nor goal structuring prompts were significantly helpful and hypotheses four and six cannot be rejected.

TABLE XII

ANCOVA FOR CONTROL ACCURACY SCORE

Source	DF	Type I SS	Type I MS	F-Value	p-value	Levene's p-value
Pretest Control Accuracy Score	1	12.164497	12.164497	10.81	0.0013	
Abstraction	1	1.415930	1.415930	1.26	0.2637	
Goal structuring	1	0.02059	0.02059	0.02	0.8926	
Abstraction x Goal structuring	1	0.37613	0.37613	0.33	0.5640	0.4016
$R^2 = 0.076499$						

Control Accuracy Score

A pretest and posttest measure of how well subjects could evaluate the overall adequacy of internal controls in a payroll environment was taken for each subject. The task of the IDAs employed here was to evaluate control adequacy. The goal of the experiment was to determine whether subjects could better evaluate control adequacy after IDA use than before IDA use. Control adequacy assessment is the overall measure of learning via IDA usage.

Subjects were provided with a partial organizational chart and five control scenarios for a hypothetical company. For each scenario, subjects were required to respond to 22 questions concerning the absence or presence of several internal controls. Responses were made via computerized instrument. After entering the value for each control, subjects were asked to provide their evaluation of the adequacy of the controls in the scenario. Possible levels of evaluations were high, moderate, and low. Janell and

Wright (1991) found that large CPA firms use a non-quantitative approach to the assessment of control risk. To make this experiment as generalizable as possible, the non-quantitative approach of practice was adopted.

Program code was written to capture subject responses for each of the scenarios. Scoring involved a two-fold process. First, each of the five scenarios were evaluated by the IDA designed for this experiment. The response files were then opened and scored manually by comparing the subject's response to the IDA evaluation. The subjects received one point for each response that matched the IDA evaluation. Possible control accuracy scores ranged from zero to five.

Hypothesis seven predicts the joint effects of abstraction and goal structuring prompts on control accuracy scores.

H_7: Difference in cognitive skill performance for both levels of abstraction is consistent over all levels of goal structuring.

Mean control accuracy scores for the four experimental groups were presented in Table XI. Results of an ANCOVA for control accuracy scores were presented in Table XII.

In order to reject hypothesis seven, there had to be a significant interactive effect of abstraction and goal structuring on the control accuracy posttest score. Results of the ANCOVA (at the 0.5604 level) show this is not the case. Taken together with the group means, results of this ANCOVA suggest that the combined effects of abstraction and goal structuring do not produce a higher measure of learning.

Speed

The final hypothesis concerned an increase in speed solution time for the group that received both abstraction and goal structuring prompts.

H_8: Difference in problem-solving speed for both levels of abstraction is consistent over all levels of goal structuring.

The time it took each subject to make the five assessments of control adequacy (described above) was recorded at the pretest and posttest. The average pretest and posttest solution times are presented in Table XIII. Table XIV contains the results for an ANCOVA performed on problem-solving speed.

TABLE XIII

GROUP PROBLEM-SOLVING SPEED MEANS (in minutes)

	Group 1	Group 2	Group 3	Group 4
Pretest Problem-Solving Speed	19.91564	18.93488	18.59538	18.37395
Posttest Problem-Solving Speed	13.67615	13.69795	13.83000	13.80368

TABLE XIV

ANCOVA FOR SPEED

Source	DF	Type I SS	Type I MS	F-Value	p-value	Levene's p-value
Pretest Speed	1	318.61242	318.61242	20.22	0.0007	
Abstraction	1	1.94639	1.94639	0.12	0.7258	
Goal structuring	1	9.43070	9.43070	0.60	0.4404	
Abstraction x Goal structuring	1	1.14819	1.14819	0.07	0.7876	0.7078
$R^2 = 0.122866$						

Two points result from analysis of problem-solving speed. The first is that all subjects, on average increased the speed in which they were able to evaluate the adequacy of internal controls. Whether this speed up is a result of learning as suggested by Anderson (1993), a result of greater familiarity with the task at hand, or a combination of both is not known. The second point resulting from this analysis is that the joint effect of abstraction and goal structuring does not produce a lesser average problem-solving speed than the absence of these two factors.

Discussion of the Findings

Anderson (1993) theorized that declarative-stage learning entailed the acquisition of facts, examples, and analogies and the storage of these in declarative memory chunks. Recall of a fact or a step in an example or analogy was dependent upon the relative strength associated with the memory chunk in which the fact or step is stored. The relative strength of a chunk could be increased by increasing the number of times it has been recalled in the past. One successful method used to strengthen a chunk was to provide the learner with explanations or elaborations about that chunk. Consistent with the theory, the current study provided subjects with explanations. These explanations were given in the form of prompts provided by an IDA.

Anderson (1993) also theorized that procedural-stage learning entailed the acquisition of production rules that were optimized. Two optimization techniques were abstraction and goal structuring. Abstraction is a process of finding similarities among the condition sides of several production rules and then forming one generalized condition for all these production rules. Goal structuring, on the other hand, requires the learner differentiate actions among several production rules with similar conditions. The current study provided subjects with decision aid prompts (abstraction and goal structuring) that were intended to help optimize production rules. Optimized production rules are theorized to be more successfully retrievable and less costly for eventual problem solving.

Results of the study conducted here failed to support Anderson's (1993) theory. This section will first summarize the hypotheses, state the predicted direction of the tests of these hypotheses, and present the outcomes of the tests of the hypotheses. Next, this section will present three possible explanations for the unexpected results produced. Finally, this section will present a direction for subsequent examination of test results.

The null hypotheses, alternative predictions and results may be summarized as:

	Null Hypothesis	**Alternative Prediction**	**Result**
1	Recall Pretest = Recall Posttest	Recall Pretest < Recall Posttest	Fail to Reject
2	Recall Posttest will be equal for all groups	Recall Posttest will be equal for all groups	Reject
3	Match Scores will be equal for all groups	Match Scores for Groups 2 and 4 > Match Scores for Groups 1 and 3	Fail to Reject
4	Control Accuracy Scores will be equal for all groups	Control Accuracy Scores for Groups 2 and 4 > Control Accuracy Scores for Groups 1 and 3	Fail to Reject
5	Change Scores will be equal for all groups	Change Scores for Groups 3 and 4 > Change Scores for Groups 1 and 2	Fail to Reject
6	Control Accuracy Scores will be equal for all groups	Control Accuracy Scores for Groups 3 and 4 > Control Accuracy Scores for Groups 1 and 2	Fail to Reject
7	Control Accuracy Scores will be equal for all groups	Group 4 Control Accuracy Scores > Control Accuracy Scores for the other groups	Fail to Reject
8	Problem-solving speed will be equal for all groups	Group 4 Problem-solving speed < Problem-solving speed for the other groups	Fail to Reject

Note that because all groups received identical explanatory prompts, no difference in recall ability was expected among the four groups.

Without exception, the results of the empirical tests for these hypotheses were contrary to the theoretical predictions. Three possible explanations are considered here. The first considers the possibility of a mismatch between the knowledge and abilities of the subjects and the IDA they used. The second explanation considers the possibility that Anderson's (1993) theory is not applicable to learning in an IDA environment. The third explanation considers whether the subjects in this study were intentional learners.

The theory of technology dominance (Arnold and Sutton, 1998) postulates a high risk of a negative relationship between good decision-making ability and use of an IDA when an expertise mismatch exists between the user and the IDA. In other words, if the IDA contains more expertise than the user possesses, decision quality will frequently decline as a result of using the decision aid. The question, then, is whether subjects in this study were mismatched with the IDA.

The truest measure of decision quality in this study were the subjects' abilities to accurately assess the adequacy of internal controls in a payroll environment (Control Accuracy Score). As Table XV indicates, Control Accuracy Scores increased significantly from pretest to posttest for each experimental group as well as for subjects as a whole. This increase could be indicative of an appropriate match between the IDAs and the users. It is, however, possible that a confounding effect exists between explanations and the two optimization prompts since all groups received identical explanatory prompts. The theory of technology dominance then might suggest that a match exists for explanatory prompts and users, but perhaps not for the optimization prompts and users.

TABLE XV

AVERAGE CONTROL ACCURACY SCORES AND T-TESTS

	All Subjects	Group 1	Group 2	Group3	Group4
Pretest Mean	2.91613	2.92308	2.84615	3.00000	2.89474
Posttest Mean	3.48387	3.64103	3.33333	3.53846	3.42105
Pretest Std. Dev.	1.1619	1.0609	1.2378	1.0513	1.2901
Posttest Std. Dev.	1.0892	0.9315	1.2353	1.0723	1.0813
T-Statistic	-7.81	-5.55	-114.22	25.68	-2.52
p-value	0.0001	0.0001	0.0001	0.0001	0.0104

Does Anderson's (1993) theory of cognitive skill acquisition apply to a situation where learning is expected from interaction with an IDA? Tests of ACT-R have been undertaken in both a decision aid context and a traditional learning context. While a great deal of evidence supports ACT-R in a traditional learning environment, IDA studies have not been as successful (see Eining, 1988; Murphy, 1990; Pei and Reneau, 1990; Eining and Dorr, 1991; Steinbart and Accola, 1994; Pei, et al., 1994; Odom and Dorr, 1995; and Hornik and Ruf, 1997). The original Adaptive Character of Thought (ACTE) theory was actually designed to be implemented and tested with a computerized routine not unlike an IDA. It, therefore, is counterintuitive that ACT-R would lose this connection.

Another explanation for findings that run contrary to theorized predictions lies in the instrument itself. If the instrument has failed to manipulate abstraction and/or goal structuring in a way that subjects were impacted, a lack of theorized results would not be unexpected.

The type of learner involved in the current study becomes the fourth explanation of the results found here. Pressley, et al. (1987), examined intentional and incidental learners. Among their findings was the fact that those learners who intend to gain expertise will do so at a much higher rate than will individuals who have identical exposure but lack an intent to learn. Could the results reported in the previous section lack conformity to theoretical predictions because not all the subjects possessed an intention to learn? Two facts suggest this may be the case.

Intent to learn may be driven by motivation to learn. While the results of the pilot test are not reported here, those results were more consistent with the theorized predictions. One of the differences between the pilot test and the current study involved incentives. The pilot study provided a monetary incentive in addition to class credit, the current study did not. However, a questionnaire provided during the last session of the current study, gives some support to the notion that motivation was lacking for subjects in the current study. One question on the survey was: "I should have been given more class credit for participation in this experiment." On a scale of 0 = Strongly Agree to 4 = Strongly Disagree, the mean response was 2.0455 and the standard deviation was 1.234. The dispersion of responses here was extreme, indicating strong agreement or disagreement with this question. Eighteen percent indicated a desire for more credit. All survey questions, means, and standard deviations are provided in Table XVI. The interface for this survey is included in Appendix A. While some of the questions were reverse scored, all questions will be stated here in a positive form to allow for more comparable means.

TABLE XVI

EXIT SURVEY QUESTIONNAIRE MEANS

Question	Standard Deviation	Mean Response
The scenarios were easy to read	0.684	0.632260
My knowledge of internal controls improved via project	0.739	1.000000
Working with computers does not make me nervous	0.856	0.659065
I should have received more credit for participation	1.234	2.045161
The experiment would have been more beneficial if it lasted longer	1.093	2.116129
This experiment did not waste my time	0.673	0.741935
I better understand internal controls	0.666	0.625806
I better recognize similarities among controls	0.701	1.051613
The use of scenarios was helpful	0.651	0.935484
I better recognize differences among controls	0.738	1.083871
All accounting courses should have projects like this	1.096	1.032258
Review questions were helpful	0.754	1.096774
Explanations were helpful	0.791	1.154839
I did not ignore explanations	1.015	1.526129
The expert system challenged me	0.818	1.393548
I want to know more about expert systems	0.810	1.180645
I tried as hard as I could	0.792	1.058065
I always accepted system recommendations	0.969	1.541936
I felt more confident evaluating the scenarios this session	0.853	1.135484
I better understand how controls work together	0.635	1.000000
I better understand differences among controls	0.686	1.058065

Responses for each question and the values for each response were: “Strongly Agree” =

0; “Agree” = 1; “Neutral” = 2; “Disagree” = 3; and “Strongly Disagree” = 4.

The second indication that some of the subjects might not be intentional learners here involves the Recall scores. At pretest, subjects were asked to provide the level and characteristic of a number of internal controls. Throughout the experiment subjects were given prompts that provided the level and characteristics of these internal controls. At posttest subjects were once again asked for level and characteristic responses. Half (78 out of 155) of the subjects made a lower score at posttest than at pretest. The only explanations for this involve confusion or lack of effort. If confusion is the explanation, then the IDA components were detrimental. However, if some subjects (as they indicated in the questionnaire) simply were not motivated to learn, then an examination of the more motivated subjects could provide additional insights.

Post Hoc Analysis

If subjects in this study may be divided between those who intended to learn and those who did not, it is the first group that is of greatest interest. How could intentional learners be separated from incidental learners in this study? One way was the criterion stated above: intentional learners should have benefited from the control level and characteristic prompts. Therefore, intentional learners would not be expected to have a lower Recall score at posttest than at pretest. Subjects for this last set of analyses were divided by Recall scores. For all subjects the pretest Recall score was subtracted from the posttest Recall scores. Those with a negative net score were classified as incidental learners. Those with a positive (or zero) net score were classified as intentional learners.

It is the second group that serves as the basis for subsequent analysis. Incidental learners totaled 77, intentional learners totaled 78. The tests reported here replicate the tests reported earlier. The mean values for intentional learners as a whole and by group are presented in Table XVII.

TABLE XVII

MEANS FOR INTENTIONAL LEARNERS

	Total	Group 1	Group 2	Group 3	Group 4
Number	78	14	21	26	17
Recall Pretest	15.0000	15.2143	14.6190	14.8462	15.5294
Recall Posttest	16.2051	16.4286	16.0000	16.1538	16.3529
Match Pretest	5.9487	5.7857	6.2381	5.5385	6.3529
Match Posttest	6.2692	5.9286	6.0476	6.5000	6.4706
Change Pretest	5.1667	5.5000	5.3333	5.1538	4.7059
Change Posttest	5.9231	6.2857	5.8571	5.9231	5.7059
Control Accuracy Pretest	2.8718	2.6429	2.7143	3.0000	3.0589
Control Accuracy Posttest	3.4615	3.8571	3.2857	3.2692	3.6471
Speed Pretest	18.9365	19.8686	19.1729	18.8646	17.9871
Speed Posttest	14.1526	13.9536	14.4338	14.3415	13.6800

The fact that Recall scores increased from pretest to posttest is a consequence of the subject selection criterion. The only thing of consequence to be gained from these scores is that all posttest recall scores, on average, increased (as opposed to remaining constant) and this increase was significant at the 0.01 level.

Group two was the only group to receive only abstraction prompts, group two was also the only group to decline from pretest to posttest on the measure (match score) designed to determine whether abstraction prompts were helpful. The other group receiving abstraction prompts showed an insignificant increase in this measure. The initial indication here is that abstraction prompts may have actually been a hindrance to learning rather than a help. All subjects, on average, increased their scores on change recognition from pretest to posttest. This was true even of the groups (groups one and two) which did not receive goal structuring prompts. The consideration of the effects of abstraction and goal structuring will be revisited in a closer evaluation of the control accuracy scores. A final point suggested from an examination of these means is that average control accuracy scores increased for all groups and problem-solving speed declined for all groups. Discussion of these points will center on the following MANCOVA and ANCOVA results (Table XVIII).

TABLE XVIII

RESULTS OF TESTS ON INTENTIONAL LEARNERS

	F - Statistic	p-value	X^2 or Levine's	p-value
MANCOVA Control Accuracy	3.7291	0.0047	782.63	0.0001
MANCOVA Change	1.9193	0.0582	969.18	0.0001
ANCOVA Recall	1.6248	0.2923	1.24	0.2998
ANCOVA Match	1.65	0.2036	1.13	0.3411
ANCOVA Change	0.30	0.5878	1.22	0.3103
ANCOVA Score	2.69	0.1000	1.47	0.2305
ANCOVA Speed	0.40	0.5277	0.63	0.5982

A MANCOVA of the six dependent variables (i.e. control level, control characteristic, match score, change score, control accuracy score, and speed) was not significant. However, each of these variables, with the exception of speed, was a total of multiple measures. Therefore, MANCOVAs were conducted for each question within each variable. Two of these MANCOVAs were significant: (1) there was significant variation in a least one evaluation of control accuracy due to abstraction and/or goal structuring (F-value = 3.7291; p-value = 0.0047) and (2) there was significant variation in at least one determination of the effect of an internal control change on control adequacy due to abstraction and/or goal structuring (F-value = 1.9193; p-value = 0.0582). These tests support further univariate analyses.

The first ANCOVA evaluated the effects of abstraction and/or goal structuring on recall. The predicted outcome of the first hypothesis was that all groups would increase their recall ability from pretest to posttest. Because all subjects in the post hoc analysis were selected on the basis of pretest to posttest improvement, prediction was self-fulfilled. The predicted outcome of the second hypothesis was that this average increase would not differ due to the effects of abstraction and/or goal structuring. Results of analysis of covariance for recall yield an F-value of 1.6248 and a p-value of 0.2923. The conclusion here is that the null hypothesis of no difference due to group assignment cannot be rejected. As predicted, abstraction and/or goal structuring prompts did not significantly affect posttest recall scores.

The ANCOVAs for Match and Change scores lead to the conclusion that the interactive effects of abstraction and goal structuring did not significantly affect the posttest scores for either the Match score (p-value = 0.2036) or the Change score (0.5878). Without significant interaction, consideration of the separate effects of either abstraction or goal structuring is not feasible. No support exists for the predicted outcomes from hypotheses three and five, abstraction and/or goal structuring seem to have no effect on either the match or change measures.

The greatest difference in limiting subjects to those who intended to learn lies in the analysis based on the marginal significance found with the control accuracy ANCOVA (F-value = 2.69; p-value = 0.10). There is an interactive effect of abstraction and goal structuring in subjects' abilities to accurately evaluate the adequacy of internal controls in a payroll environment. The quality of this interaction may be understood via an evaluation of pairwise comparisons of group means. Such comparisons are summarized in Table XIX.

TABLE XIX

PAIRWISE COMPARISONS (LSD) OF CONTROL ACCURACY SCORE MEANS FOR INTENTIONAL LEARNERS

	Group 1	Group 2	Group 3	Group 4
Posttest Control Accuracy Score Means	3.49426800	3.38046138	4.06849557	3.28116919
Group 1	.....	0.9545	0.0989	0.5039
Group 2	0.9545	.....	0.1142	0.5773
Group 3	0.0989	0.1142	.....	0.0283
Group 4	0.5039	0.5773	0.0283	.....

Group three, the group that received only goal structuring prompts, had the highest average control accuracy score. This average was significantly higher (p-value = 0.0283) than the group four average. The difference between the two groups was that the latter also received abstraction prompts. Group three also produced an average that was higher (with marginal significance of p = 0.0989) than the group two average. Group two received only abstraction prompts. Finally, the group three average was higher than the control group (group one) average, but not significantly so. One conclusion that may be drawn here is that goal structuring prompts are beneficial to the intentional learner, but abstraction prompts seem to diminish this effect. In terms of the hypotheses (numbers four, six, and seven), one null hypothesis may be rejected. While abstraction prompts do not increase control accuracy scores (hypothesis four), and while the combined effect of abstraction and goal structuring are equally suspect (hypothesis seven), goal structuring prompts alone (hypothesis six) appear to have a positive effect on control accuracy scores.

The final analysis here concerns the effects of abstraction and/or goal structuring on problem-solving speed. ANCOVA results again fail to support the prediction concerning hypothesis eight. There seems to be no joint effect of the two, and it is not appropriate to examine the separate effects. An interesting observation concerning speed exists. Correlations were run on all variables in this study. There exists a significant and negative correlation between problem-solving speed and control accuracy scores for all subjects (-0.15493; $p = 0.0542$). The interpretation here, in light of Anderson (1993), is that as control accuracy scores increase, problem-solving speed declines.

Summary

This chapter has presented the results of the experiment outlined in Chapter Four. A summary of those results shows that when all subjects are evaluated, outcomes do not support the theory underlying the study. However, there was reason to suspect that not all subjects gave their best effort throughout the investigation, thus bringing to question the results. Subjects were subsequently divided into intentional versus incidental learners and subsequent analysis was performed on the intentional learners. Markedly different results were obtained based on this analysis. Most importantly, goal structuring prompts significantly improved internal control adequacy evaluations. There continued to be some appearance, however, that abstraction prompts may have a detrimental effect. This raises the question of whether the optimization technique of abstraction is somewhat automatic for the learner and whether goal structuring is less automatic. If so, developers of IDAs may enhance the training ability of aids by including goal structuring direction; future research is indicated.

CHAPTER VI

CONCLUSION

Summary

Anderson's (1993) theory of cognitive skill acquisition stipulates that a learner must progress through two stages on his/her path toward acquiring expertise. In the first stage, the learner must obtain a set of facts or chunks. Further, these chunks must be adequately strengthened so the probability of being able to recall an essential fact is sufficient. In the second stage, the learner must develop a set of production rules. Production rules are condition - action pairs that allow a learner to progress from the initial question to an ultimate solution. In addition, these rules must be optimized for successful retrieval from memory. Two optimization techniques are abstraction (i.e., generalization to match similar conditions) and goal structuring (i.e., differentiation to react to differing outcomes).

Research concerning acquiring expertise via IDA use has been guided by this theory. However, prior research has yielded mixed results for manipulations of explanations that may aid in the ability to recall chunks. Moreover, prior research has not examined the combined and individual effects of manipulations that may direct the learner to discover similarities and differences among rules. This study reexamined the effects of explanations on recall. Further, the effects of abstraction and goal structuring on the ability to demonstrate a cognitive skill were examined.

In a laboratory experiment that spanned a four week interval, subjects were randomly assigned to one of four different IDAs. The IDAs differed by the types of prompts provided to subjects. The experimental task in this study was to evaluate the adequacy of internal controls in a payroll environment. All subjects received prompts that provided level and characteristic definitions about these internal controls. Half of the subjects also received prompts asking them to consider similarities among several controls. Half of the subjects received prompts requesting them to change an internal control and then determine the effect that change might have on overall control adequacy. One hundred and fifty five subjects, who had previous instruction in internal controls, completed the experiment.

Anderson (1993) stated a need for a learner to first acquire facts about a new learning situation and then build the strength of the chunks in which those facts were stored to increase the probability that the chunk could be recalled. In a control assessment task, the facts were considered to be the internal controls themselves. More specifically, the facts were the level (i.e. preventive, detective, or corrective) of the internal control and the characteristic (i.e. access, accounting records, authorization, independent verification, or separation of duty) of the control. It was believed that prompts which provided level and control information about each of the internal controls presented in the experiment would cause subjects to be better able to recall facts about these controls. A pretest and posttest measure of recall ability was taken for each subject, based on a prior belief, measure should increase for all subjects from pretest to posttest. An examination of these measures showed that this was not the case. Three of the four groups demonstrated a decrease in recall ability from pretest to posttest.

According to Anderson (1993) facts are used by a learner to construct production rules. A set of production rules (also called a production system) is the basis for all cognitive skills. While production rules are comprised of facts, a subtle difference exists between the two. Facts reside in declarative memory and may be verbally explained. These facts are the "what to do" portion of learning. Production rules reside in procedural memory and are conceptual in nature. Production rules are difficult (or impossible) to verbalize but represent the "how to do it" portion of learning.

Establishing a set of production rules is not enough. According to Anderson (1993) the production system must be fine tuned to make it most usable. The learner's goal is to find a production rule that answers the question at hand. The learner will first examine production rules that have been successful solving prior questions. A learner will also avoid rules that are too costly in terms of total cognitive effort. Optimization of the production system yields rules that are both more successful and less costly. Abstraction is one optimization technique. Here a learner will search through the set of rules with similar conditions. Then the learner will form one generalized rule from several similar rules. A generalized rule is believed to be one that will be successful. Generalization can, however be detrimental if a rule is not sensitive enough to attend to critically differing outcomes. Therefore, a second optimization technique, goal structuring, is necessary. While abstraction seeks to limit the number of production rules, goal structuring increases the size of a production system to make it suitably sensitive to differences.

In this study, abstraction was operationalized as IDA prompts that asked subjects to consider how one internal control was similar to another. Goal structuring was operationalized as IDA prompts that required subjects to make changes in the internal controls presented and to consider the effect of those changes on the IDA's evaluation of internal control adequacy.

Because abstraction and goal structuring are second-stage independent variables, the effects of their manipulation was measured as second-stage knowledge acquisition. Four second-stage knowledge measures were employed: (1) how well subjects could match similar internal controls (Match Score); (2) how well subject could determine the effect on control adequacy that resulted from changing internal controls (Change Score); (3) how well subjects could, without the aid of an IDA, evaluate the adequacy of a combination of internal controls (Control Accuracy Score); and (4) how quickly subjects could formulate their evaluation of internal control accuracy (Speed).

Initial analysis found no groups significantly differed from the others on any of these measures. One explanation for the lack of significant findings was that subjects in this study were not adequately motivated to perform well. Based on first-stage learning scores, only half of the subjects appeared to have an intention to learn. A second set of analyses was performed on the subjects who were determined to be intentional learners. This second set of analyses led to conclusions that paralleled Anderson's 1993 theory.

Recall, the measure of first-stage learning, increased, on average, for all subjects. Further, no significant difference existed among the average recall scores for any group. The overall increase was expected because this was the measure used to separate intentional learners from incidental learners for this set of analyses. A lack of difference among groups on this measure was expected since all groups received the same explanations concerning the level and characteristics of the internal controls.

No difference was found for the effects of abstraction and/or goals structuring on subjects ability to match similar controls. Examination of the averages of the experimental groups, in fact, implied that abstraction prompts were actually detrimental in helping individuals make good matching choices. One explanation is that abstraction is a natural process for learners and an attempt to increase this technique was not only unnecessary, but also confusing.

Goal structuring prompts, on the other hand, did prove beneficial in two regards. A measure of the effect of goal structuring prompts was the ability to recognize the effects of different internal controls on control adequacy assessments (change score). The two groups that received these prompts produced higher average change scores than did the two groups that did not receive these prompts. Another measure of the effect of goal structuring was the ability to accurately assess internal control adequacy (control accuracy score). The group that received only goal structuring prompts produced the highest average control accuracy scores.

Finally, there was no difference in problem-solving speed among any of the experimental groups. Of interest, however, is the fact that all experimental groups demonstrated an increase in problem-solving speed. In addition, a significant and negative correlation existed between problem-solving speed and problem-solving accuracy.

Contributions

Based on post hoc investigation, three benefits may accrue from this study. First, this study demonstrated that prompts requiring learners to attend to differences between rules were beneficial. As was presented in Table XIX, the group that received goal structuring prompts also performed control adequacy assessment at the highest level. The contribution of this demonstration is two-fold. First, this is a new finding. Second, the goal structuring prompts presented here are replicable in any IDA. Hornik and Ruf (1997) found benefits for generalizing activities, but their findings were dependent upon an IDA that allowed the user access to a log of previously-solved problems. The present work presents a scheme that is adaptable for systems that do not have log-viewing capacities. Projections from these results should be tempered by the fact that post hoc investigation is the focus here.

A second benefit is that while the cognitive psychology literature provided the theory that guided this exploration, little information existed to guide its implementation. Specifically, a method of operationalizing abstraction or goal structuring was not known. The present study offers something back to the cognitive psychology researchers, one method of operationalizing their theories.

A final benefit of this study is provided to developers of IDAs. IDAs have the potential to reduce the training costs a company faces if the systems include tutorial features. This study provides IDA developers with some of the features that may be included in a system designed to train. Moreover, this study provides IDA developers with a method of including those features. Future researchers and developers should consider the strengths and weaknesses of the design approaches that have been put forth in this study given the conflicting results between the experimental and post hoc analysis.

Limitations

As with all experimental investigations, there are limitations to this study. One such limitation is that this was a controlled experiment in a laboratory setting. The results of this study may not be fully generalizable to all situations employing IDAs. The subjects in this experiment were tested on a number of criteria. Testing, at least overt testing, is not generally employed in a professional setting. Indirect testing, in terms of job advancement, is done.

Students were used as surrogates for novice auditors in this experiment. While the educational and experiential background of both senior-level students and inexperienced auditors may be quite similar, the two populations are not identical. Therefore, there is a limit as to how well the findings within the first population are generalizable to the second.

While all prompts and explanations provided in this study required that subjects at least move their cursors to the prompts and explanations, whether subjects actually read the prompts or explanations is not known. The possibility exists that results would differ if subject attention were forced, but a method of forcing that attention is not known.

Because all subjects received identical prompts offering explanations about internal controls, the effects of these prompts may have been confounded within the treatments for abstraction and goal structuring. The design of the experiment makes it impossible to determine whether any confounding exists. Future investigation might separately examine whether explanations, abstraction, and/or goal structuring combine to increase learning.

It was determined that some subjects in this study lacked motivation. A first-stage learning measure was used to separate unmotivated subjects from analysis. A differing explanation might have been that some subjects simply did not understand and learn from this study. If that is the case, the separation measure is not appropriate.

Implications for Future Research

As with Pei et al. (1994) abstraction and goal structuring prompts were presented in fixed quantity. The question of how often to present prompts has yet to be addressed but should be. Prompting at some rate seems to be beneficial, but Gal and Steinbart (1992) found that constant prompting is ineffective. There must exist an optimal prompting rate that can be determined. It is also probable, but unknown, that the prompting rate might vary due to a number of factors. These factors include the complexity of the task and how well an IDA and user are matched. Without this information, IDA developers are hindered from creating the most effective product.

Anderson (1993) suggested that learners first generalize and then discriminate in their progress toward skill acquisition. The present study presented abstraction and goal structuring prompts almost simultaneously. Only the fourth group received both types of prompting, but that group received both prompts within each scenario evaluation. Greater learning may take place if learners first received a series of abstraction prompts then, after some repetition, prompts to discriminate, or vice versa. In addition, all groups received identical explanations. This offers the possibility that the effects of explanations might be confounded with the effects of abstraction and goal structuring. Future investigation might employ a 2 x 2 x 2 factorial arrangement, the third factor would be the presence or absence of explanations. To isolate simple effects, this design would require eight experimental groups. Further, a switching replications approach with intermediate measurements might help determine whether there is an order effect for abstraction and/or goal structuring.

Anderson (1993) suggests that explanations can increase chunk strength and that production rules need to be optimized. There are, however, other factors that affect learning. This study has touched on the importance of intention to learn. Pei and Reneau (1990) demonstrated a need to attend to the mental models of the learner. Steinbart and Accola (1994) showed that involvement was an important facet of learning. Mascha (2001) introduced the idea of task complexity and its effect on knowledge transfer through IDA interaction. An integration of all these factors may merit some consideration as well.

As the literature review was conducted, an interesting subject came to light. While several studies employed one or more versions of Anderson's ACT theory, there lacked a clear consensus of what was implied in each. In fact, the name of the theory itself was stated incorrectly on several occasions. The impression was that there is a need to clearly outline each version of Anderson's theory and compare the theory to the interpretations provided in studies using the theory. This analysis would be of tremendous benefit to researchers who wish to rely on Anderson in future studies as it would present a picture of what has been done according to theory and what has been done according to slightly stilted interpretations of the theory.

This work marks a laboratory examination of the last unexamined elements of Anderson's (1993) cognitive skill acquisition theory (i.e., abstraction and goal structuring). Because the results found here (or lack thereof) may indicate a problem with the instrument, one of the first things that must be investigated is the validity of that instrument. Also of great importance is the need to reexamine all elements of cognitive skill acquisition theory in a field setting. A field setting may remove many of the limitations previously stated and a truly generalizable set of findings may be established. A number of IDAs have been developed for and are being used by professionals in a real job setting. Value may be found in the introduction of some of the learning prompts that have proven successful in a laboratory setting to these production IDAs to see if the laboratory results hold. A study of this nature would be problematic but not impossible. Such an investigation would require a partnership with the IDA developer to alter existing software to incorporate new learning features. In addition, a partnership with the professionals using these systems would be required. This is, however, a step that must be taken before the knowledge we have gained through research can be implemented in practice.

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APPENDIXES

APPENDIX A

DOCUMENTS AND INTERFACES SPECIFIC TO SOLICITATION OF INFORMATION FROM SUBJECTS

Introduction Interface

Introduction

Thank you for participating in this study. The results of your responses throughout this investigation will help developers of expert systems to better design these systems. You should also develop a better understanding of how internal controls work together.

Please take as much time as necessary to provide your best response.

Please answer all questions.

You will receive up to 50 points of class credit for working accurately through all four sessions.

Continue

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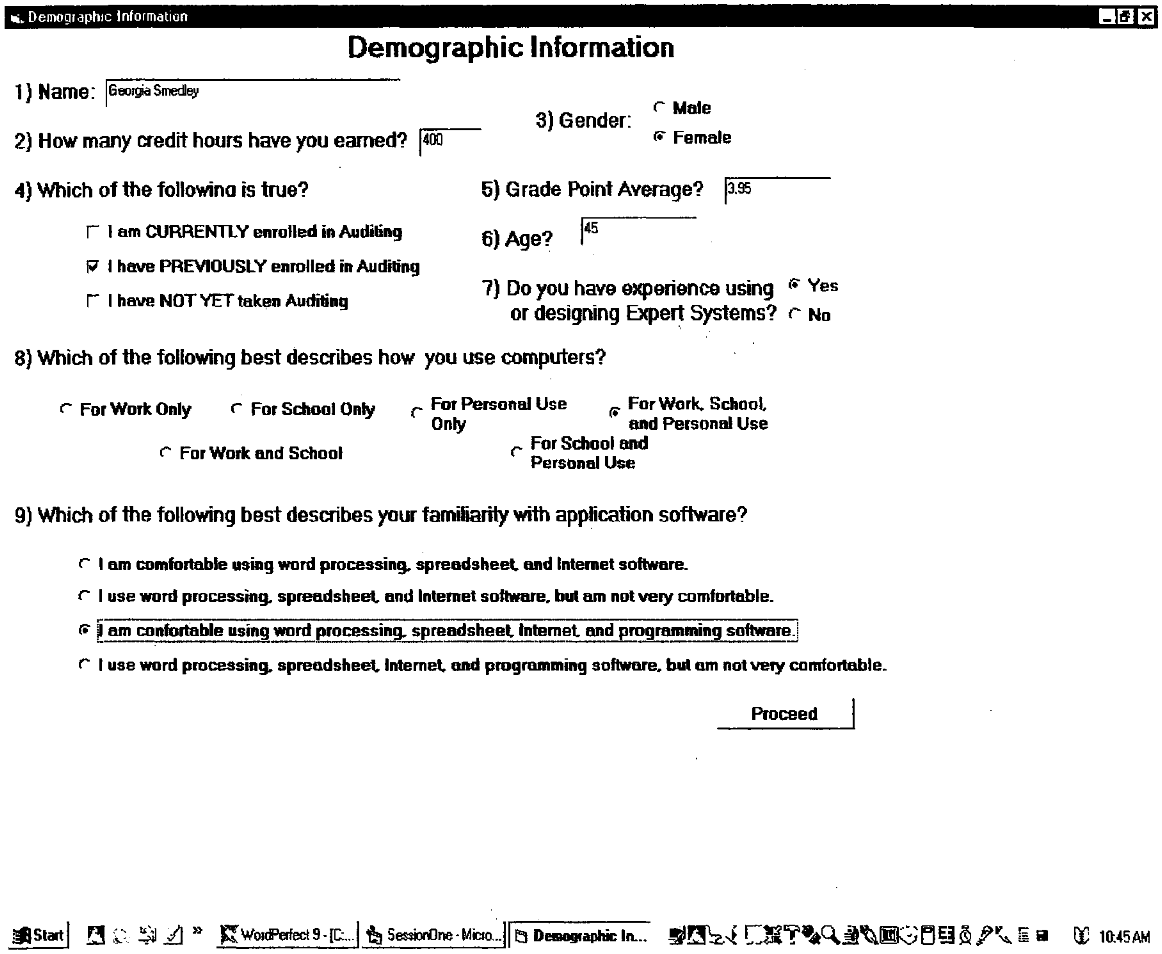
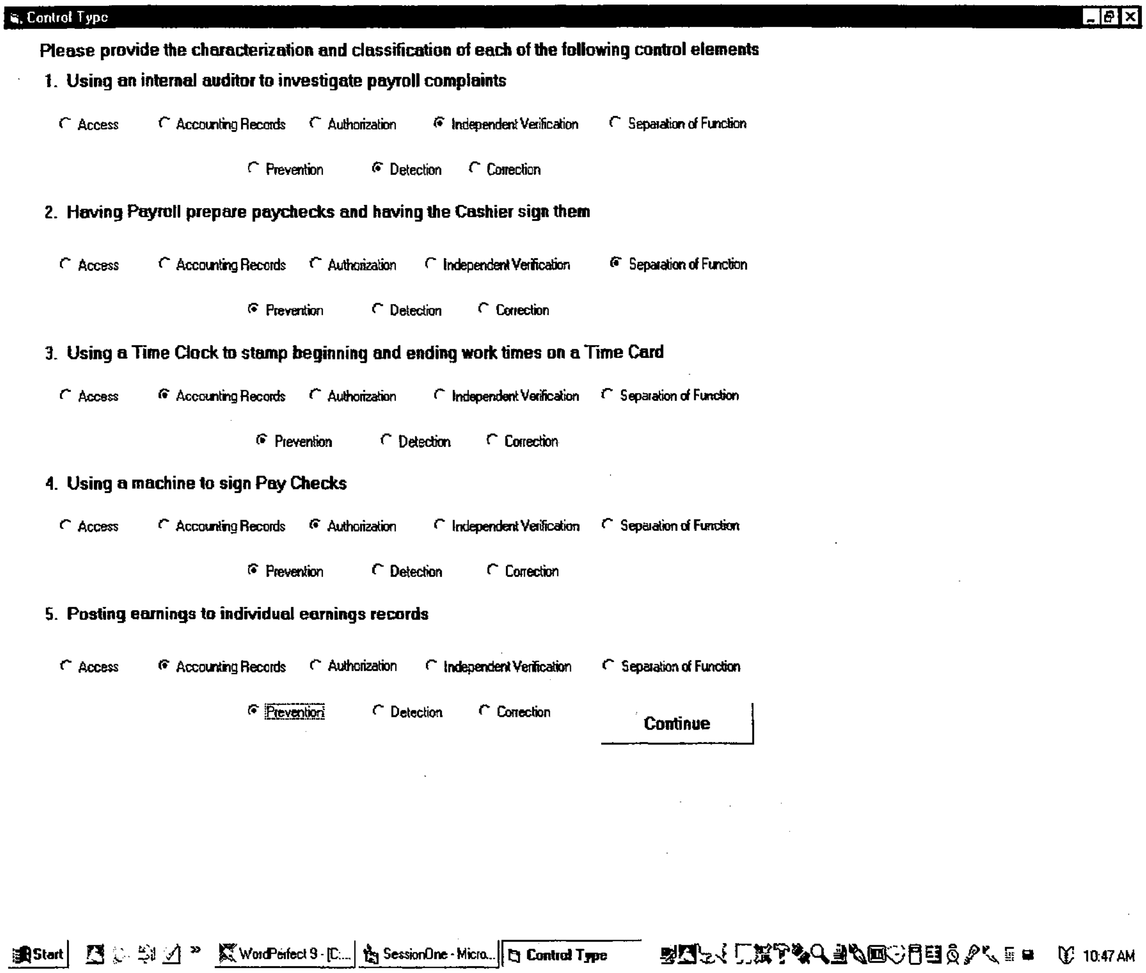
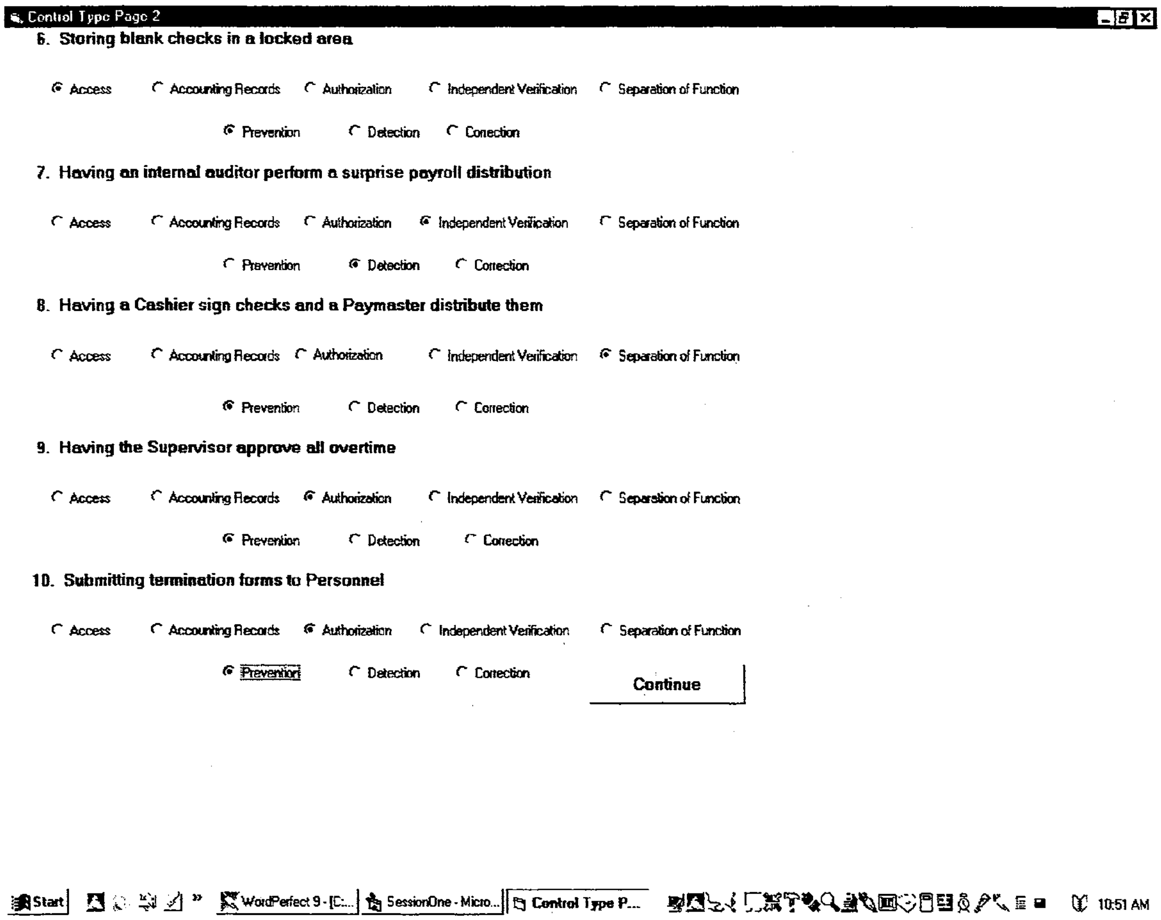
Demographic Information Interface



Control Type Quiz Interface – Screen 1



Control Type Quiz Interface – Screen 2



Matching Quiz – Screen 1

Match

This screen lists several control elements that are followed by four choices. One of the four choices more closely parallels the given control element than the others. Click on the choice that most closely parallels the given control element.

1. Using a Time Clock to stamp beginning and ending work times on the Time Card.

- ○ Using a machine to sign checks.
- ○ Preparing payroll registers.
- ◉ Using a separate bank account for payroll.
- ○ Storing blank checks in a locked area.

2. Comparing Job Cards to Time Cards.

- ○ Using a separate bank account for payroll.
- ○ Having the Cashier sign checks and the PayMaster distribute them.
- ◉ Seeing if the distribution summary and the payroll register agree.
- ○ Having the auditor investigate payroll inaccuracy reports.

3. Storing blank checks in a locked area.

- ○ Having the Supervisor approve overtime.
- ◉ Using a machine to sign checks.
- ○ Using a separate bank account for payroll.
- ○ Seeing if the distribution summary and the payroll register agree.

4. Having a Supervisor approve overtime.

- ○ Having Payroll post earning to individual accounts.
- ○ Having a PayMaster distribute paychecks.
- ○ Comparing the Job Cards to the Time Cards.
- ◉ Having Personnel authorize pay rates.

5. Having the Cashier sign checks and a PayMaster distribute them.

- ○ Using a separate bank account for payroll.
- ○ Personnel maintains hiring information and authorizes payrate changes.
- ◉ The Supervisor approves overtime and Payroll records time worked.
- ○ Storing blank checks in a locked area.

Continue

Start | WordPerfect 9 - [C... | SessionOne - Micro... | Match | 10:54 AM

Matching Quiz – Screen 2

Match

6. Using a machine to sign paychecks.

- ( ) Using a time clock to stamp times on a time card.
- ( ) Comparing Job Cards to Time Cards.
- ( ) Using a separate bank account for payroll.
- (•) Storing blank checks in a locked area.

7. Having personnel approve payrates and payroll post earnings to individual accounts.

- ( ) Using a separate bank account for payroll.
- (•) Having the Cashier sign checks and the PayMaster distribute them.
- ( ) Seeing if the distribution summary and the payroll register agree.
- ( ) Having the auditor investigate payroll inaccuracy reports.

8. Having personnel authorize payrates.

- (•) Having the Supervisor approve overtime.
- ( ) Using a machine to sign checks.
- ( ) Using a separate bank account for payroll.
- ( ) Seeing if the distribution summary and the payroll register agree.

9. Having a separate bank account for payroll.

- (•) Having Payroll post earning to individual accounts.
- ( ) Having a PayMaster distribute paychecks.
- ( ) Comparing the Job Cards to the Time Cards.
- ( ) Having Personnel authorize pay rates.

10. Having Payroll enter pay information and a cashier sign checks.

- ( ) Using a separate bank account for payroll.
- ( ) Personnel maintains hiring information and authorizes payrate changes.
- (•) The Supervisor approves overtime and Payroll records time worked.
- ( ) Storing blank checks in a locked area.

Continue

Start | WordPerfect 9 - [C... | SessionOne - Micro... | Match | 10:57 AM

Assessing Effects of Changes – Screen 1

Change Quiz

Each of the following questions states a hypothetical evaluation of the adequacy of internal controls in a payroll environment. Each question states one control, among the many that were used in determining the stated evaluation. You are asked to determine the resulting change in the adequacy of internal controls if that one control were changed.

1) You have evaluated the adequacy of internal controls to be "MODERATE" because, in part, the supervisor distributes paychecks.

You have now discovered that the internal auditor makes surprise distributions of paychecks.
Will your new evaluation:
(•) Increase ( ) Remain the Same ( ) Decrease

2) You have evaluated the adequacy of internal controls to be "HIGH" because, in part, you believed blank checks were tightly controlled.

Now you have discovered that blank checks are not kept in a locked area.
Will your new evaluation:
( ) Increase ( ) Remain the Same (•) Decrease

3) You have evaluated the adequacy of internal controls to be "LOW" because, in part, Personnel maintains hiring information and distributes paychecks.

Now you have found that a PayMaster distributes paychecks.
Will your new evaluation:
(•) Increase ( ) Remain the Same ( ) Decrease

4) You have evaluated the adequacy of internal controls to be "MODERATE" because, in part, no one reconciled the payroll register and the labor distribution summary.

Now you have discovered that Accounts Payable performs this reconciliation.
Will your new evaluation:
( ) Increase (•) Remain the Same ( ) Decrease

5) You have evaluated the adequacy of internal controls to be "MODERATE" because, in part, a check-signing machine was not used.

Now you have found that a check-signing machine is used.
Will your new evaluation:
(•) Increase ( ) Remain the Same ( ) Decrease

Continue

Start | WordPerfect 9 - [C... | SessionOne - Micro... | Change Quiz | 11:00 AM

Assessing Effects of Changes – Screen 2

Change Quiz

6) You have evaluated the adequacy of internal controls to be "MODERATE" because, in part, the supervisor distributes paychecks.

You have now discovered that the cashier distributes paychecks.
Will your new evaluation:
( ) Increase (•) Remain the Same ( ) Decrease

7) You have evaluated the adequacy of internal controls to be "MODERATE" because, in part, the cashier both signed and distributed paychecks.

Now you have discovered that the supervisor distributes paychecks.
Will your new evaluation:
( ) Increase (•) Remain the Same ( ) Decrease

8) You have evaluated the adequacy of internal controls to be "MODERATE" because, in part, a time clock was not being used.

Now you have found that the time clock was used.
Will your new evaluation:
(•) Increase ( ) Remain the Same ( ) Decrease

9) You have evaluated the adequacy of internal controls to be "MODERATE" because, in part, no one approved overtime.

Now you have discovered that payroll approves overtime.
Will your new evaluation:
( ) Increase (•) Remain the Same ( ) Decrease

10) You have evaluated the adequacy of internal controls to be "MODERATE" because, in part, the internal auditor made surprise distributions of paychecks.

Now you have found that a Pay Master always makes this distribution.
Will your new evaluation:
( ) Increase ( ) Remain the Same (•) Decrease

Continue

Start | WordPerfect 9 - [C... | SessionOne - Micro... | Change Quiz | 11:04 AM

Scenario Evaluation Screen

Scenario One

1. Hiring and payrates are authorized by:-	○ Payroll	◉ Personnel	○ Supervisor	
2. Changes in payrate are authorized by:	○ Payroll	◉ Personnel	○ Supervisor	
3. Employment termination forms are submitted to:	○ Payroll	◉ Personnel	○ Supervisor	
4. Is a timeclock used?	○ No	◉ Yes		
5. Jobcards are approved by:	○ No One	○ Payroll	◉ Supervisor	
6. Overtime is approved by:	○ No One	○ Payroll	◉ Supervisor	
7. Jobcards are compared to timecards by:	◉ General Ledger	○ No One	○ Supervisor	
8. Preparation of paychecks and payroll registers are performed by:	○ Auditor	○ Cashier	○ PayMaster	◉ Payroll
9. Earning are posted to individual records by:	◉ Payroll	○ Personnel	○ Supervisor	
10. Payroll distribution voucher is prepared by:-	◉ Accounts Payable	○ Payroll		
11. Labor distribution summary is prepared by:	◉ Accounts Payable	○ General Ledger		
12. Who compares the labor distribution summary and payroll register?	○ Cost Acctg	◉ General Ledger	○ No One	
13. Is a check signing machine used?	○ No	◉ Yes		
14. Who controls unsigned (blank) checks?	◉ Cashier	○ No One	○ Payroll	
15. Who is responsible for signing checks?	○ Auditor	◉ Cashier	○ Payroll	○ Supervisor
16. Is a separate checking account used for payroll?	○ No	◉ Yes		
17. Who distributes payroll checks?	○ Auditor	○ Cashier	◉ PayMaster	○ Supervisor
18. Who has responsibility for unclaimed checks?	○ Auditor	◉ Cashier	○ PayMaster	○ Supervisor
19. Who distributes payroll on a surprise basis?	◉ Auditor	○ No One		
20. Who compares payroll to budgeted figures?-	◉ Auditor	○ No One		
21. Who investigates payroll complaints?	◉ Auditor	○ No One		

What is your assessment of the internal controls as shown in Scenario One?

○ **Low**
○ **Moderate**
◉ **High**

Continue

Start | WordPerfect 9 - [C... | SessionOne - Micro... | Scenario One | 11:07 AM

Exit Survey – Screen 1

Exit Survey

Please provide an HONEST and ACCURATE response to each of the following statements. The credit you receive for participating in this experiment will IN NO WAY be influenced by your responses.

1. The scenarios were easy to read.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
2. My knowledge of internal controls improved because of this project.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
3. Working with computers makes me nervous.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4. I should have receive more class credit for participating in this experiment.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5. My knowledge of internal controls improved because of this project.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6. This experiment would have been more beneficial if it had lasted longer than four sessions.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7. This experiment was a total waste of my time.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
8. I understand less about internal controls now than when I started this experiment.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
9. My ability to recognize similarities among controls improved through this project.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
10. The use of scenarios was helpful in understandingcontrol components.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
11. My ability to recognize how controls differ improved because of this project.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Continue

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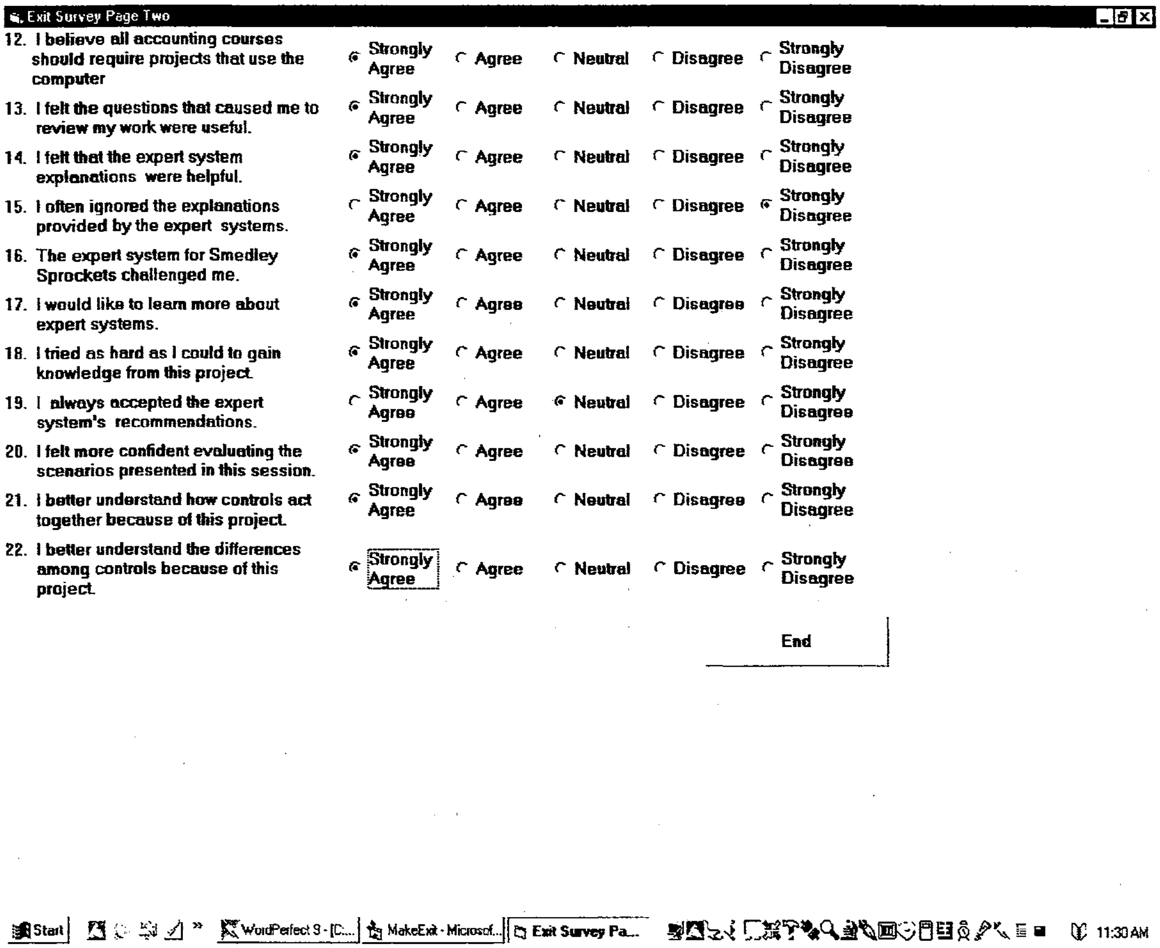
Exit Survey – Screen 2



Exit Survey Page Two

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
12. I believe all accounting courses should require projects that use the computer	(•)	( )	( )	( )	( )
13. I felt the questions that caused me to review my work were useful.	(•)	( )	( )	( )	( )
14. I felt that the expert system explanations were helpful.	(•)	( )	( )	( )	( )
15. I often ignored the explanations provided by the expert systems.	( )	( )	( )	( )	(•)
16. The expert system for Smedley Sprockets challenged me.	(•)	( )	( )	( )	( )
17. I would like to learn more about expert systems.	(•)	( )	( )	( )	( )
18. I tried as hard as I could to gain knowledge from this project.	(•)	( )	( )	( )	( )
19. I always accepted the expert system's recommendations.	( )	( )	(•)	( )	( )
20. I felt more confident evaluating the scenarios presented in this session.	(•)	( )	( )	( )	( )
21. I better understand how controls act together because of this project.	(•)	( )	( )	( )	( )
22. I better understand the differences among controls because of this project.	(•)	( )	( )	( )	( )

End

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APPENDIX B

CONTROL EVALUATION INTERFACES, ORGANIZATIONAL CHART, AND SCENARIOS

Experimental Session Input Screen for Group One and Group Two

Scenario One

1. Last year's evaluation of internal controls was:	( ) Low	(•) High	( ) Moderate	
2. Hiring and payrate are authorized by:	( ) Payroll	(•) Personnel	( ) Supervisor	
3. Changes in payrate are authorized by:	( ) Payroll	(•) Personnel	( ) Supervisor	
4. Employment termination forms are submitted to:	( ) Payroll	(•) Personnel	( ) Supervisor	
5. Is a timeclock used?	( ) No	(•) Yes		
6. Jobcards are approved by:	( ) No One	(•) Payroll	( ) Supervisor	
7. Overtime is approved by:	( ) No One	(•) Payroll	( ) Supervisor	
8. Jobcards are compared to timecards by:	( ) General Ledger	(•) No One	( ) Supervisor	
9. Preparation of paychecks and payroll registers are performed by:	( ) Auditor	( ) Cashier	(•) PayMaster	( ) Payroll
10. Earning are posted to individual records by:	( ) Payroll	(•) Personnel	( ) Supervisor	
11. Payroll distribution voucher is prepared by:	( ) Accounts Payable	( ) Payroll		
12. Labor distribution summary is prepared by:	( ) Accounts Payable	( ) General Ledger		
13. Who compares the distribution voucher and summary?	( ) Cost Acctg	( ) General Ledger	( ) No One	
14. Is a check signing machine used?	( ) No	( ) Yes		
15. Who controls unsigned (blank) checks?	( ) Cashier	( ) No One	( ) Payroll	
16. Who is responsible for signing checks?	( ) Auditor	( ) Cashier	( ) Payroll	( ) Supervisor
17. Is a separate checking account used for payroll?	( ) No	( ) Yes		
18. Who distributes payroll checks?	( ) Auditor	( ) Cashier	( ) PayMaster	( ) Supervisor
19. Who has responsibility for unclaimed checks?	( ) Auditor	( ) Cashier	( ) PayMaster	( ) Supervisor
20. Who distributes payroll on a surprise basis?	( ) Auditor	( ) No One		
21. Who compares payroll to budgeted figures?	( ) Auditor	( ) No One		
22. Who investigates payroll complaints?	( ) Auditor	( ) No One		

Please enter all information from Scenario One on the left and then click on the GREEN button to receive the System's evaluation of Internal Control Adequacy.

[Provide System Appraisal of Control Adequacy]

Click "Continue"

Continue

Experimental Session Input Screen for Group Three and Group Four

Scenario One

1. Last year's evaluation of internal controls was:	○ Low ○ High ○ Moderate
2. Hiring and payrate are authorized by:	○ Payroll ○ Personnel ○ Supervisor
3. Changes in payrate are authorized by:	○ Payroll ○ Personnel ○ Supervisor
4. Employment termination forms are submitted to:	○ Payroll ○ Personnel ○ Supervisor
5. Is a timeclock used?	○ No ○ Yes
6. Jobcards are approved by:	○ No One ○ Payroll ○ Supervisor
7. Overtime is approved by:	○ No One ○ Payroll ○ Supervisor
8. Jobcards are compared to timecards by:	○ General Ledger ○ No One ○ Supervisor
9. Preparation of paychecks and payroll registers are performed by:	○ Auditor ○ Cashier ○ PayMaster ○ Payroll
10. Earning are posted to individual records by:	○ Payroll ○ Personnel ○ Supervisor
11. Payroll distribution voucher is prepared by:	○ Accounts Payable ○ Payroll
12. Labor distribution summary is prepared by:	○ Accounts Payable ○ General Ledger
13. Who compares the distribution voucher and summary?	○ Cost Acctg ○ General Ledger ○ No One
14. Is a check signing machine used?	○ No ○ Yes
15. Who controls unsigned (blank) checks?	○ Cashier ○ No One ○ Payroll
16. Who is responsible for signing checks?	○ Auditor ○ Cashier ○ Payroll ○ Supervisor
17. Is a separate checking account used for payroll?	○ No ○ Yes
18. Who distributes payroll checks?	○ Auditor ○ Cashier ○ PayMaster ○ Supervisor
19. Who has responsibility for unclaimed checks?	○ Auditor ○ Cashier ○ PayMaster ○ Supervisor
20. Who distributes payroll on a surprise basis?	○ Auditor ○ No One
21. Who compares payroll to budgeted figures?	○ Auditor ○ No One
22. Who investigates payroll complaints?	○ Auditor ○ No One

Please enter all information from Scenario One on the left and then click on the GREEN button to receive the System's evaluation of Internal Control Adequacy.

[Provide System Appraisal of Control Adequacy]

Now click the RED "Make A Change" button. Make the requested change to the information on the left and click on the GREEN button to observe the effect of that change on the System's evaluation of Internal Control Adequacy.

[Make A Change]

Now click the PINK button, make the requested change, and click the GREEN button.

[Make Another Change]

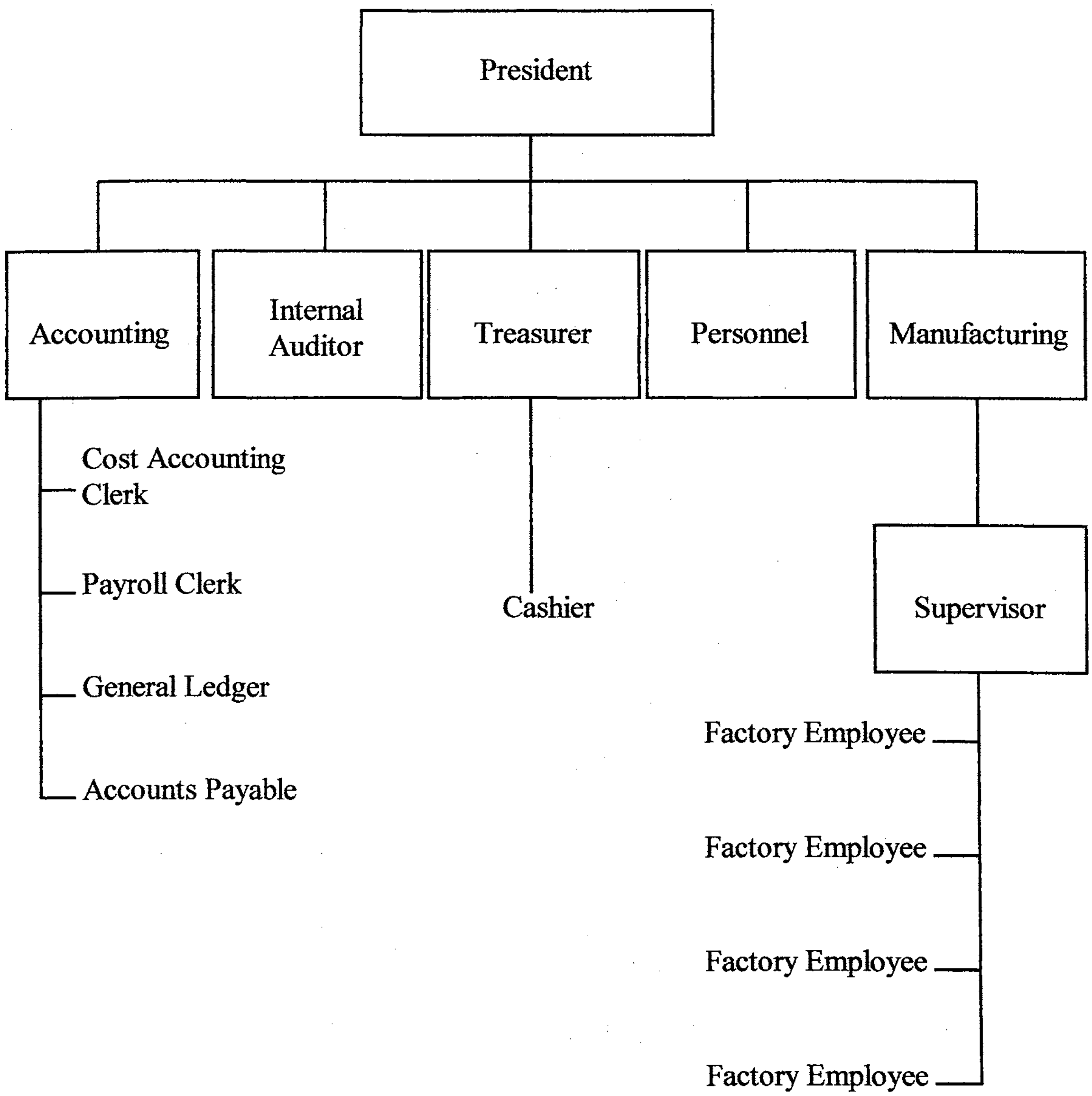
Finally, click the PALE PINK button, make the requested change, and click the GREEN button.

[Make One More Change]

Click "Continue"

[Continue]

Partial Organization Chart



Scenario 1 (Pretest and Posttest)

During last year's audit, the evaluation of internal control over payroll was determined to be high.

Factory employees are hired by the personnel department which determines the appropriate pay rate. The personnel department sends notice of employment and the pay rate to the payroll clerk. All changes in pay rate are authorized by the personnel department. When factory employees terminate their employment, they must complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees manually record their starting and stopping times on timecards. The factory employees record the time on each job on jobcards which are approved by the supervisor. Any overtime worked is authorized by the supervisor. At the end of each work week, the total hours from the timecards are compared with total hours on the jobcards by the general ledger department.

The payroll clerk prepares the paychecks and the payroll register using the hours from the time cards and the current pay rate. The payroll clerk then posts the information to the individual earnings records. Accounts payable checks the payroll register and prepares the payroll distribution voucher. Using the information from the jobcards, accounts payable prepares the labor distribution summary. The general ledger clerk is responsible for comparing the payroll register and the labor distribution summary and reconciling any differences.

The company does not use a check signing machine and all unsigned checks are not tightly controlled. The cashier has responsibility for signing the checks after she thoroughly examines the payroll distribution voucher. A separate bank account is used for payroll. The cashier distributes the payroll checks. Any unclaimed checks are retained by the cashier.

An internal auditor distributes the payroll on a surprise basis. The internal auditor also regularly compares the amount of the payroll with the budgeted figure and investigates any significant differences. All employee complaints about their pay are handled by the internal auditor.

Scenario 2 (Pretest and Posttest)

During last year's audit, the evaluation of internal control over payroll was determined to be low.

Factory employees are hired by the supervisor who determines the appropriate pay rate. Notice of employment is sent to the personnel department which notifies the payroll clerk. All changes in pay rate are authorized by the personnel department. When factory employees terminate their employment, they must complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees manually record their starting and stopping times on timecards. The factory employees record the time on each job on jobcards. Any overtime worked is authorized by the supervisor. At the end of each work week, the total hours from the timecards are compared with total hours on the jobcards by the general ledger department.

The auditor prepares the paychecks and the payroll register using the hours from the timecards and the current pay rate. The payroll clerk then posts the information to the individual earnings records. The payroll clerk checks the payroll register and prepares the payroll distribution voucher. Using the information from the jobcards, accounts payable clerk prepares the labor distribution summary. The general ledger clerk is responsible for comparing the payroll register and the labor distribution summary and reconciling any differences.

The company does not use a check signing machine and all unsigned checks are not tightly controlled. The cashier has responsibility for signing the checks after she thoroughly examines the payroll distribution voucher. A separate bank account is used for payroll. The cashier distributes the payroll checks. Any unclaimed checks are retained by the cashier.

An internal auditor distributes the payroll on a surprise basis. All employee complaints about their pay are handled by the internal auditor.

Scenario 3 (Pretest and Posttest)

During last year's audit, the evaluation of internal control over payroll was determined to be moderate.

Factory employees are hired by the payroll clerk who determines the appropriate pay rate. Notice of employment is sent to the personnel department which notifies the supervisor and payroll clerk. All changes in pay rate are authorized by the supervisor. When factory employees terminate their employment, they must complete a form and submit it to the supervisor who notifies the payroll clerk.

Employees manually record their starting and stopping times on timecards. The factory employees record the time on each job on jobcards which are approved by the supervisor. Any overtime worked is authorized by the payroll clerk. At the end of each work week, the total hours from the timecards are compared with total hours on the jobcards by the general ledger department.

The pay master prepares the paychecks and the payroll register using the hours from the timecards and the current pay rate. The payroll clerk then posts the information to the individual earnings records. The payroll clerk checks the payroll register and prepares the payroll distribution voucher. Using the information from the jobcards, the general ledger clerk prepares the labor distribution summary.

The company does not use a check signing machine but all unsigned checks are tightly controlled by the cashier. The cashier has responsibility for signing the checks after she thoroughly examines the payroll distribution voucher. Factory paychecks are written on the company's only checking account. The cashier distributes the payroll checks. Any unclaimed checks are retained by the cashier.

An internal auditor distributes the payroll on the first payday of every month.

Scenario 4 (Pretest and Posttest)

During last year's audit, the evaluation of internal control over payroll was determined to be low.

Factory employees are hired by the supervisor who determines the appropriate pay rate. Notice of employment and the pay rate are sent to payroll. All changes in pay rate are authorized by the supervisor. When factory employees terminate their employment, they must complete a form and submit it to the supervisor which notifies the payroll clerk.

Employees manually record their starting and stopping times on timecards. Neither the jobcards nor overtime require approval. Time cards are never compared to job cards.

The cashier prepares the paychecks and the payroll register using the hours from the timecards and the current pay rate. The payroll clerk then posts the information to the individual earnings records. The accounts payable clerk checks the payroll register and prepares the payroll distribution voucher. Using the information from the jobcards, the general ledger clerk prepares the labor distribution summary. The general ledger clerk compares the labor distribution summary and the payroll distribution voucher.

The company does not use a check signing machine and all unsigned checks are not tightly controlled. The cashier has responsibility for signing the checks after she thoroughly examines the payroll distribution voucher. Factory paychecks are written on the company's only checking account.. The cashier distributes the payroll checks. Any unclaimed checks are retained by the cashier.

An internal auditor distributes the payroll on the first payday of every month.

Scenario 5 (Pretest and Posttest)

During last year's audit, the evaluation of internal control over payroll was determined to be low.

Factory employees are hired by the personnel department which determines the appropriate pay rate. Notice of employment and the pay rate are sent to payroll. All changes in pay rate are authorized by personnel. When factory employees terminate their employment, they must complete a form and submit it to the personnel which notifies the payroll clerk.

Employees record their starting and stopping times by inserting their timecards in the timeclock located near the factory entrance. The supervisor is responsible for approving jobcards and authorizing overtime. At the end of each work week, the total hours from the timecards are compared with total hours on the jobcards by the general ledger department.

The payroll clerk prepares the paychecks and the payroll register using the hours from the timecards and the current pay rate. The payroll clerk then posts the information to the individual earnings records. The accounts payable clerk checks the payroll register and prepares the payroll distribution voucher. Using the information from the jobcards, the general ledger clerk prepares the labor distribution summary. Cost accounting compares the labor distribution summary and the payroll distribution voucher and reconciling any differences.

The company does uses a check signing machine and all unsigned checks are tightly controlled by the internal auditor. The cashier has responsibility for signing the checks after she thoroughly examines the payroll distribution voucher. Factory paychecks are written on a separate checking account. The pay master distributes the payroll checks. Any unclaimed checks are retained by the auditor.

An internal auditor distributes the payroll on a surprise basis. The internal auditor is also responsible for investigating large variances he finds when the payroll voucher is compared to a budgeted figure. In addition, all employee complaints concerning their paychecks are investigated by the internal auditor.

APPENDIX C

DECISION TREES

Separation of Function Decision Tree
Pay Check

Who Prepares the Check?	Who Signs the Check?	Who Distributes the Check?	Outcome
Payroll	Cashier	Cashier	Low
		Supervisor	Low
		Auditor	High
		Pay Master	High
	Payroll	Cashier	Low
		Supervisor	Low
		Auditor	Low
		Pay Master	Low
	Auditor	Cashier	High
		Supervisor	Low
		Auditor	Low
		Pay Master	High
	Supervisor	Cashier	High
		Supervisor	Low
		Auditor	High
		Pay Master	High
Auditor	Cashier	Cashier	Moderate
		Supervisor	Low
		Auditor	Moderate
		Pay Master	Moderate
	Payroll	Cashier	Moderate
		Supervisor	Low
		Auditor	Low
		Pay Master	Moderate
	Auditor	Cashier	Low
		Supervisor	Low
		Auditor	Low
		Pay Master	Low
	Supervisor	Cashier	Moderate
		Supervisor	Low
		Auditor	Low
		Pay Master	Moderate

Separation of Function Decision Tree
Pay Check (Continued)

Who Prepares the Check?	Who Signs the Check?	Who Distributes the Check?	Outcome
PayMaster	Cashier	Cashier	Low
		Supervisor	Low
		Auditor	Moderate
		Pay Master	Low
	Payroll	Cashier	Moderate
		Supervisor	Moderate
		Auditor	Moderate
		Pay Master	Low
	Auditor	Cashier	Moderate
		Supervisor	Moderate
		Auditor	Low
		Pay Master	Low
	Supervisor	Cashier	Moderate
		Supervisor	Low
		Auditor	Moderate
		Pay Master	Low
Cashier	Cashier	Cashier	Low
		Supervisor	Low
		Auditor	Low
		Pay Master	Low
	Payroll	Cashier	Low
		Supervisor	Moderate
		Auditor	Moderate
		Pay Master	Moderate
	Auditor	Cashier	Low
		Supervisor	Moderate
		Auditor	Low
		Pay Master	Moderate
	Supervisor	Cashier	Low
		Supervisor	Low
		Auditor	Moderate
		Pay Master	Moderate

Separation of Function Decision Tree
Pay Information

Who Maintains Pay Rate?	Who Approves Job Card?	Who Updates Individual Records?	Outcome
Personnel	Supervisor	Payroll	High
		Personnel	Low
		Supervisor	Low
	Payroll	Payroll	Low
		Personnel	Low
		Supervisor	Moderate
	No One	Payroll	Moderate
		Personnel	Low
		Supervisor	Moderate
Payroll	Supervisor	Payroll	Low
		Personnel	Moderate
		Supervisor	Low
	Payroll	Payroll	Low
		Personnel	Low
		Supervisor	Low
	No One	Payroll	Low
		Personnel	Moderate
		Supervisor	Moderate
Supervisor	Supervisor	Payroll	Low
		Personnel	Low
		Supervisor	Low
	Payroll	Payroll	Low
		Personnel	Moderate
		Supervisor	Low
	No One	Payroll	Low
		Personnel	Moderate
		Supervisor	Low

Separation of Function Decision Tree
Time Card

Is a Time Clock Used?	Who Updates Individual Records?	Who Authorizes Overtime?	Outcome
Yes	Payroll	Supervisor	High
		Payroll	Low
		No One	Moderate
	Personnel	Supervisor	Moderate
		Payroll	Moderate
		No One	Moderate
	Supervisor	Supervisor	Low
		Payroll	Moderate
		No One	Low
No	Payroll	Supervisor	Moderate
		Payroll	Low
		No One	Low
	Personnel	Supervisor	Low
		Payroll	Low
		No One	Low
	Supervisor	Supervisor	Low
		Payroll	Low
		No One	Low

Separation of Function Point Calculation

Separation of Function Pay Check	Separation of Function Pay Information	Separation of Function Time Card	Points
Low	Low	Low	0
Low	Low	Moderate	1
Low	Moderate	Low	1
Moderate	Low	Low	1
Low	Moderate	Moderate	2
Moderate	Low	Moderate	2
Moderate	Moderate	Low	2
High	Low	Low	2
Low	High	Low	2
Low	Low	High	2
Moderate	Moderate	Moderate	3
Low	Moderate	High	3
Low	High	Moderate	3
Moderate	High	Low	3
Moderate	Low	High	3
High	Low	Moderate	3
High	Moderate	Low	3
Moderate	Moderate	High	4
Moderate	High	Moderate	4
High	Moderate	Moderate	4
High	High	Low	4
High	Low	High	4
Low	High	High	4
High	Moderate	High	5
High	High	Moderate	5
Moderate	High	High	5
High	High	High	6

Expert Opinion Decision Tree - Separation of Function is 6

Imprest Account	Comparison of Job Card And Time Card	Reconciliation of Labor Summary and Distribution Voucher	Surprise Payroll Distribution	Points	Outcome
Yes	Supervisor	Cost Accounting	Auditor	10	High
			No One	9	High
		General Ledger	Auditor	10	High
			No One	9	High
		No One	Auditor	9	High
			No One	8	High
	General Ledger	Cost Accounting	Auditor	10	High
			No One	9	High
		General Ledger	Auditor	10	High
			No One	9	High
		No One	Auditor	9	High
			No One	8	High
	No One	Cost Accounting	Auditor	9	High
			No One	8	High
		General Ledger	Auditor	9	High
			No One	8	High
		No One	Auditor	8	High
			No One	7	Moderate
No	Supervisor	Cost Accounting	Auditor	9	High
			No One	8	High
		General Ledger	Auditor	9	High
			No One	8	High
		No One	Auditor	8	High
			No One	7	Moderate
	General Ledger	Cost Accounting	Auditor	9	High
			No One	8	High
		General Ledger	Auditor	9	High
			No One	8	High
		No One	Auditor	8	High
			No One	7	Moderate
	No One	Cost Accounting	Auditor	8	High
			No One	7	Moderate
		General Ledger	Auditor	8	High
			No One	7	Moderate
		No One	Auditor	7	Moderate
			No One	6	Moderate

Expert Opinion Decision Tree - Separation of Function is 5

Imprest Account	Comparison of Job Card And Time Card	Reconciliation of Labor Summary and Distribution Voucher	Surprise Payroll Distribution	Points	Outcome
		Cost Accounting	Auditor	9	High
			No One	8	High
	Supervisor	General Ledger	Auditor	9	High
			No One	8	High
		No One	Auditor	8	High
			No One	7	Moderate
		Cost Accounting	Auditor	9	High
			No One	8	High
Yes	General Ledger	General Ledger	Auditor	9	High
			No One	8	High
		No One	Auditor	8	High
			No One	7	Moderate
		Cost Accounting	Auditor	8	High
			No One	7	Moderate
	No One	General Ledger	Auditor	8	High
			No One	7	Moderate
		No One	Auditor	7	Moderate
			No One	6	Moderate
		Cost Accounting	Auditor	8	High
			No One	7	Moderate
	Supervisor	General Ledger	Auditor	8	High
			No One	7	Moderate
		No One	Auditor	7	Moderate
			No One	6	Moderate
		Cost Accounting	Auditor	8	High
			No One	7	Moderate
No	General Ledger	General Ledger	Auditor	8	High
			No One	7	Moderate
		No One	Auditor	7	Moderate
			No One	6	Moderate
		Cost Accounting	Auditor	7	Moderate
			No One	6	Moderate
	No One	General Ledger	Auditor	7	Moderate
			No One	6	Moderate
		No One	Auditor	6	Moderate
			No One	5	Moderate

Expert Opinion Decision Tree - Separation of Function is 4

Imprest Account	Comparison of Job Card And Time Card	Reconciliation of Labor Summary and Distribution Voucher	Surprise Payroll Distribution	Points	Outcome
Yes	Supervisor	Cost Accounting	Auditor	8	High
			No One	7	Moderate
		General Ledger	Auditor	8	High
			No One	7	Moderate
		No One	Auditor	7	Moderate
			No One	6	Moderate
	General Ledger	Cost Accounting	Auditor	8	High
			No One	7	Moderate
		General Ledger	Auditor	8	High
			No One	7	Moderate
		No One	Auditor	7	Moderate
			No One	6	Moderate
	No One	Cost Accounting	Auditor	7	Moderate
			No One	6	Moderate
		General Ledger	Auditor	7	Moderate
			No One	6	Moderate
		No One	Auditor	6	Moderate
			No One	5	Moderate
No	Supervisor	Cost Accounting	Auditor	7	Moderate
			No One	6	Moderate
		General Ledger	Auditor	7	Moderate
			No One	6	Moderate
		No One	Auditor	6	Moderate
			No One	5	Moderate
	General Ledger	Cost Accounting	Auditor	7	Moserate
			No One	6	Moderate
		General Ledger	Auditor	7	Moderate
			No One	6	Moderate
		No One	Auditor	6	Moderate
			No One	5	Moderate
	No One	Cost Accounting	Auditor	6	Moderate
			No One	5	Moderate
		General Ledger	Auditor	6	Moderate
			No One	5	Moderate
		No One	Auditor	5	Moderate
			No One	4	Moderate

Expert Opinion Decision Tree - Separation of Function is 3

Imprest Account	Comparison of Job Card And Time Card	Reconciliation of Labor Summary and Distribution Voucher	Surprise Payroll Distribution	Points	Outcome
Yes	Supervisor	Cost Accounting	Auditor	7	Moderate
			No One	6	Moderate
		General Ledger	Auditor	7	Moderate
			No One	6	Moderate
		No One	Auditor	6	Moderate
			No One	5	Moderate
	General Ledger	Cost Accounting	Auditor	7	Moderate
			No One	6	Moderate
		General Ledger	Auditor	7	Moderate
			No One	6	Moderate
		No One	Auditor	6	Moderate
			No One	5	Moderate
	No One	Cost Accounting	Auditor	6	Moderate
			No One	5	Moderate
		General Ledger	Auditor	6	Moderate
			No One	5	Moderate
		No One	Auditor	5	Moderate
			No One	4	Moderate
No	Supervisor	Cost Accounting	Auditor	6	Moderate
			No One	5	Moderate
		General Ledger	Auditor	6	Moderate
			No One	5	Moderate
		No One	Auditor	5	Moderate
			No One	4	Moderate
	General Ledger	Cost Accounting	Auditor	6	Moserate
			No One	5	Moderate
		General Ledger	Auditor	6	Moderate
			No One	5	Moderate
		No One	Auditor	5	Moderate
			No One	4	Moderate
	No One	Cost Accounting	Auditor	5	Moderate
			No One	4	Moderate
		General Ledger	Auditor	5	Moderate
			No One	4	Moderate
		No One	Auditor	4	Moderate
			No One	3	Low

Expert Opinion Decision Tree - Separation of Function is 2

Imprest Account	Comparison of Job Card And Time Card	Reconciliation of Labor Summary and Distribution Voucher	Surprise Payroll Distribution	Points	Outcome
Yes	Supervisor	Cost Accounting	Auditor	6	Moderate
Yes	Supervisor	Cost Accounting	No One	5	Moderate
Yes	Supervisor	General Ledger	Auditor	6	Moderate
Yes	Supervisor	General Ledger	No One	5	Moderate
Yes	Supervisor	No One	Auditor	5	Moderate
Yes	Supervisor	No One	No One	4	Moderate
Yes	General Ledger	Cost Accounting	Auditor	6	Moderate
Yes	General Ledger	Cost Accounting	No One	5	Moderate
Yes	General Ledger	General Ledger	Auditor	6	Moderate
Yes	General Ledger	General Ledger	No One	5	Moderate
Yes	General Ledger	No One	Auditor	5	Moderate
Yes	General Ledger	No One	No One	4	Moderate
Yes	No One	Cost Accounting	Auditor	5	Moderate
Yes	No One	Cost Accounting	No One	4	Moderate
Yes	No One	General Ledger	Auditor	5	Moderate
Yes	No One	General Ledger	No One	4	Moderate
Yes	No One	No One	Auditor	4	Moderate
Yes	No One	No One	No One	3	Low
No	Supervisor	Cost Accounting	Auditor	5	Moderate
No	Supervisor	Cost Accounting	No One	4	Moderate
No	Supervisor	General Ledger	Auditor	5	Moderate
No	Supervisor	General Ledger	No One	4	Moderate
No	Supervisor	No One	Auditor	4	Moderate
No	Supervisor	No One	No One	3	Low
No	General Ledger	Cost Accounting	Auditor	5	Moserate
No	General Ledger	Cost Accounting	No One	4	Moderate
No	General Ledger	General Ledger	Auditor	5	Moderate
No	General Ledger	General Ledger	No One	4	Moderate
No	General Ledger	No One	Auditor	4	Moderate
No	General Ledger	No One	No One	3	Low
No	No One	Cost Accounting	Auditor	4	Moderate
No	No One	Cost Accounting	No One	3	Low
No	No One	General Ledger	Auditor	4	Moderate
No	No One	General Ledger	No One	3	Low
No	No One	No One	Auditor	3	Low
No	No One	No One	No One	2	Low

Expert Opinion Decision Tree - Separation of Function is 1

Imprest Account	Comparison of Job Card And Time Card	Reconciliation of Labor Summary and Distribution Voucher	Surprise Payroll Distribution	Points	Outcome
Yes	Supervisor	Cost Accounting	Auditor	5	Moderate
			No One	4	Moderate
		General Ledger	Auditor	5	Moderate
			No One	4	Moderate
		No One	Auditor	4	Moderate
			No One	3	Low
	General Ledger	Cost Accounting	Auditor	5	Moderate
			No One	4	Moderate
		General Ledger	Auditor	5	Moderate
			No One	4	Moderate
		No One	Auditor	4	Moderate
			No One	3	Low
	No One	Cost Accounting	Auditor	4	Moderate
			No One	3	Low
		General Ledger	Auditor	4	Moderate
			No One	3	Low
		No One	Auditor	3	Low
			No One	2	Low
No	Supervisor	Cost Accounting	Auditor	4	Moderate
			No One	3	Low
		General Ledger	Auditor	4	Moderate
			No One	3	Low
		No One	Auditor	3	Low
			No One	2	Low
	General Ledger	Cost Accounting	Auditor	4	Moserate
			No One	3	Low
		General Ledger	Auditor	4	Moderate
			No One	3	Low
		No One	Auditor	3	Low
			No One	2	Low
	No One	Cost Accounting	Auditor	3	Low
			No One	2	Low
		General Ledger	Auditor	3	Low
			No One	2	Low
		No One	Auditor	2	Low
			No One	1	Low

Expert Opinion Decision Tree - Separation of Function is 0

Imprest Account	Comparison of Job Card And Time Card	Reconciliation of Labor Summary and Distribution Voucher	Surprise Payroll Distribution	Points	Outcome
Yes	Supervisor	Cost Accounting	Auditor	4	Moderate
			No One	3	Low
		General Ledger	Auditor	4	Moderate
			No One	3	Low
		No One	Auditor	3	Low
			No One	2	Low
	General Ledger	Cost Accounting	Auditor	4	Moderate
			No One	3	Low
		General Ledger	Auditor	4	Moderate
			No One	3	Low
		No One	Auditor	3	Low
			No One	2	Low
	No One	Cost Accounting	Auditor	3	Low
			No One	2	Low
		General Ledger	Auditor	3	Low
			No One	2	Low
		No One	Auditor	2	Low
			No One	1	Low
No	Supervisor	Cost Accounting	Auditor	3	Low
			No One	2	Low
		General Ledger	Auditor	3	Low
			No One	2	Low
		No One	Auditor	2	Low
			No One	1	Low
	General Ledger	Cost Accounting	Auditor	3	Low
			No One	2	Low
		General Ledger	Auditor	3	Low
			No One	2	Low
		No One	Auditor	2	Low
			No One	1	Low
	No One	Cost Accounting	Auditor	2	Low
			No One	1	Low
		General Ledger	Auditor	2	Low
			No One	1	Low
		No One	Auditor	1	Low
			No One	0	Low

APPENDIX D

VISUAL BASIC CODE

Intelligent Decision Aid Logic Code

Dimension of variable statements:

```
Dim TC As Integer (TC = Time Card )
        TC = 0
Dim TCV As String (TVC = Value assigned to separation of duty over the Time
        Card)
Dim PC As Integer (PC = Pay Check)
        PC = 0
Dim PCV As String (PCV = Value assigned to separation of duty over the Pay
        Check)
Dim PI As Integer (PI = Pay Information)
        PI = 0
Dim PIV As String (PIV = Value assigned to Pay Information separation of duty)
Dim Sof As Integer (Sof =
        Sof = 0
Dim SofV As String (SofV = Strength of Time Card, Pay Check, and Pay
        Information separation of duty)
Dim GoOn As Boolean
        GoOn = True
```

Assignment of value to TC (Time Card)'

```
If Opt5Yes.Value = True And Opt10Pay.Value = True And Opt7Sup.Value =
        True Then
        TC = 2
End If
If Opt5Yes.Value = True And Opt10Pay.Value = True And Opt7No.Value =
        True Then
        TC = 1
End If
If Opt5Yes.Value = True And Opt10Per.Value = True Then
        TC = 1
End If
If Opt5Yes.Value = True And Opt10Sup.Value = True And Opt7Pay.Value =
        True Then
        TC = 1
End If
If Opt5No.Value = True And Opt10Pay.Value = True And Opt7Sup.Value =
        True Then
        TC = 1
End If
```

Assignment of value to TCV (Separation of duty over Time Card)

```
If TC = 0 Then
        TCV = "Low"
End If
If TC = 1 Then
        TCV = "Moderate"
End If
If TC = 2 Then
        TCV = "High"
End If
```

Assignment of value to PC (Pay Check)

```
If Opt9Pay.Value = True And Opt16Cash.Value = True And Opt18Aud.Value =
True Then
        PC = 2
End If
If Opt9Pay.Value = True And Opt16Cash.Value = True And Opt18PM.Value =
        True Then
        PC = 2
End If
If Opt9Pay.Value = True And Opt16Aud.Value = True And Opt18Cash.Value =
        True Then
        PC = 2
End If
If Opt9Pay.Value = True And Opt16Aud.Value = True And Opt18PM.Value =
        True Then
        PC = 2
End If
If Opt9Pay.Value = True And Opt16Sup.Value = True And Opt18Sup.Value =
        False Then
        PC = 1
End If
If Opt9Aud.Value = True And Opt16Cash.Value = True And Opt18Sup.Value =
        True Then
        PC = 1
End If
If Opt9Aud.Value = True And Opt16Cash.Value = True And Opt18PM.Value =
        True Then
        PC = 1
End If
If Opt9Aud.Value = True And Opt16Pay.Value = True And Opt18Cash.Value =
        True Then
        PC = 1
End If
```

```
If Opt9Aud.Value = True And Opt16Pay.Value = True And Opt18PM.Value =
        True Then
        PC = 1
End If
If Opt9Aud.Value = True And Opt16Sup.Value = True And Opt18Cash.Value =
        True Then
        PC = 1
End If
If Opt9Aud.Value = True And Opt16Sup.Value = True And Opt18PM.Value =
        True Then
        PC = 1
End If
If Opt9PM.Value = True And Opt16Cash.Value = True And Opt18Aud.Value =
        True Then
        PC = 1
End If
If Opt9PM.Value = True And Opt16Pay.Value = True And Opt18PM.Value =
        False Then
        PC = 1
End If
If Opt9PM.Value = True And Opt16Aud.Value = True And Opt18Cash.Value =
        True Then
        PC = 1
End If
If Opt9PM.Value = True And Opt16Aud.Value = True And Opt18Sup.Value =
        True Then
        PC = 1
End If
If Opt9PM.Value = True And Opt16Sup.Value = True And Opt18Cash.Value =
        True Then
        PC = 1
End If
If Opt9PM.Value = True And Opt16Sup.Value = True And Opt18Aud.Value =
        True Then
        PC = 1
End If
If Opt9Cash.Value = True And Opt16Pay.Value = True And Opt18Cash.Value =
        False Then
        PC = 1
End If
If Opt9Cash.Value = True And Opt16Aud.Value = True And Opt18Sup.Value =
        True Then
        PC = 1
End If
```

```
If Opt9Cash.Value = True And Opt16Aud.Value = True And Opt18PM.Value =
        True Then
        PC = 1
End If
If Opt9Cash.Value = True And Opt16Sup.Value = True And Opt18Aud.Value =
        True Then
        PC = 1
End If
If Opt9Cash.Value = True And Opt16Sup.Value = True And Opt18PM.Value =
        True Then
        PC = 1
End If
```

Assignment of value to PCV (Separation of duties - Pay Check)

```
If PC = 0 Then
        PCV = "Low"
End If
If PC = 1 Then
        PCV = "Moderate"
End If
If PC = 2 Then
        PCV = "High"
End If
```

Assignment of value to PI (Pay Information)

```
If Opt2Per.Value = True And Opt6Sup.Value = True And Opt10Pay.Value =
        True Then
        PI = 2
End If
If Opt2Per.Value = True And Opt6Pay.Value = True And Opt10Sup.Value =
        True Then
        PI = 1
End If
If Opt2Per.Value = True And Opt6No.Value = True And Opt10Per.Value = False
        Then
        PI = 1
 End If
If Opt2Pay.Value = True And Opt6Sup.Value = True And Opt10Per.Value =
        True Then
        PI = 1
End If
```

```
If Opt2Pay.Value = True And Opt6No.Value = True And Opt10Pay.Value =
        False Then
        PI = 1
End If
If Opt2Sup.Value = True And Opt6Pay.Value = True And Opt10Per.Value =
        True Then
        PI = 1
End If
If Opt2Sup.Value = True And Opt6No.Value = True And Opt10Per.Value =
        True Then
        PI = 1
End If
```

Assignment of value to PIV (Pay Information separation of duty)

```
If PI = 0 Then
        PIV = "Low"
End If
If PI = 1 Then
        PIV = "Moderate"
End If
If PI = 2 Then
        PIV = "High"
End If
```

Assignment of value to Sof

```
Sof = Sof + TC + PC + PI
```

Assignment of value to SofV (Separation of Duties)

```
If Sof = 6 Or Sof = 5 Then
        SofV = "HIGH"
End If
If Sof = 4 Or Sof = 3 Then
        SofV = "MODERATE"
End If
If Sof < 3 Then
        SofV = "LOW"
End If
```

Assignment of other values

```
Dim IP As String 'Is an imprest account used'
        If Opt17Yes.Value = True Then
                IP = "Yes"
                Else: IP = "No"
        End If
```

```
        Dim JCRec As String 'Reconciliation of Job Card and Time Card'
                If Opt8Sup.Value = True Or Opt8GL.Value = True Then
                        JCRec = "Yes"
                        Else: JCRec = "No"
                End If
        Dim LSRec As String 'Reconciliation of Labor Summary and Distribution
                Voucher'
                If Opt13Cost.Value = True Or Opt13GL.Value = True Then
                        LSRec = "Yes"
                        Else: LSRec = "No"
                End If
        Dim Surprise As String 'Surprise Payroll Distribution'
                If Opt20Aud.Value = True Then
                        Surprise = "Yes"
                        Else: Surprise = "No"
                End If

Assignment of  values to strength of Others
        Dim Other As Integer
                Other = 0
                If Opt17Yes.Value = True And Opt8Sup.Value = True And
                        Opt13Cost.Value = True And Opt20Aud.Value = True Then
                        Other = 4
                End If
                If Opt17Yes.Value = True And Opt8Sup.Value = True And
                        Opt13Cost.Value = True And Opt20No.Value = True Then
                        Other = 3
                End If
                If Opt17Yes.Value = True And Opt8Sup.Value = True And
                        Opt13GL.Value = True And Opt20Aud.Value = True Then
                        Other = 4
                End If
                If Opt17Yes.Value = True And Opt8Sup.Value = True And
                        Opt13GL.Value = True And Opt20No.Value = True Then
                        Other = 3
                End If
                If Opt17Yes.Value = True And Opt8Sup.Value = True And
                        Opt13No.Value = True And Opt20Aud.Value = True Then
                        Other = 3
                End If
                If Opt17Yes.Value = True And Opt8Sup.Value = True And
                        Opt13No.Value = True And Opt20No.Value = True Then
                        Other = 2
                End If
```

```
If Opt17Yes.Value = True And Opt8GL.Value = True And
        Opt13Cost.Value = True And Opt20Aud.Value = True Then
        Other = 4
End If
If Opt17Yes.Value = True And Opt8GL.Value = True And
        Opt13Cost.Value = True And Opt20No.Value = True Then
        Other = 3
End If
If Opt17Yes.Value = True And Opt8GL.Value = True And
        Opt13GL.Value = True And Opt20Aud.Value = True Then
        Other = 4
End If
If Opt17Yes.Value = True And Opt8GL.Value = True And
        Opt13GL.Value = True And Opt20No.Value = True Then
        Other = 3
End If
If Opt17Yes.Value = True And Opt8GL.Value = True And
        Opt13No.Value = True And Opt20Aud.Value = True Then
        Other = 3
End If
If Opt17Yes.Value = True And Opt8GL.Value = True And
        Opt13No.Value = True And Opt20No.Value = True Then
        Other = 2
End If
If Opt17Yes.Value = True And Opt8No.Value = True And
        Opt13Cost.Value = True And Opt20Aud.Value = True Then
        Other = 3
End If
If Opt17Yes.Value = True And Opt8No.Value = True And
        Opt13Cost.Value = True And Opt20No.Value = True Then
        Other = 2
End If
If Opt17Yes.Value = True And Opt8No.Value = True And
        Opt13GL.Value = True And Opt20Aud.Value = True Then
        Other = 3
End If
If Opt17Yes.Value = True And Opt8No.Value = True And
        Opt13GL.Value = True And Opt20No.Value = True Then
        Other = 2
End If
If Opt17Yes.Value = True And Opt8No.Value = True And
        Opt13No.Value = True And Opt20Aud.Value = True Then
        Other = 2
End If
```

```
If Opt17Yes.Value = True And Opt8No.Value = True And
        Opt13No.Value = True And Opt20No.Value = True Then
        Other = 1
End If
If Opt17No.Value = True And Opt8Sup.Value = True And
        Opt13Cost.Value = True And Opt20Aud.Value = True Then
        Other = 3
End If
If Opt17No.Value = True And Opt8Sup.Value = True And
        Opt13Cost.Value = True And Opt20No.Value = True Then
        Other = 2
End If
If Opt17No.Value = True And Opt8Sup.Value = True And
        Opt13GL.Value = True And Opt20Aud.Value = True Then
        Other = 3
End If
If Opt17No.Value = True And Opt8Sup.Value = True And
        Opt13GL.Value = True And Opt20No.Value = True Then
        Other = 2
End If
If Opt17No.Value = True And Opt8Sup.Value = True And
        Opt13No.Value = True And Opt20Aud.Value = True Then
        Other = 2
End If
If Opt17No.Value = True And Opt8Sup.Value = True And
        Opt13No.Value = True And Opt20No.Value = True Then
        Other = 1
End If
If Opt17No.Value = True And Opt8GL.Value = True And
        Opt13Cost.Value = True And Opt20Aud.Value = True Then
        Other = 3
End If
If Opt17No.Value = True And Opt8GL.Value = True And
        Opt13Cost.Value = True And Opt20No.Value = True Then
        Other = 2
End If
If Opt17No.Value = True And Opt8GL.Value = True And
        Opt13GL.Value = True And Opt20Aud.Value = True Then
        Other = 3
End If
If Opt17No.Value = True And Opt8GL.Value = True And
        Opt13GL.Value = True And Opt20No.Value = True Then
        Other = 2
End If
```

```
If Opt17No.Value = True And Opt8GL.Value = True And
        Opt13No.Value = True And Opt20Aud.Value = True Then
        Other = 2
End If
If Opt17No.Value = True And Opt8GL.Value = True And
        Opt13No.Value = True And Opt20No.Value = True Then
        Other = 1
End If
If Opt17No.Value = True And Opt8No.Value = True And
        Opt13Cost.Value = True And Opt20Aud.Value = True Then
        Other = 2
End If
If Opt17No.Value = True And Opt8No.Value = True And
        Opt13Cost.Value = True And Opt20No.Value = True Then
        Other = 1
End If
If Opt17No.Value = True And Opt8No.Value = True And
        Opt13GL.Value = True And Opt20Aud.Value = True Then
        Other = 2
End If
If Opt17No.Value = True And Opt8No.Value = True And
        Opt13GL.Value = True And Opt20No.Value = True Then
        Other = 1
End If
If Opt17No.Value = True And Opt8No.Value = True And
        Opt13No.Value = True And Opt20Aud.Value = True Then
        Other = 1
End If
If Opt17No.Value = True And Opt8No.Value = True And
        Opt13No.Value = True And Opt20No.Value = True Then
        Other = 0
End If
```

Assignment of Final Decision

```
Dim Outcome As String
        Outcome = "MODERATE"
Dim Totals As Integer
        Totals = 0
Totals = Sof + Other
        If Totals > 7 Then
                Outcome = "HIGH"
        End If
        If Totals < 4 Then
                Outcome = "LOW"
        End If
```

Relate Decision and Process to User

```
MsgBox "Separation of Function over the Time Card is " & TCV & "." & "
        Separation of Function over the Pay Check is " & PCV & "." & "
        Separation of Function over Pay Information is " & PIV & "." & "
                OVERALL SEPARATION OF FUNCTION is " & SofV & "
                Is there a separate bank account for payroll?  " & IP & "
                Does anyone reconcile the Job Cards and the Time Cards? " &
                        JCRec & "
                Does anyone reconcile the Distribution Summary and the
                        Distribution Voucher? "& LSRec & "
                Is payroll distributed on a surprise basis? " & Surprise & "
        THE OVERALL ADEQUACY OF INTERNAL CONTROLS FOR THIS
                SCENARIO IS " & Outcome
```

Visual Basic Code for Each Option Button

```
Private Sub Opt1Hi_Click()
        If Opt1Hi.Value = True Then
                MsgBox "The level of control adequacy determined last year tells you how
                        extensively you need to review internal controls this year."
        End If
End Sub

Private Sub Opt1Lo_Click()
        If Opt1Hi.Value = True Then
                MsgBox "The level of control adequacy determined last year tells you how
                        extensively you need to review internal controls this year."
        End If
End Sub

Private Sub Opt1Mod_Click()
        If Opt1Hi.Value = True Then
                MsgBox "The level of control adequacy determined last year tells you how
                        extensively you need to review internal controls this year."
        End If
End Sub

Private Sub Opt2Pay_Click()
        If Opt1Lo.Value = False And Opt1Hi.Value = False And Opt1Mod.Value = False
                Then
                MsgBox "Please answer Question #1."
                Opt2Pay.Value = False
        End If
        If Opt2Pay.Value = True Then
                MsgBox "This is an authorization function designed to prevent
                        inappropriate personnel from being paid or to prevent paying an
                        employee at a wrong rate."
        End If
End Sub
```

```
Private Sub Opt2Per_Click()
        If Opt1Lo.Value = False And Opt1Hi.Value = False And Opt1Mod.Value = False
                Then
                MsgBox "Please answer Question #1."
                Opt2Per.Value = False
        End If
        If Opt2Pay.Value = True Then
                MsgBox "This is an authorization function designed to prevent
                        inappropriate personnel from being paid or to prevent paying an
                        employee at a wrong rate."
        End If
End Sub

Private Sub Opt2Sup_Click()
        If Opt1Lo.Value = False And Opt1Hi.Value = False And Opt1Mod.Value = False
                Then
                MsgBox "Please answer Question #1."
                Opt2Sup.Value = False
        End If
        If Opt2Pay.Value = True Then
                MsgBox "This is an authorization function designed to prevent
                        inappropriate personnel from being paid or to prevent paying an
                        employee at a wrong rate."
        End If
End Sub

Private Sub Opt3Pay_Click()
        If Opt2Pay.Value = False And Opt2Per.Value = False And Opt2Sup.Value =
                False Then
                MsgBox "Please answer Question #2."
                Opt3Pay.Value = False
        End If
End Sub

Private Sub Opt3Per_Click()
        If Opt2Pay.Value = False And Opt2Per.Value = False And Opt2Sup.Value =
                False Then
                MsgBox "Please answer Question #2."
                Opt3Per.Value = False
        End If
End Sub
```

```
Private Sub Opt3Sup_Click()
        If Opt2Pay.Value = False And Opt2Per.Value = False And Opt2Sup.Value =
                False Then
                MsgBox "Please answer Question #2."
                Opt3Sup.Value = False
        End If
End Sub

Private Sub Opt4Pay_Click()
        If Opt3Pay.Value = False And Opt3Per.Value = False And Opt3Sup.Value =
                False Then
                MsgBox "Please answer Question #3."
                Opt4Pay.Value = False
        End If
End Sub

Private Sub Opt4Per_Click()
        If Opt3Pay.Value = False And Opt3Per.Value = False And Opt3Sup.Value =
                False Then
                MsgBox "Please answer Question #3."
                Opt4Per.Value = False
        End If
End Sub

Private Sub Opt4Sup_Click()
        If Opt3Pay.Value = False And Opt3Per.Value = False And Opt3Sup.Value =
                False Then
                MsgBox "Please answer Question #3."
                Opt4Sup.Value = False
        End If
End Sub

Private Sub Opt5No_Click()
        If Opt4Pay.Value = False And Opt4Per.Value = False And Opt4Sup.Value =
                False Then
                MsgBox "Please answer Question #4."
                Opt5No.Value = False
        End If
End Sub
```

```
Private Sub Opt5Yes_Click()
        If Opt4Pay.Value = False And Opt4Per.Value = False And Opt4Sup.Value =
                False Then
                MsgBox "Please answer Question #4."
                Opt5Yes.Value = False
        End If
End Sub

Private Sub Opt6Per_Click()
        If Opt5No.Value = False And Opt5Yes.Value = False Then
                MsgBox "Please answer Question #5."
                Opt6Per.Value = False
        End If
        If Opt6Per.Value = True Then
                MsgBox "This is an authorization function designed to detect inaccurate
                        work information."
        End If
End Sub

Private Sub Opt6Pay_Click()
        If Opt5No.Value = False And Opt5Yes.Value = False Then
                MsgBox "Please answer Question #5."
                Opt6Pay.Value = False
        End If
        If Opt6No.Value = True Then
                MsgBox "This is an authorization function designed to detect inaccurate
                        work information."
        End If
End Sub

Private Sub Opt6Sup_Click()
        If Opt5No.Value = False And Opt5Yes.Value = False Then
                MsgBox "Please answer Question #5."
                Opt6Sup.Value = False
        End If
        If Opt6No.Value = True Then
                MsgBox "This is an authorization function designed to detect inaccurate
                        work information."
        End If
End Sub
```

```
Private Sub Opt7Per_Click()
        If Opt6Per.Value = False And Opt6Pay.Value = False And Opt6Sup.Value =
                False Then
                MsgBox "Please answer Question #6."
                Opt7Per.Value = False
        End If
End Sub

Private Sub Opt7Pay_Click()
        If Opt6Per.Value = False And Opt6Pay.Value = False And Opt6Sup.Value =
                False Then
                MsgBox "Please answer Question #6."
                Opt7Pay.Value = False
        End If
End Sub

Private Sub Opt7Sup_Click()
        If Opt6Per.Value = False And Opt6Pay.Value = False And Opt6Sup.Value =
                False Then
                MsgBox "Please answer Question #6."
                Opt7Sup.Value = False
        End If
End Sub

Private Sub Opt8GL_Click()
        If Opt7Per.Value = False And Opt7Pay.Value = False And Opt7Sup.Value =
                False Then
                MsgBox "Please answer Question #7."
                Opt8GL.Value = False
        End If
End Sub

Private Sub Opt8No_Click()
        If Opt7Per.Value = False And Opt7Pay.Value = False And Opt7Sup.Value =
                False Then
                MsgBox "Please answer Question #7."
                Opt8No.Value = False
        End If
End Sub
```

```
Private Sub Opt8Sup_Click()
        If Opt7Per.Value = False And Opt7Pay.Value = False And Opt7Sup.Value =
                False Then
                MsgBox "Please answer Question #7."
                Opt8Sup.Value = False
        End If
End Sub

Private Sub Opt9Aud_Click()
        If Opt8GL.Value = False And Opt8No.Value = False And Opt8Sup.Value = False
                Then
                MsgBox "Please answer Question #8."
                Opt9Aud.Value = False
        End If
End Sub

Private Sub Opt9Cash_Click()
        If Opt8GL.Value = False And Opt8No.Value = False And Opt8Sup.Value = False
                Then
                MsgBox "Please answer Question #8."
                Opt9Cash.Value = False
        End If
End Sub

Private Sub Opt9Pay_Click()
        If Opt8GL.Value = False And Opt8No.Value = False And Opt8Sup.Value = False
                Then
                MsgBox "Please answer Question #8."
                Opt9Pay.Value = False
        End If
End Sub

Private Sub Opt9PM_Click()
        If Opt8GL.Value = False And Opt8No.Value = False And Opt8Sup.Value = False
                Then
                MsgBox "Please answer Question #8."
                Opt9PM.Value = False
        End If
End Sub
```

```
Private Sub Opt10Pay_Click()
        If Opt9Aud.Value = False And Opt9Cash.Value = False And Opt9PM.Value =
                False And Opt9Pay.Value = False Then
                MsgBox "Please answer Question #9."
                Opt10Pay.Value = False
        End If
        If Opt10Pay.Value = True Then
                MsgBox "This is an accounting records control that helps prevent
                        inaccurate and incomplete records.  There is separation of function
                        over pay information if the person responsible for maintaining the
                        payrate (#2), the person responsible for approving the job card
                        (#6) and this person are different."
        End If
End Sub

Private Sub Opt10Per_Click()
        If Opt9Aud.Value = False And Opt9Cash.Value = False And Opt9PM.Value =
                False And Opt9Pay.Value = False Then
                MsgBox "Please answer Question #9."
                Opt10Per.Value = False
        End If
        If Opt10Per.Value = True Then
                MsgBox "This is an accounting records control that helps prevent
                        inaccurate and incomplete records.  There is separation of function
                        over pay information if the person responsible for maintaining the
                        payrate (#2), the person responsible for approving the job card
                        (#6) and this person are different."
        End If
End Sub

Private Sub Opt10Sup_Click()
        If Opt9Aud.Value = False And Opt9Cash.Value = False And Opt9PM.Value =
                False And Opt9Pay.Value = False Then
                MsgBox "Please answer Question #9."
                Opt10Sup.Value = False
        End If
        If Opt10PSup.Value = True Then
                MsgBox "This is an accounting records control that helps prevent
                        inaccurate and incomplete records.  There is separation of function
                        over pay information if the person responsible for maintaining the
                        payrate (#2), the person responsible for approving the job card
                        (#6) and this person are different."
        End If
End Sub
```

```
Private Sub Opt11AP_Click()
        If Opt10Pay.Value = False And Opt10Per.Value = False And Opt10Sup.Value =
                False Then
                MsgBox "Please answer Question 10."
                Opt11AP.Value = False
        End If
        If Opt11Pay.Value = True Then
                MsgBox "The distribution voucher represents an accounting records
                        function designed to prevent errors."
        End If
End Sub

Private Sub Opt11Pay_Click()
        If Opt10Pay.Value = False And Opt10Per.Value = False And Opt10Sup.Value =
                False Then
                MsgBox "Please answer Question 10."
                Opt11Pay.Value = False
        End If
        If Opt11Pay.Value = True Then
                MsgBox "The distribution voucher represents an accounting records
                        function designed to prevent errors."
        End If
End Sub

Private Sub Opt12AP_Click()
        If Opt11AP.Value = False And Opt11Pay.Value = False Then
                MsgBox "Please answer Question 11."
                Opt12AP.Value = False
        End If
End Sub

Private Sub Opt12GL_Click()
        If Opt11AP.Value = False And Opt11Pay.Value = False Then
                MsgBox "Please answer Question 11."
                Opt12GL.Value = False
        End If
End Sub

Private Sub Opt13Cost_Click()
        If Opt12AP.Value = False And Opt12GL.Value = False Then
                MsgBox "Please answer Question 12."
                Opt13Cost.Value = False
        End If
End Sub
```

```
Private Sub Opt13GL_Click()
        If Opt12AP.Value = False And Opt12GL.Value = False Then
                MsgBox "Please answer Question 12."
                Opt13GL.Value = False
        End If
End Sub

Private Sub Opt13No_Click()
        If Opt12AP.Value = False And Opt12GL.Value = False Then
                MsgBox "Please answer Question 12."
                Opt13No.Value = False
        End If
End Sub

Private Sub Opt14No_Click()
        If Opt13Cost.Value = False And Opt13GL.Value = False And Opt13No.Value =
                False Then
                MsgBox "Please answer Question 13."
                Opt14No.Value = False
        End If
        If Opt14No.Value = True Then
                MsgBox "This is an access function designed to prevent fraud in the
                        signing of checks."
        End If
End Sub

Private Sub Opt14Yes_Click()
        If Opt13Cost.Value = False And Opt13GL.Value = False And Opt13No.Value =
                False Then
                MsgBox "Please answer Question 13."
                Opt14Yes.Value = False
        End If
        If Opt14No.Value = True Then
                MsgBox "This is an access function designed to prevent fraud in the
                        signing of checks."
        End If
End Sub

Private Sub Opt15Cash_Click()
        If Opt14No.Value = False And Opt14Yes.Value = False Then
                MsgBox "Please answer Question 14."
                Opt15Cash.Value = False
        End If
End Sub
```

```
Private Sub Opt15No_Click()
        If Opt14No.Value = False And Opt14Yes.Value = False Then
                MsgBox "Please answer Question 14."
                Opt15No.Value = False
        End If
End Sub

Private Sub Opt15Pay_Click()
        If Opt14No.Value = False And Opt14Yes.Value = False Then
                MsgBox "Please answer Question 14."
                Opt15Pay.Value = False
        End If
End Sub

Private Sub Opt16Aud_Click()
        If Opt15Cash.Value = False And Opt15No.Value = False And Opt15Pay.Value =
                False Then
                MsgBox "Please answer Question 15."
                Opt16Aud.Value = False
        End If
End Sub

Private Sub Opt16Cash_Click()
        If Opt15Cash.Value = False And Opt15No.Value = False And Opt15Pay.Value =
                False Then
                MsgBox "Please answer Question 15."
                Opt16Cash.Value = False
        End If
End Sub


Private Sub Opt16Pay_Click()
        If Opt15Cash.Value = False And Opt15No.Value = False And Opt15Pay.Value =
                False Then
                MsgBox "Please answer Question 15."
                Opt16Pay.Value = False
        End If
End Sub
```

```
Private Sub Opt16Sup_Click()
        If Opt15Cash.Value = False And Opt15No.Value = False And Opt15Pay.Value =
                False Then
                MsgBox "Please answer Question 15."
                Opt16Sup.Value = False
        End If
End Sub

Private Sub Opt17No_Click()
        If Opt16Aud.Value = False And Opt16Cash.Value = False And Opt16Pay.Value
                = False And Opt16Sup.Value = False Then
                MsgBox "Please answer Question #16."
                Opt17No.Value = False
        End If
End Sub

Private Sub Opt17Yes_Click()
        If Opt16Aud.Value = False And Opt16Cash.Value = False And Opt16Pay.Value
                = False And Opt16Sup.Value = False Then
                MsgBox "Please answer Question #16."
                Opt17Yes.Value = False
        End If
End Sub

Private Sub Opt18Aud_Click()
        If Opt17No.Value = False And Opt17Yes.Value = False Then
                MsgBox "Please answer Question #17."
                Opt18Aud.Value = False
        End If
End Sub

Private Sub Opt18Cash_Click()
        If Opt17No.Value = False And Opt17Yes.Value = False Then
                MsgBox "Please answer Question #17."
                Opt18Cash.Value = False
        End If
End Sub

Private Sub Opt18PM_Click()
        If Opt17No.Value = False And Opt17Yes.Value = False Then
                MsgBox "Please answer Question #17."
                Opt18PM.Value = False
        End If
End Sub
```

```
Private Sub Opt18Sup_Click()
        If Opt17No.Value = False And Opt17Yes.Value = False Then
                MsgBox "Please answer Question #17."
                Opt18Sup.Value = False
        End If
End Sub

Private Sub Opt19Aud_Click()
        If Opt18Aud.Value = False And Opt18Cash.Value = False And Opt18PM.Value
                = False And Opt18Sup.Value = False Then
                MsgBox "Please answer Question #18."
                Opt19Aud.Value = False
        End If
End Sub

Private Sub Opt19Cash_Click()
        If Opt18Aud.Value = False And Opt18Cash.Value = False And Opt18PM.Value
                = False And Opt18Sup.Value = False Then
                MsgBox "Please answer Question #18."
                Opt19Cash.Value = False
        End If
End Sub

Private Sub Opt19PM_Click()
        If Opt18Aud.Value = False And Opt18Cash.Value = False And Opt18PM.Value
                = False And Opt18Sup.Value = False Then
                MsgBox "Please answer Question #18."
                Opt19PM.Value = False
        End If
End Sub

Private Sub Opt19Sup_Click()
        If Opt18Aud.Value = False And Opt18Cash.Value = False And Opt18PM.Value
                = False And Opt18Sup.Value = False Then
                MsgBox "Please answer Question #18."
                Opt19Sup.Value = False
        End If
End Sub
```

```
Private Sub Opt20Aud_Click()
	If Opt19Aud.Value = False And Opt19Cash.Value = False And Opt19PM.Value
		= False And Opt19Sup.Value = False Then
		MsgBox "Please answer Question #19."
		Opt20Aud.Value = False
	End If
End Sub

Private Sub Opt20No_Click()
	If Opt19Aud.Value = False And Opt19Cash.Value = False And Opt19PM.Value
		= False And Opt19Sup.Value = False Then
		MsgBox "Please answer Question #19."
		Opt20No.Value = False
	End If
End Sub

Private Sub Opt21Aud_Click()
	If Opt20No.Value = False And Opt20Aud.Value = False Then
		MsgBox "Please answer Question #20."
		Opt21Aud.Value = False
	End If
End Sub

Private Sub Opt21No_Click()
	If Opt20No.Value = False And Opt20Aud.Value = False Then
		MsgBox "Please answer Question #20."
		Opt21N0.Value = False
	End If
End Sub

Private Sub Opt22Aud_Click()
	If Opt21No.Value = False And Opt21Aud.Value = False Then
		MsgBox "Please answer Question #21."
		Opt22Aud.Value = False
	End If
End Sub

Private Sub Opt22No_Click()
	If Opt21No.Value = False And Opt21Aud.Value = False Then
		MsgBox "Please answer Question #21."
		Opt22No.Value = False
	End If
End Sub
```

```
Private Sub OptAnsHi_Click()
        If Opt22Aud.Value = False And Opt22No.Value = False Then
                MsgBox "Please answer Question 22."
                OptAnsHi.Value = False
        End If
End Sub

Private Sub OptAnsLo_Click()
        If Opt22Aud.Value = False And Opt22No.Value = False Then
                MsgBox "Please answer Question 22."
                OptAnsLo.Value = False
        End If
End Sub

Private Sub OptAnsMod_Click()
        If Opt22Aud.Value = False And Opt22No.Value = False Then
                MsgBox "Please answer Question 22."
                OptAnsMod.Value = False
        End If
End Sub
```

Legend for *Visual Basic* Variables

Question	Value	Variable Name
1. Last year's evaluation of internal controls was:	Low Moderate High	Opt1Lo Opt1Mod Opt1Hi
2. Hiring and payrate are authorized by:	Payroll Personnel Supervisor	Opt2Pay Opt2Per Opt2Sup
3. Changes in payrate are authorized by:	Payroll Personnel Supervisor	Opt3Pay Opt3Per Opt3Sup
4. Employment termination forms are submitted to:	Payroll Personnel Supervisor	Opt4Pay Opt4Per Opt4Sup
5. Is a time clock used?	No Yes	Opt5No Opt5Yes
6. Jobcards are approved by:	No One Payroll Supervisor	Opt6No Opt6Pay Opt6Sup
7. Overtime is approved by:	No One Payroll Supervisor	Opt7No Opt7Pay Opt7Sup
8. Jobcards are compared to timecards by:	General Ledger No One Supervisor	Opt8GL Opt8No Opt8Sup
9. Preparation of paychecks and payroll registers are performed by:	Auditor Cashier Paymaster Payroll	Opt9Aud Opt9Cash Opt9Pay Opt9PM
10. Earnings are posted to individual records by:	Payroll Personnel Supervisor	Opt10Pay Opt10Per Opt10Sup
11. Payroll distribution voucher is prepared by:	Accounts Payable Payroll	Opt11AP Opt11Pay
12. Labor distribution summary is prepared by:	Accounts Payable General Ledger	Opt12AP Opt12GL
13. Who compares distribution voucher and summary?	Cost Accounting General Ledger No One	Opt13Cost Opt13GL Opt13No
14. Is a check signing machine used?	No Yes	Opt14No Opt14Yes

15. Who controls unsigned checks?	Cashier No One Payroll	Opt15Cash Opt15No Opt15Pay
16. Who is responsible for signing checks?	Auditor Cashier Payroll Supervisor	Opt16Aud Opt16Cash Opt16Pay Opt16Sup
17. Is a separate checking account used for payroll?	No Yes	Opt17No Opt17Yes
18. Who distributes payroll checks?	Auditor Cashier Paymaster Supervisor	Opt18Aud Opt18Cash Opt18Pay Opt18Sup
19. Who has responsibility for unclaimed checks?	Auditor Cashier Paymaster Supervisor	Opt19Aud Opt19Cash Opt19Pay Opt19Sup
20. Who distributes payroll on a surprise basis?	Auditor No One	Opt20Aud Opt20No
21. Who compares payroll to budgeted figures?	Auditor No One	Opt21Aud Opt21No
22. Who investigates payroll complaints?	Auditor No One	Opt22Aud Opt22No

APPENDIX E

HUMAN STUDIES COMPLIANCE FORMS

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

DATE: 03-10-99 **IRB #: BU-99-016**

Proposal Title: ATTENDING TO SIMILARITIES AND DIFFERENCES: AN EXAMINATION OF THE EFFECTS OF GENERALIZATION AND DISCRIMINATION ON COGNITIVE SKILL ACQUISITION FROM EXPERT SYSTEMS

Principal Investigator(s): David Smith Murphy, Georgia Ann Smedley

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

Signature: Carol Olson

Date: March 12, 1999

Carol Olson, Director of University Research Compliance
cc: Georgia Ann Smedley

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

DATE: November 5, 1999

TO: Georgia Smedley
Accounting
6003

FROM: Dr. William E. Schulze, Director
Office of Sponsored Programs (X1357)

RE: Status of Human Subject Protocol Entitled:
"Attending to Similarities and Differences: An Examination of the Effects of Generalization and Discrimination on Cognitive Skill Acquisition from Expert System"
OSP #201F1199-151e

The protocol for the project referenced above has been reviewed by the Office of Sponsored Programs and it has been determined that it meets the criteria for exemption from full review by the UNLV human subjects Institutional Review Board. This protocol is approved for a period of one year from the date of this notification and work on the project may proceed.

Should the use of human subjects described in this protocol continue beyond a year from the date of this notification, it will be necessary to request an extension.

If you have any questions regarding this information, please contact the Office of Sponsored Programs at 895-1357.

cc: OSP File

Office of Sponsored Programs
4505 Maryland Parkway • Box 451037 • Las Vegas, Nevada 89154-1037
(702) 895-1357 • FAX (702) 895-4242

University of Nevada, Las Vegas
Department of Accounting

Information:
I am Georgia Smedley from the UNLV Department of Accounting. You are invited to participate in a research study investigating the effects of different prompts on learning via the use of an Expert System.

Procedures:
For the next four classes, during our regular class meeting time, you will be asked to use the computer at your seat to respond to questions and to analyze the adequacy of internal controls in a number of different scenarios. To receive full class credit for participation, you must attend all four experimental sessions, fully respond to all questions, and complete the forms for each scenario. This study involves the use of four different expert systems. The system assigned to you may be different from that of your neighbor. Should you choose not to participate in this study, you may still use the expert system, but you will be required to submit a 1 to 2 page paper in order to receive class credit.

Benefits of Participation:
By participating in this study, you will be contributing to the body of knowledge concerning how people learn from expert system use. Further, you will be exposed to a number of control scenarios. This exposure and the prompts provided from the expert system should increase your understanding of the interaction of internal controls and your comfort in assessing control adequacy. This is an important step in your preparation to become professional accountants.

Risks:
This research experiment involves the use of computers and an expert system. Because the expert system is software that is unfamiliar to you, you may become anxious and feel out of your element. You are encouraged to alert me if, at any time during the experiment, you become uncomfortable.

Contact:
If you have any questions about this study, or if you experience adverse effects as a result of participation in this study, you may contact me at 895-3994. For questions regarding the rights of research subjects, you may contact the UNLV Office of Sponsored Programs at 895-1357.

Participation:
Your participation in this study is voluntary. You may refuse to participate in this study or in any part of this study and you may withdraw at any time without prejudice to your relations with the university. If you choose not to participate or if you choose to withdraw from this study, 50 points of class credit may be earned via a written assignment. You are encouraged to ask questions about this study prior to its beginning or any time during the study. You will be given a copy of this form.

Confidentiality:
All information gathered in this study will be kept completely confidential. No reference will be made in written or oral materials which could link you to this study.

Consent:
I have read the above information and agree to participate in this study.

_______________________________ _______________

Signature of Participant **Date**

_______________________________ _______________

Signature of Researcher **Date**

VITA

Georgia Ann Smedley

Candidate for the Degree of

Doctor of Philosophy

Thesis: THE EFFECTS OF OPTIMIZATION ON COGNITIVE SKILL ACQUISITION FROM INTELLIGENT DECISION AIDS

Major Field: Business Administration

Biographical:

Personal Data: Born in Denver, Colorado April 7, 1955, the daughter of William E. and Margaret M. Smedley.

Education: Graduated from Grand Junction High School, Grand Junction, Colorado in June 1973; received a Bachelor of Arts degree in Social Sciences from Mesa State College in August 1976; received a Master of Science - Accounting degree from the University of Arkansas - Fayetteville in December 1992; completed requirements for the Doctor of Philosophy degree at Oklahoma State University in August, 2001.

Professional Experience: Small business owner, Delta, Colorado 1977-1985; Bookkeeper 1986-1987; U.S. National Park Ranger 1986-1994; Payroll accountant 1994; Teaching Associate, Oklahoma State University 1994-1999; Lecturer, University of Nevada, Las Vegas 1999 - present.

Professional Memberships:
American Accounting Association
Accounting Information Systems section of AAA
Institute of Internal Auditors