AN EXAMINATION OF THE INTERACTION OF ELABORATION ALTERNATIVES AND ELABORATION PLACEMENT ON EXPERT SYSTEM-BASED INCIDENTAL LEARNING

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Submitted to the Faculty of the
Graduate College of the
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in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
July, 1993

To my family: Shannon, Marcus, Jr., and One on the way

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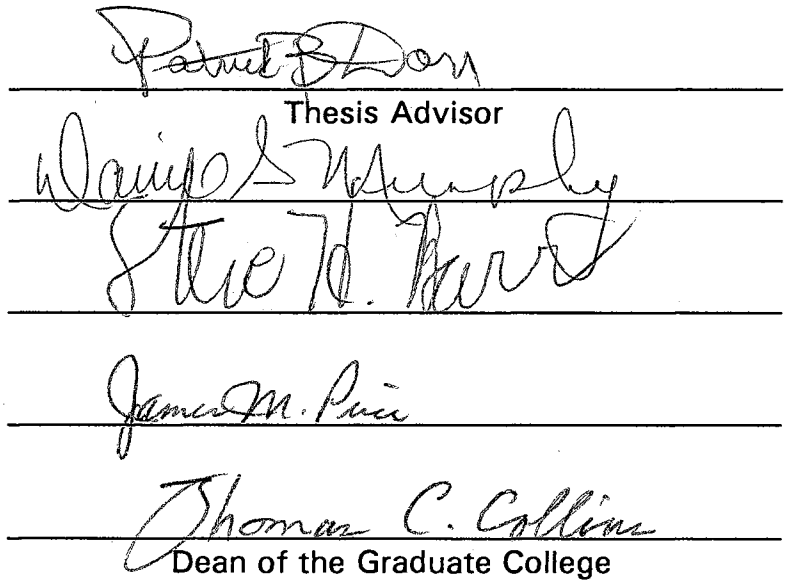

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PREFACE

Expert systems (ES) are being used as decision aids in many public accounting firms and their use will continue to increase due to the effectiveness and efficiency provided. With this increased use, a concern should be whether the individual using the ES is learning incidentally the task being performed. Learning through experience has been found to be a critical ingredient in the development of expertise in a particular knowledge domain. The question that needs to be addressed is whether the ES provides the necessary experience.

This study addresses the incidental learning issue. To test for incidental learning, six ESs were developed using identical knowledge bases, but different user interfaces. The six different user interfaces were developed based on a cognitive psychology learning strategy called elaboration. Two different methods of elaboration were utilized, elaboration placement and elaboration type.

Normal ESs provide an explanation to the user at the end of the consultation and then only at the user's request. The six ESs designed for and used in this study provided the user with forced explanations either continuously or at the end of the consultation. These explanations were one of three types; imprecise, precise, or precise with example.

The subjects were given a pretest examination and were required to

evaluate a set of cases prior to using the ESs. Once these were completed, the subjects were given fifteen cases to evaluate using the ES as a decision aid. They evaluated five cases during each of three sessions over a three week period. After completing this learning phase of the experiment, the subjects were given a posttest examination and were required to evaluate four cases without the use of the ES. The accuracy of the pretest examinations and pretest evaluations were used as covariates in determining the amount of incidental learning that occurred. The examinations were used to measure declarative knowledge; the evaluations were used to measure procedural knowledge. A 3 x 2 Completely Randomized Factorial Analysis of Covariance (CRFAC - 23) design was used in the analysis.

The analysis found a significant interaction effect between elaboration placement and elaboration type for the development of declarative knowledge. Due to this interaction, an analysis of the simple main effects was performed. This resulted in finding significant differences between the elaboration placement groups when the elaboration type was precise with example, and also significant differences between the elaboration type groups when the elaboration placement was at the end of the session. No effects were found on the development of procedural knowledge. These findings suggest the placement of the elaboration has an impact on the development of declarative knowledge, with the impact magnified when the precise with example elaboration type is used and/or when the placement of the elaboration is at the end of session.

I wish to express my sincere gratitude to the individuals who assisted

me in this project and during my coursework at Oklahoma State University. In particular, I wish to thank my committee chairman, Dr. Patrick Dorr, for his advice, guidance, and patience throughout this project. I am also grateful to my other committee members, Dr. David S. Murphy, Dr. Steven Barr, and Dr. James Price, for their valuable contributions during this project.

I wish to express my deepest appreciation to my wife, Shannon Odom, for her love, devotion, constant support, encouragement, understanding, patience, and inspiration throughout the entire process. Without her, this accomplishment would not have been possible. To my son, Marcus Odom, Jr., for giving the boost I needed going into my proposal and for helping me keep my focus since. To the One on the way for providing me with the additional encouragement prior to my defense. To my parents, Maurice and Virginia Odom, for all of their love, support, and encouragement from the beginning of my formal educational process many years ago until the end. To my in-laws, Dickey and Peggy Reid, for their support since I married their wonderful daughter. I am also thankful to my brothers, Marvin and Mike, and my sister, Jennifer, and their families for their love and support.

Last, but most important of all, I want to thank God for giving me the hope and faith that is able to succumb any and all trials that are presented to me during my time on His earth.

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CHAPTER I

THE RESEARCH PROBLEM

Introduction

The use of expert system (ES) technology has significantly affected accounting and accountants. Public accounting firms are currently utilizing ESs in making decisions impacting the audit examination. Brown (1989) discusses 478 papers in her annotated bibliography of accounting ESs. Further support for the development and use of ESs is provided by O'Leary and Watkins (1989) in their review of ESs in auditing. Brown and Murphy (1990), in a review of ES use in public accounting, discuss thirty-seven different audit-related expert systems that are either in use or under development by the "Big Six" accounting firms. This development and use of ESs, which is predicted to expand even more due to the increased competition in public accounting (Bailey, et al., 1988), evidences the importance of ESs as a resource in accounting.

ESs solve semi-structured problems that are normally solved by human experts. Rule-based ESs have three major components:

1. user interface,
2. inference engine, and

3. knowledge base.

The user interacts with the ES using the interface, which consists of a query facility and an explanation facility. The query facility asks questions; the explanation facility allows the user to challenge the ES and examine the reasoning process underlying the ES's solution. The inference engine is a program that translates the knowledge in the knowledge base into hypotheses. The knowledge base contains facts and heuristics derived from an expert. Figure 1 pictures an expert system with the components as described above.

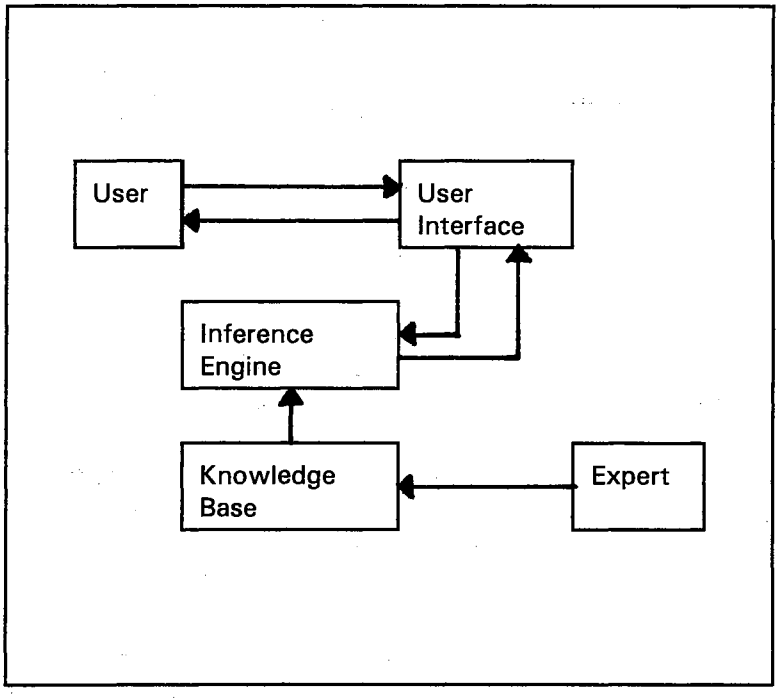


Figure 1. Expert System

An example of an application of ESs in an audit context is an

evaluation of the strength or weakness of a client firm's internal control structure. The primary goal of the ES is to be used as a decision aid, providing expert-level knowledge to an auditor, who may lack the necessary experience, in determining the reliance which can be placed on the controls of the client. Pei and Reneau state that

> Rule-based expert systems (RBESs) are computer programs that apply domain-specific knowledge to problem solving. Unlike other decision aids, an RBES is intended to assist or possibly replace users in solving problems of narrow scope that require rich expert knowledge.(1990, 263)

According to this definition, ESs may replace an expert in certain domain-specific problems. The user of the ES would not necessarily need to understand how to solve the problem to achieve success using an ES.

A secondary concern of the firm should be whether the novice auditor is learning incidentally through the use of the ES. If learning occurs when learning is not the intention, it is referred to as incidental learning (Pressley, 1987; Anderson, 1990). In the auditing context presented above, if the novice auditor can incidentally learn while using the ES as a decision aid, it would be beneficial to the accounting firm. Learning through experience has been found to be a critical ingredient in the development of expertise in a particular knowledge domain such as auditing (Waller and Felix, 1984). Is the novice auditor gaining enough insight through the use of an ES to build the expertise needed for other related or higher-level audit decisions?

Purpose of the Study

ES Research

The majority of the accounting ES literature has centered on the primary goal of ESs. This literature is concerned with the developmental process involved in building a specific ES that will replicate an experts advice (Kelly, et al., 1986; Shpilberg and Graham, 1986; Graham, et al., 1991; Gal and Steinbart, 1986; Steinbart, 1987; Hansen and Messier, 1986; Dungan and Chandler, 1985; Selfridge and Biggs, 1988; O'Leary, 1987; Boer and Livnat, 1990; Ribar, 1988, 1990; Graham, 1990). Two overlapping conclusions of this research are that (1) knowledge acquisition is a "bottleneck" during the development of an ES and (2) "better" solutions, (i.e., solutions more in line with the solutions that the expert would arrive at), occur with ES use than without ES use. This overwhelming emphasis on the development of ESs in the accounting research, in part, may be a response to the need to improve judgment and decision making in accounting.

Judgment and Decision Making

The desire to improve decision-making in accounting has resulted in numerous research studies, two monographs, and an American Accounting Association committee study. The major focus of this research has been on

measuring the consistency, consensus, and efficiency of decision-making (Ashton and Willingham, 1988). The overall results of this research has been mixed; however, two consistent results that have emerged are 1) that statistical models predict more accurately than do the subjects the models are based on, and 2) that subjects are very reluctant to base their decisions solely on a statistical model.

Libby (1981) outlined three options that could improve judgment and decision making. These options, based on the three basic strategies for improving the quality of decisions as outlined by the 1977 American Accounting Association Committee on Human Information Processing are

1. Changing the information,
2. Educating the decision maker to change the way he or she processes information, and
3. Replacing the decision maker with a model.(3)

The development and use of ESs in accounting may be a response to the first and third options discussed by Libby. Ashton and Willingham state:

> The development of decision aids for improving unassisted decision making is perhaps the most direct practical result of audit decision research, as well as of decision research in general. . . . The most elaborate (and costly) form of audit decision aid is knowledge-based expert systems. (1988, 5-6)

It is believed that ES use "will facilitate audit decisions and make audits more efficient and effective" (Shafer, Shenoy, and Srivastava, 1988, 61) because an ES is a model that will take user-provided data, process the data,

and provide the user with a decision. This entire process is completed with relatively little user involvement. This increase in efficiency and effectiveness may be the reason that the major accounting firms are committing increasingly greater resources to the development of ESs (Boritz and Brown, 1986; Shpilberg and Graham, 1986; Ashton and Willingham, 1988; Brown and Murphy, 1990).

However, the second option may have been lost in the rush to develop ESs. The second option--educating the decision-maker to change the way he or she processes information--relates to what will be called the behavioral aspect of using ESs. Prior to the advent of ESs, the novice auditor was required to explicitly determine the data that was relevant or irrelevant in making a particular decision. This active involvement in gathering and reflecting on the data has been shown to greatly increase the degree of learning that occurs in the performance of the task (Waller and Felix, 1984; Anderson, 1990). Using an ES will likely reduce the cognitive processing normally required by the novice auditor due to the ES performing such tasks as determining the data which is relevant or irrelevant and also determining the weight to be given a particular factor in the final evaluation. Research into this behavioral aspect of ES use is very limited to date.

Behavioral ES Research

Several studies have attempted to address the extent to which a

novice learns through the use of an ES; however, the results have been somewhat contradictory. These studies have focused on how much the ES user learns in comparison to a non-user while evaluating identical situations. In these studies, one group of subjects uses an ES to evaluate cases while the other group does not. Studies of this type include Eining (1988), Murphy (1989), Oz (1989), and Odom and Murphy (1991). Eining (1988), Oz (1989), and Odom and Murphy (1991) each found that the subjects using the ESs learned more than the subjects not using the ESs. Murphy's (1989) results were opposite to these. The general conclusion of these studies is that ES use does affect the development of the user's domain-specific knowledge. The conflicting results may be due to the design of the ESs used in the studies.

How should the ES be designed to facilitate knowledge transfer? ESs must provide information to users in such a way as to facilitate the development of knowledge if the ES is to become an effective training aid. Of the three components in an ES, (the user interface, the inference engine, and the knowledge base), only the user interface is exposed to the user. Therefore, only the user interface directly affects the development of the users' knowledge and should be the logical area of emphasis in ES research. However, as previously stated, this has not been the primary direction of ES research. Pei and Reneau state that "most ES research has been oriented toward acquiring and representing knowledge with little concern for the user

interface" (1990, 264). Gal and Steinbart discuss the need to

> find ways to design the interface of expert systems so as to encourage the type of active involvement by users that facilitates their learning the decision strategy being followed by the system without sacrificing the efficiency needed to use the system as a decision aid. (1990, 18)

In some very recent papers, this design issue has begun to be studied. The results of this area of research are based on the comparing of subjects' evaluations after using decision aids that were designed differently. Studies of this type include Pei and Reneau (1990), Reneau (1991), and Gal and Steinbart (1991).

Pei and Reneau (1990) studied the effect of designing ESs in which the knowledge structure of the rule base was either consistent or inconsistent with the user's mental representation of knowledge in the task domain. They found that the consistency of the rule base and the user's mental model did affect learning and decision certainty. Reneau (1991) used four different decision aids developed by manipulating the sequence and the amount of information presented. He found that subjects' judgments are more accurate when the more important information is presented last and when no distractor information is presented. Judgment confidence was found to be unrelated to the manipulations. Gal and Steinbart (1991) studied the use of alternative user interface designs in an intentional learning experiment. They had three user interface designs: (1) passive, (2) prompt to think about the solution prior to seeing the ESs solution, and (3) prompt

to think and to type a solution prior to seeing the ESs solution. The users of the 'think-and-type' design learned significantly more than the other two designs.

Although the research of Pei and Reneau (1990), Reneau (1991), and Gal and Steinbart (1991) look at design issues, the designs in these studies are not practically feasible because they sacrifice the efficiency of the ES. Pei and Reneau (1990) structured the ES's knowledge base based on the user's mental model of the task, a design which will require a different ES for each user. Gal and Steinbart's (1991) study found that the best design was one which required the user to think and type a solution prior to seeing the ES's solution, a design which would sacrifice the efficiency of the ES and likely be unacceptable in field applications.

Scope of the Study

This study builds on the new paradigm for research in ESs as discussed by Pei and Reneau (1990). They state:

> Learning from ESs involves a complicated cognitive process. Learning should not be taken for granted; rather, a thorough understanding of this process should be pursued. On the basis of mental models theory and the preliminary evidence from this research, we argue that existing ESs' capabilities for knowledge transfer may be limited. If ESs are to be successful devices for knowledge transfer, user cognitive processes in learning, problem solving, and system interface should be explicitly considered. (283)

This study attempts to determine if cognitive psychology learning strategies are transferable to ES design research so as to enhance learning without sacrificing efficiency as discussed by Gal and Steinbart (1990). A thorough discussion of the cognitive processes of learning is introduced in this study. These processes are then used in designing a user interface that should facilitate knowledge transfer.

The instructional component of the ESs is analyzed by investigating the learning effect of providing subjects with ESs in which a potentially important variable--the explanation facility--is manipulated. Typically, the explanation facility provides the rules followed in arriving at a solution at the end of a session and only upon the request of the user. The study consists of six groups of subjects using six ESs built from identical knowledge. The only difference among the six ESs is in their structure. The explanation facility is manipulated so that users are provided with either intraconsultation explanations, (explanations provided constantly during the consultation), or with explanations at the end of the consultation, (the traditional method). A further manipulation is in the type of explanation provided, either imprecise (general explanation stating only the type of problem encountered), precise (specific explanation of the problem encountered), or precise with example (specific explanation of the problem encounter with an example of a possible consequence of the problem). These manipulations are based on research in the areas of cognitive psychology and educational psychology. This

research has generally shown that elaboration of target information can have a dramatic impact on the degree, accuracy, and speed of information that can be recalled by a subject.

The subjects solved several cases with the aid of the ES, and learning was measured upon completion of the treatment. The measurement was based upon pretest and posttest examinations and evaluations, each taken without the use of the ES. The treatment was administered in a laboratory setting over a period of several weeks.

The general research question is "What is the effect of ES design on the development of the users' knowledge?". If the ES design is shown to affect the development of the users' knowledge, the next question is "Which manipulation of the explanation facility is best for the development of the users' knowledge?".

Summary

This thesis is organized as follows. Chapter II develops the theoretical foundation that is the basis for the research study. Chapter III consists of a description of the research instrument and a description of the experimental design. The research hypotheses that are tested are also developed in Chapter III. The analysis performed are described in Chapter IV, followed by a discussion of the implications and limitations.

CHAPTER II

THEORETICAL FOUNDATION

Introduction

The theoretical basis for this study comes from the information processing literature in the field of cognitive psychology. This study focuses on the ***cognitive*** analysis of ***intellectual*** behavior, which tries to explain how people solve problems and how they learn in terms of mental constructs. Thus, the theory consists of a discussion of the "mental processes that underlie intellectual performance" (Gagné, 1985, 7). This theoretical framework is called the information processing paradigm.

Information Processing Model

We need to understand how decision-makers process information in order to evaluate the effect of ES use on educating the decision-maker to change the way he or she processes information. The basic features of the information-processing model are presented in Figure 2. Each box in the model represents a separate state through which information flows during processing.

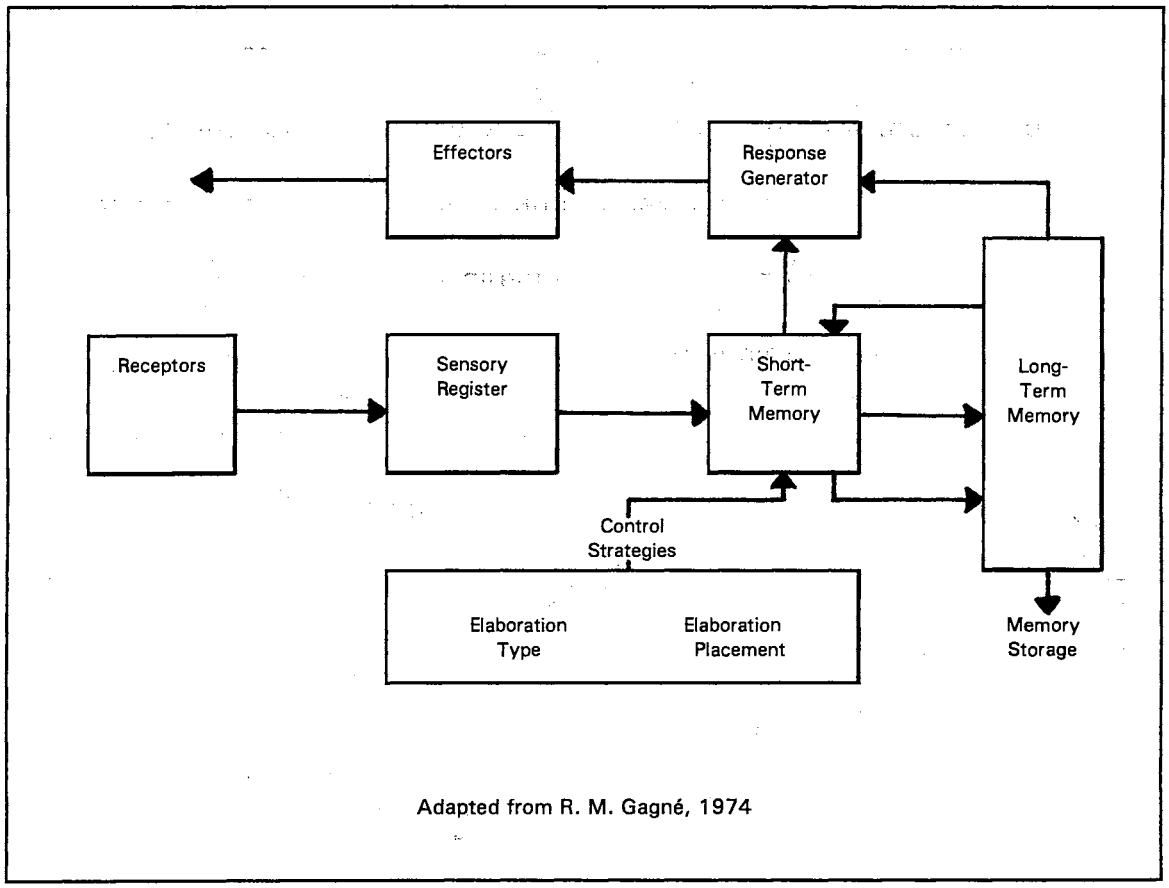


Figure 2. Information Processing Model

Receptors are the initial point of contact between the environment and the individual. The types of receptors include taste receptors, auditory receptors and visual receptors. In this experimental setting, information will be received by the subjects as they read the questions and explanations provided by the ES. This information will be sent as signals to the *sensory register* in the central nervous system. The sensory register, which is responsible for initial perception of the information, can hold a fairly large

amount of information, but only for a very brief period of time. Information in the sensory register is easily disrupted by new information. Moreover, the information will decay quickly if further processing does not occur (Sperling, 1960; Averbach and Coriell, 1961; Cowan, et al., 1982).

The information not lost from the sensory register moves to the *short-term memory*, also referred to as working memory due to the conscious mental information processing which occurs there. Short-term memory has a limited duration and capacity. Duration is the time period that information stays in short-term memory. Studies by Peterson and Peterson (1959), Murdock (1961), and Rundus (1971) show the duration in short-term memory to be no more than about ten seconds, unless it is prolonged using a memory strategy such as elaboration. Capacity is the quantity of information that can be in short-term memory at any time. Miller (1956) and Bower and Springston (1970) have shown that memory strategies can also increase short-term memory capacity.

Once coded, information is stored in *long-term memory*. Gagné (1985) describes coding as a transformation process where new information is integrated, in various ways, with known information. Long-term memory is very durable and has a very large capacity (Standing, et al., 1970; Standing, 1973; Bahrick, et al., 1975). Bahrick, et al., (1975) provides empirical evidence that long-term memory is durable up to 53 years.

The *response generators* retrieves information from long-term

memory, either directly or by way of short-term memory. Once retrieved, information awaiting action is organized in the response generator. Once organized, the resulting response is delivered via the *effectors*, which include muscle movement for writing and the voice apparatus for speaking (Gagné, 1985). Observing the action of the effectors reveals the amount of processing and learning.

As information flows through the states of the information processing model, certain kinds of transformations called learning processes occur.

Learning Processes

Learning processes are the activities that transform information received from the environment into a format that can be stored in long-term memory. Figure 3 is an expansion of the previous information processing model with the learning processes. The learning processes occur at the connections between the states of the model.

The first learning process shown in Figure 3 is *reception of information*. The information received, which passes from the receptors to the sensory register, depends upon which information the learner attends to in the environment. *Pattern recognition* is a learning process which recognizes information based on the information's relationship to prior knowledge (Anderson, 1985). Once recognized, the information is classified into the pattern and transferred to short-term memory.

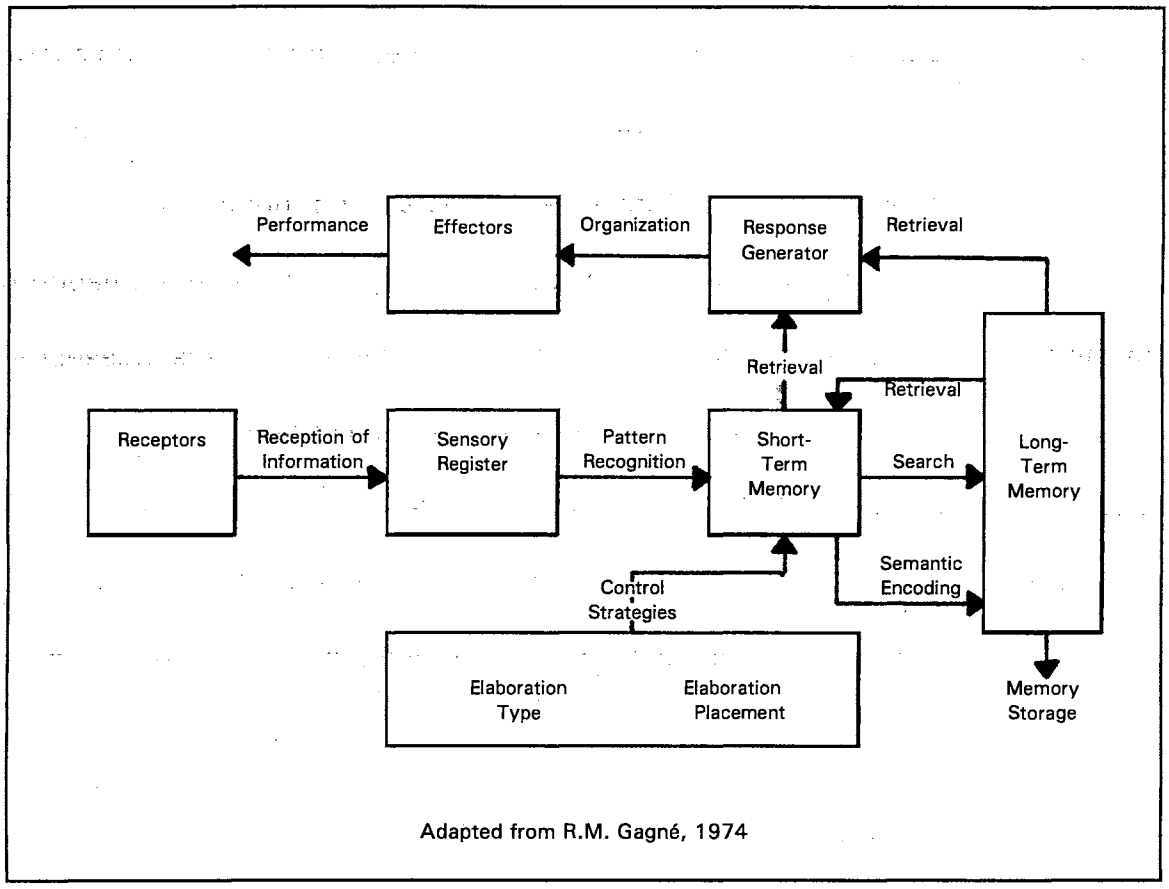


Figure 3. Information Processing Model with Learning Processes

Since short-term memory has limited duration and capacity, the control strategies are important because they keep the information active in short-term memory, allowing for preparation for long-term memory. The prolonged activity also allows the information to interact with other incoming information. *Semantic encoding* is the learning process that transforms the information into the necessary state for storage in long-term memory as either declarative or procedural knowledge. These types of knowledge and the way each type is represented in long-term memory storage will be

discussed shortly.

For learning to have occurred, the information must be recallable. The learning processes that perform this recall function are *search* and *retrieval*. The search and retrieval processes involve the search for the desired information in long-term memory and retrieval of the desired information to the response generator either directly or by way of short-term memory. Direct retrieval is called automatic processing; indirect retrieval is call controlled processing.

Automatic processing occurs when information flows directly from long-term memory to the response generator. This information is at a level such that no additional processing is needed. Controlled processing occurs when information flows from long-term memory to short-term memory, where conscious processing occurs prior to its being transferred to the response generator. This process is necessary when additional information is to be added to the stored information prior to retrieval (Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977).

Organization is the learning process that prepares the retrieved information for *performance* by the effectors. This performance verifies that learning has occurred. As previously mentioned, the information is stored in long-term memory as either declarative or procedural knowledge, two distinctly different types of knowledge, each being uniquely acquired, developed, and stored.

Knowledge Types

Declarative Knowledge

Declarative knowledge is knowledge ***that*** something is true. It is static knowledge, but it may vary considerably in topic and scope. Since declarative knowledge is factual, it is stored as a group of individual items and not as one fluid action; consequently, the recall of declarative knowledge is somewhat slow and requires a conscious effort. This conscious effort occurs when related information is in short-term memory and the declarative knowledge is activated from long-term memory, resulting in the occurrence of the previously discussed controlled processing (Anderson, 1976; R. Gagné, 1977).

Declarative knowledge is stored in long-term memory as propositions, a basic unit of knowledge-representation in the human information processing system. Each proposition represents a complete idea, but can join to form propositional networks through interaction. Any two propositions with a common element are interrelated through this element (Collins and Quillian, 1969; Hayes-Roth and Thorndyke, 1979).

Procedural Knowledge

Procedural knowledge is knowledge of ***how*** to do something. The knowledge is dynamic and, when activated, entails a transformation of

information. Once learned, procedural knowledge is more automatic; thus a conscious effort is not needed to activate procedural knowledge and, once activated, it will operate faster than declarative knowledge.

A production, a more active representational form than the proposition, is used to represent procedural knowledge in the information processing system. A production consists of condition-action rules similar to the IF-THEN clauses used in many rule-based ESs. The IF clause specifies the condition that must exist before the action listed in the THEN clause can be performed. Thus a production acts upon presented information rather than reproducing information as does the proposition (R. Gagné, 1977; Anderson, 1976).

Knowledge Acquisition

The acquisition is dependent upon the treatment of the knowledge in short-term memory. ***Spread of activation***, one way to acquire new knowledge, involves combining new information with prior knowledge. As new information enters short-term memory, new propositions are formed, which can be integrated with prior knowledge stored as old propositions. These old propositions are inactive and make up a large portion of the long-term memory store (Anderson, 1983; Gagné, 1985).

Problems with knowledge acquisition occur because short-term memory has a limited duration and capacity as discussed previously. The

limited duration causes problems during the new information encoding process. The limited capacity can be taken up very quickly during the spread of activation process. These problems can be somewhat circumvented by using a control strategy which, if used properly, facilitates the construction of propositions and the development of productions.

Control Strategy

Elaboration is a control strategy which can aid the encoding and spread of activation processes by providing redundant or alternative pathways along which activation can spread (Anderson, 1976), and by facilitating deeper cognitive processing which results in a heightened ability for inferring information that can not actually be remembered (Reder, 1982). Elaboration is the process of adding something to the to-be-learned information to make it more meaningful (Weinstein, 1982, 1988). The learner must be actively involved in processing the to-be-learned information for the elaborations to be effective. The elaboration could be an inference, an example, or anything else that will facilitate recall. Levin (1988) states that "elaboration involves meaning-enhancing additions, constructions, or generations that improve one's memory for what is being learned."

Elaborations can either be generated by the learner or presented to the learner along with the to-be-learned information (Reder, 1982; Wang, 1983). Stein and Bransford (1979) have shown that experimenter (designer)

elaborations can be better than subject elaborations if carefully chosen. Pressley, et al., state that

> Novices, lacking topical knowledge, often do not automatically link newly encountered relations to information that could make the significance of the relations more understandable and thus, make material more memorable. (1987, 291)

For this reason, the elaborations that are used in this study are experimenter generated.

The amount, type, and placement of elaborations is also important for developing declarative knowledge. Palmere, et al., (1983) investigated the effect of elaboration on studying for a test. The results of their study were consistent with the idea that more extensive elaboration promotes greater recall. They provided subjects with a main-idea sentence combined with either three, two, or one supporting sentences. The main-idea sentence was recalled better when combined with three supporting sentences. These results support Anderson and Reder's statement that

> memory for any particular proposition will depend on the subjects' ability to reconstruct it from those propositions that are active. This ability will in turn depend on the amount of elaboration made at study. (1979, 388)

Craik and Tulving (1975) and Mayer (1980) have also studied elaboration and found that with increased elaboration, the search for prior experiences expands, increasing the likelihood of the new knowledge being related with the prior knowledge (ie., more propositions supporting the idea). This will

have a significant effect on the amount of recall.

The type of elaborations also affects the development of declarative knowledge (Craik and Tulving, 1975; Anderson and Biddle, 1975; Britton, et al., 1978; Wang, 1983; Phifer, et al., 1983; Stein, et al., 1984; Pressley, et al., 1987; and Levin, 1988). Craik and Tulving (1975, 291) state that "memory performance depends on the elaborateness of the final encoding. Retention is enhanced when the encoding context is more fully descriptive . . ." Therefore, as the number of details supporting an idea increases, so too should the recall. Two types of elaborations that have been studied are precise and imprecise elaborations (Stein, et al., 1984; Pressley, et al., 1987; and Levin, 1988). Precise elaborations are contextually related to the problem being studied. Imprecise elaborations are noncontextual and provide only relational information. Stein, et al. (1984) looked at elaborative processes that would help a novice gain expertise in a new domain of knowledge. They found that the elaborations should not only make a relationship more meaningful and less arbitrary, but should also establish unique relationships among concepts. Both precise and imprecise elaborations can reduce arbitrariness by making the memory trace more distinct, however, precise elaborations may establish a more unique relationship among the concepts. They state

> Elaborations that help people understand the significance of relationships therefore help them remember relational information as well as specific information about the key concepts involved in the

> relationship. . . . elaborations that enhance both relational and item-specific information, i.e., precise elaborations, do not require the activation of associatively related concepts that learners have previously acquired. (528)

The placement of elaborations which will best support incidental learning by the user is also important. Little research has been done to address this issue, with most studies showing the advantage of advance organizers, i.e., summaries at the beginning of a text chapter, over review questions at the end of a chapter (Anderson and Biddle, 1975; Gagné, 1985). The two alternatives that appear available to the developer of an ES are: (1) provide elaborations on a continuous basis as the user answers the various queries generated by the ES; and, (2) provide elaborations at the end of the ES session. The later is the most often placement choice in traditional ES design; however, the explanation is normally only a description of the rules followed by the ES.

The information processing model presented earlier suggests that for feedback to be useful, the particular action under consideration must be active in working memory. This fact along with the evidence supporting a very limited capacity and duration for working (short-term) memory would seem to support providing elaboration at many points during the ES session. This design would allow the user to process each elaboration individually and effectively store them close to similar propositions in long-term memory. Berry and Broadbent (1987) have shown that subjects that receive multiple

explanations perform better than subjects that receive a single block at the beginning. One possible risk of providing elaborations throughout the ES session, such as the control evaluation of this study, may be that the user will not identify what "combination" of weaknesses are significant.

Placement of the elaborations at the end of the session may also have theoretical support. Significant research has shown "pattern recognition" to be an important element in learning complex procedural tasks (Gagné, 1985). Studies investigating the cognitive processes of "experts" have shown that these experts have, after significant time and experience, developed the ability to recognize and process "chunks" of related information (Miller, 1956; De Groot, 1965; Chase and Simon, 1973). By providing complete elaborations at the end of the ES session the user might be better able to recognize patterns, i.e., relationships, leading to the system evaluation.

One possible risk, however, of providing all of the elaborations at the end of the ES session is that the user may not be able to effectively process the information with available working memory due to a cognitive overload (Te'eni, 1991). The user may tend to focus on some subset of the elaborations or process the information out of context (Brehmer, 1980), and, as a result, not store information which is important to developing procedural knowledge.

The control strategy, elaboration, was manipulated through changing

the type and placement of the additional information presented as shown in Table I.

TABLE I

SUMMARY OF SUBJECT GROUPS

Group	Elaboration Type	Elaboration Placement
1	Imprecise	Intraconsultation
2	Precise	
3	Precise w/example	
4	Imprecise	End
5	Precise	
6	Precise w/example	

Incidental vs. Intentional Learning

The intent to learn is not really important for learning to occur (Hyde and Jenkins, 1973; Postman, 1964). This point is important to this experiment due to the fact that the ESs were primarily used as a decision aid for the novice auditor. Any learning that occurs will be incidental learning. Studies have shown that incidental learning can be better than intentional learning if the elaborations presented to the learner are effective (Pressley, 1987). What is of concern in learning is not the intention, but the way in which the learner processes the material during its presentation. If individuals engage in mental activities that are more conducive to learning,

i.e., elaborative processing, then learning should occur regardless of intention.

Summary

The theoretical foundation for the research study was described in detail in this chapter. The discussion dissected the information processing model into its many components. The effect of each of these components on the learning process was then explained. The key elements of the learning process were the development of the propositions in short-term memory and the development of the productions in long-term memory. Elaboration, a control strategy, was discussed as a facilitator of the proposition development process in short-term memory. A key to information processing and learning is that the intention to learn does not have to be present for learning to occur.

Chapter III will build upon the theoretical foundation presented in this chapter. Elaboration will be operationalized as the treatments that will be used in testing the hypotheses that will be developed in Chapter III.

CHAPTER III

RESEARCH METHOD

Introduction

The research question was investigated in a laboratory study. The subjects evaluated cases with the aid of an ES. Subsequently, the effect of each ES on the development of the subjects' declarative and procedural knowledge was examined.

Subjects

Upper level accounting students enrolled in an accounting information systems course served as the subjects. The task is one usually assigned to entry level auditors in an accounting firm. Upper level accounting students are believed to be an adequate representation of entry level auditors in this type of study.

Oklahoma State University (OSU) requires approval from the Oklahoma State University Institutional Review Board (IRB) for all research dealing with human subjects conducted by OSU researchers on the OSU campus. The approval of the IRB must be received prior to start of the

study and their decision is based on a review of all research instruments that will be utilized during the study.

In the study, the subjects performed a decision-making task; however, the focus of the study was not on how well decisions were made, but on how much the students learned during the study. The purpose of this study was to evaluate how different cognitive learning strategies embedded in ESs facilitate learning (i.e. the development of declarative and procedural knowledge). If it can be demonstrated that students learn when using ESs embedded with certain learning strategies, then it would be expected that novice professionals' knowledge would also increase when using ESs designed accordingly.

Experimental Task

This study measured the development of declarative and procedural knowledge. The task was one that would allow for these measurements and also one that the subjects could perform. The task also was one that could be administered over a short time to allow the subjects to perform multiple iterations of the task.

The task used was the evaluation of internal control over payroll. This is a realistic task for entry level auditors. According to the second standard of field work, "A sufficient understanding of the internal control structure is to be obtained to plan the audit and to determine the nature, timing and

extent of tests to be performed." The importance of internal control evaluation is also evidenced by *Statements on Auditing Standards No. 55, Consideration of the Internal Control Structure in a Financial Statement Audit*, (AICPA, 1988). Internal control is one of the topics covered in the accounting information systems course from which the subjects were drawn.

Expert System

The subjects used an ES based on SAS No. 55. Six ESs were constructed with the user interface of each ES manipulated based on the control strategy previously discussed. Each of the ESs contained identical knowledge bases.

Experimental Procedure and Research Instrument

Introduction

Each subject was given an identical research instrument consisting of seven parts as shown in Figure 4:

(1) general instructions and background information,
(2) demographic questionnaire,
(3) internal control pretest examination,
(4) internal control pretest evaluations,
(5) internal control learning cases,
(6) internal control posttest examination, and
(7) internal control posttest evaluations.

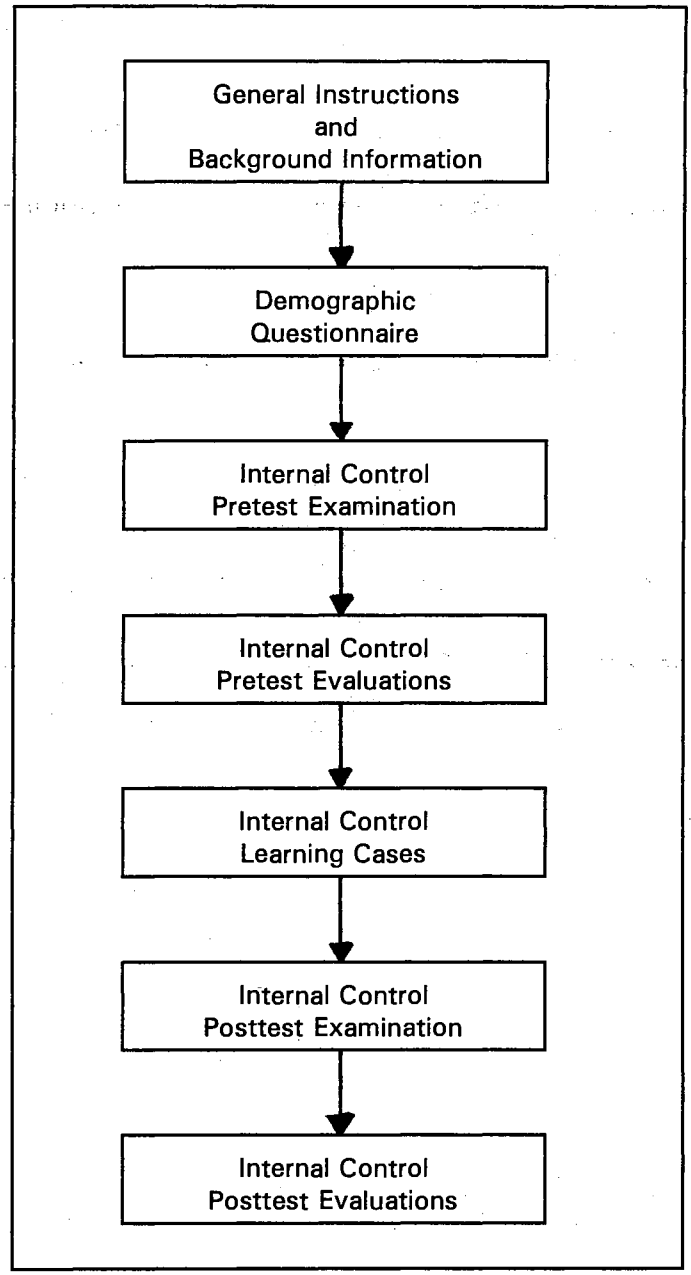


Figure 4. Experimental Procedure

Instructions and Background

The subjects were asked to assume the role of a staff auditor in charge of the evaluation of a specific area of internal control. They were

told that they must evaluate several internal control situations with the aid of an ES and that points would be assigned based on their improvement. An example of the instructions given to the subjects is shown in Appendix A.

Background information on one company was provided to the subjects to use for all the cases they evaluated (Appendix B). By the time the experiment began, the subjects had been introduced to internal control evaluation in their accounting information systems class. This helped ensure that the subjects were at the same knowledge level at the beginning of the experiment; however, the knowledge level was tested with two separate pretests discussed below.

Demographic Questionnaire

The homogeneity of the experimental groups was also evaluated with data collected on each subject at the beginning of the experiment. A questionnaire requesting each subject's age, gender, educational background, and educational performance was administered. A copy of the questionnaire is presented in Appendix C.

Pretest Examination

This examination tested the subjects' declarative knowledge of internal control prior to experimental manipulation. The test consisted of multiple choice questions about internal control. The scores achieved on

this examination were used as a test for homogeneity of the experimental groups and were also used as a covariate in the measurement of the development of the users' declarative knowledge. A copy of the examination is presented in Appendix D.

Cook and Campbell (1979) note that gain score analysis, the use of the difference between pretest and posttest scores as the dependent variable, is generally less precise than covariance analysis. Gain score analysis does not test for interaction effects between the pretest and treatments.

Pretest Evaluation

The subjects evaluated internal control for an initial set of four cases prior to being introduced to the ESs. These evaluations served as another test for group homogeneity and were used as a covariate in the measurement of the development of the users' procedural knowledge. The set of cases that were used for the pretest evaluations is presented in Appendix E.

Learning Cases

The internal control cases that the subjects evaluated consisted of a narrative description of the characteristics as used by Eining (1988). The narrative format helped alleviate the bias toward particular cues. The cases

are included in Appendix F.

Fifteen cases were evaluated by the subjects over a three-week period using the ESs. Each subject attended one one-hour session per week during which five cases were evaluated. These cases were used to provide the subjects with the experience needed to develop declarative and procedural knowledge.

The three-week period was used due to theoretical support for spacing to-be-learned material over time. Anderson (1990) provides a discussion of this research which suggests that spaced study is superior to mass study, especially on complex tasks. Spaced study leads to superior encoding of information in long-term memory and thus better retention. Since each encoding is made in a slightly different context, i.e., emotional, physical, this increases the likelihood that these contextual settings will overlap the testing (application) setting. Another reason that spaced study may lead to superior learning is the incubation effect. The incubation effect is where learning is not occurring while working on a task, so by going away from the task for some time, upon returning to it, a fresh approach can lead to a solution. Research has also shown that spaced study has even more profound effects on skill learning, i.e., learning of procedural knowledge versus declarative knowledge. Thus, with spaced study, the subjects should have had a greater chance for learning to have occurred.

Posttest Examination

The subjects' declarative knowledge was measured subsequent to the experimental manipulation. The posttest was taken without the use of any ESs. This test was a multiple choice test identical to the pretest examination (Appendix D), with the questions scrambled.

Posttest Evaluation

Four cases were evaluated without the use of the ESs subsequent to the experimental manipulation. These four cases were the same cases evaluated in the pretest evaluation (Appendix E). The results were used to measure the development of procedural knowledge.

Research Design

The research design (Figure 5) was a pretest-posttest design with

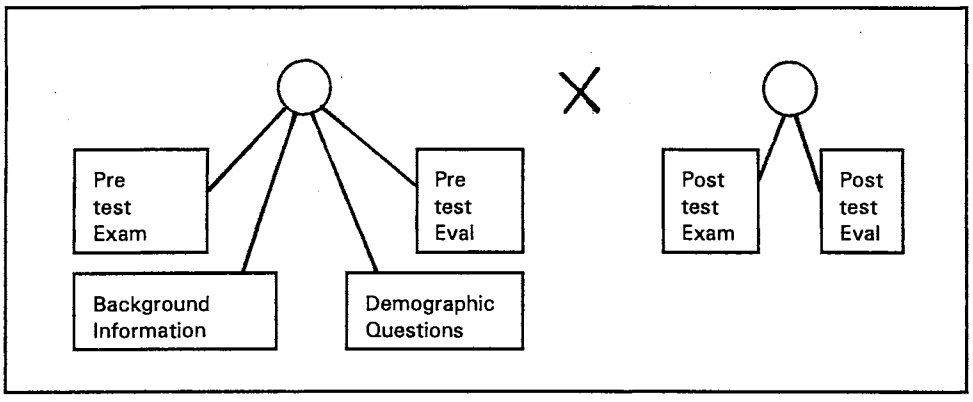


Figure 5. Research Design

randomization. Five sections of Accounting Information Systems (AIS) were used as the subjects in the study. The students were randomly assigned to one of the six ESs designed for the research study resulting in an equal representation of each ES in each AIS section. The students were not notified that there were six different ESs in use.

Experimental Design

Introduction

The experimental design was a 3 x 2 Completely Randomized Factorial Analysis of Covariance (CRFAC-23) design as shown in Figure 6 (Kirk, 1982). There were two separate pretest and posttest measures; one for declarative knowledge and one for procedural knowledge. All treatment levels of interest were included in the experiment, resulting in a fixed-effects model, Model I, for the study as described by Kirk (1982, 354).

The design used statistical control to reduce variability due to experimental error and to obtain unbiased estimates of treatment effects, thereby obtaining a more powerful test of a false null hypothesis.

Statistical Control

Statistical control is an approach that can be used to eliminate potential sources of bias from an experiment and analysis of covariance (ANCOVA) is one method of statistical control. ANCOVA combines

MAIN EFFECTS:

Elaboration Type

levels: 1) Imprecise
2) Precise
3) Precise with Example

Elaboration Placement

levels: 1) Continuous
2) End

INTERACTION EFFECTS:

Elaboration Type x Elaboration Placement

	Imprecise	Precise	Precise w/Example	
Continuous	n = 21	n = 21	n = 21	n = 63
End	n = 21	n = 21	n = 21	n = 63
	n = 42	n = 42	n = 42	N = 126

Figure 6. Experimental Design

regression analysis with analysis of variance (ANOVA) to adjust a dependent variable based on one or more concomitant variables, also called covariates. The concomitant variables are selected based on their relationship with the error variance associated with the dependent variable. By removing the portion of the error variance associated with the concomitant variable, a smaller error variance results and, hence, a more powerful test of a false null hypothesis. The effects eliminated by the covariance adjustment must be

irrelevant to the objectives of the experiment, because the concomitant variables cannot be analyzed further.

Concomitant Variables

The pretest examination scores and the pretest evaluation scores met the selection criteria of concomitant variables in this experiment. These scores should affect the dependent variables and further analysis of these scores is irrelevant to the experiment.

Treatment Variables

Elaboration was operationalized as the explanations for the decision aids in this experiment, since using this control strategy either directly or indirectly should improve learning as discussed in Chapter II. The two treatments were elaboration type with three (3) levels and elaboration placement with two (2) levels. Each of these treatments were selected based on the research previously discussed. The three levels of elaboration type were: 1) ES with base comment and imprecise elaboration, 2) ES with base comment and precise elaboration, and 3) ES with base comment, precise elaboration, and an example. The two levels of elaboration placement in the experiment were: 1) intraconsultation (the elaborations given continuously during the session with the ES), and 2) end of consultation (the elaborations given only after the ES session was

completed). This resulted in six treatment levels in the design with each treatment level being administered to twenty-one subjects.

Dependent Variables

Introduction

The dependent variables were selected to measure declarative and procedural knowledge. As an individual develops declarative knowledge, the effectiveness in answering questions pertaining to the subject domain should improve. As an individual develops procedural knowledge, decision-making effectiveness should improve. The variable selected to measure both subject domain knowledge and decision-making effectiveness in this study was accuracy. Anderson (1990) discusses this variable as a dimension of improvement that arises due to learning.

Declarative Knowledge

Introduction. Declarative knowledge is knowledge of the facts and theories of a topic and is recalled through a conscious effort. Before we can fully understand a topic, we must learn declarative knowledge on that topic. The subjects in this study should have began developing declarative knowledge, (i.e. building propositions), about internal control during the initial classroom instruction. This declarative knowledge should have been further developed during the evaluation of the internal control cases in the

learning phase of the experiment, resulting in the building of the propositional networks previously discussed.

One way to measure declarative knowledge is to test the subjects' ability to verify or recall information. The posttest examination, which was used to measure declarative knowledge in this experiment, examined the subjects on the factual and theoretical information relating to internal control. The accuracy (number of correct answers) of the subjects on this examination was used to measure the development of declarative knowledge. This posttest accuracy measurement was adjusted through analysis of covariance using the pretest examination accuracy measurement.

Hypotheses Generation. In a completely randomized factorial design with two treatments, the first analysis performed is to check for any interactions between the two treatments. Finding interactions, or the lack of interactions, will determine the direction that will be taken for further analysis on the individual treatments. If no interactions exist, the main effects of the individual treatments can be analyzed, however, if interactions are present, the main effects analysis will not provide reliable results. If this occurs, the further analysis will consist of analysis of the simple main effects.

This leads to the first hypothesis tested using the adjusted dependent variable for declarative knowledge discussed above. The interaction of the elaboration type with elaboration placement was examined. Each of these

control strategies have been shown to facilitate learning. Whether these two control strategies will interact when used in conjunction with one another is not known. The hypothesis tested to examine if they do interact, stated in the null form, is:

> $H_0$1: There will be no difference in the development of declarative knowledge between the treatment groups due to the different types of elaborations interacting with the different placements of the elaborations in the ESs as measured by the subjects' achievement on a posttest examination.
>
> $H_0$1: $(\alpha\beta)_{jk} = 0$ for all j, k

If elaboration placement is successful in facilitating learning, individuals who use ESs designed using this control strategy should increase their declarative knowledge of the subject domain while using the ES. The elaborations can be placed in different locations in the ES design. Different placements of elaborations may result in differences in knowledge development. This leads to the second hypothesis, stated in the null form:

> $H_0$2: There will be no difference in the development of declarative knowledge between the treatment groups due to the different placements of elaborations embedded in the design of the ESs as measured by the subjects' achievement on a posttest examination.
>
> $H_0$2: $\alpha_j = 0$ for all j

If elaboration type is successful in facilitating learning, individuals who

use ESs designed using this control strategy should increase their declarative knowledge of the subject domain while using the ES. Several types of elaborations can used in the ES design. Different types of elaborations may result in differences in knowledge development. This leads to the third hypothesis, stated in the null form:

> $H_0$3: There will be no difference in the development of declarative knowledge between the treatment groups due to the different types of elaborations embedded in the design of the ESs as measured by the subjects' achievement on a posttest examination.
>
> $H_0$3: $\beta_k = 0$ for all k

The research study also looks at the development of procedural knowledge during the use of ESs designed with the control strategies described. The next section discusses procedural knowledge and develops the hypotheses tested.

Procedural Knowledge

Introduction. Procedural knowledge is different from declarative knowledge, in that, procedural knowledge involves a transformation of information instead of a simple recall. It is important to know facts about a topic, but to be able to apply these facts requires procedural knowledge. As declarative knowledge is used, procedural representations of the action sequence begin to develop; therefore, practice is very important in the

development of procedural knowledge.

Procedural knowledge was measured by requiring learners to do something other than recognize or recall. The measurement of procedural knowledge was based on the subjects' accuracy on the evaluation of the posttest cases without an ES. Accuracy was measured as the mean absolute error (MAE), which was determined by the difference between the subjects' evaluations and the ESs' evaluations for the same cases divided by the total number of cases evaluated. The equation to determine the MAE is the same used by Eining (1988).

$$MAEs = \left[\sum_{i=1}^{4} ABS(E_{ei} - E_{si}) \right] / 4 \qquad (1)$$

where,

MAEs = Mean Absolute Error for subject s
E_{ei} = Evaluation of Expert System for scenario i
E_{si} = Evaluation of subject s for scenario i
ABS = Absolute value

Since the ESs were the means for developing the subjects' procedural knowledge, the ESs' evaluations can be used as a benchmark upon which the subjects should converge. The subjects' evaluations of the pretest cases without the use of the ES was used to adjust the evaluations of the posttest cases using analysis of covariance.

Hypotheses Generation. For the reasons discussed previously, the first analysis performed is to check for any interactions between the two

treatments. This leads to the first hypothesis tested using the adjusted dependent variable for procedural knowledge discussed above. The interaction of the elaboration type with the elaboration placement was examined. The hypothesis tested, stated in the null form, is:

> $H_0$4: There will be no difference in the development of procedural knowledge between the treatment groups due to the different types of elaborations interacting with the different placements of the elaborations in the ESs as measured by the subjects' accuracy on the evaluations of the posttest internal control cases.
>
> $H_0$4: $(\alpha\beta)_{jk} = 0$ for all j, k

If elaboration placement is successful in facilitating learning, individuals who use ESs designed using this control strategy should show an improvement in their procedural knowledge. This improvement should result in increased accuracy in applying the factual knowledge of a subject to solve a problem. Different placements of elaborations may result in differences in the development of procedural knowledge. This leads to the fifth hypothesis, stated in the null form:

> $H_0$5: There will be no difference in the development of procedural knowledge between the treatment groups due to the different placements of elaborations embedded in the design of the ESs as measured by the subjects' accuracy on the evaluations of the posttest internal control cases.
>
> $H_0$5: $\alpha_j = 0$ for all j

If elaboration type is successful in facilitating learning, individuals who use ESs designed using this control strategy should show an improvement in their procedural knowledge. This improvement should result in increased accuracy in applying the factual knowledge of a subject to solve a problem. Different types of elaborations may result in differences in the development of procedural knowledge. This leads to the sixth hypothesis, stated in the null form:

> $H_0$6: There will be no difference in the development of procedural knowledge between the treatment groups due to the different types of elaborations embedded in the design of the ESs as measured by the subjects' accuracy on the evaluations of the posttest internal control cases.
>
> $H_0$6: $\beta_k = 0$ for all k

Experimental Design Models

Introduction

The same formal experimental design model equation can be used for the evaluation of both sets of hypotheses; the hypotheses for the development of declarative knowledge and the hypotheses for the development of procedural knowledge. The model will be shown first prior to the adjustment for the covariate being made to the dependent variables, this will be followed by the adjusted model that was utilized in the

experiment.

The unadjusted model is

$$Y_{ijk} = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \beta_w(X_{ijk} - X...) + \epsilon_{i(jk)}$$
$$(i = 1, \ldots, n; j = 1, \ldots, p; k = 1, \ldots, q).$$

where

Y_{ijk} = the unadjusted criterion measure
μ = the overall population mean
α_j = the effect of treatment level *j* and is subject to $\Sigma^p_{j=1}\ \alpha_j = 0$
β_k = the effect of treatment level *k* and is subject to $\Sigma^q_{k=1}\ \beta_k = 0$
$(\alpha\beta)_{jk}$ = the joint effect of treatment levels *j* and *k* and is subject to the restrictions $\Sigma^p_{j=1}(\alpha\beta)_{jk} = 0$ and $\Sigma^q_{k=1}\ (\alpha\beta)_{jk} = 0$
β_w = the *within-groups* linear regression coefficient
X_{ijk} = the covariate for subject *i* in treatment level *j*
X... = the mean of the covariate
ϵ_{ij} = the experimental error that is $NID(0, \sigma_\epsilon^2)$.

The analysis of covariance adjustment to the dependent variable will result in

$$Y_{adjijk} = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \epsilon_{i(jk)}$$
$$(i = 1, \ldots, n; j = 1, \ldots, p; k = 1, \ldots, q).$$

where,

Y_{adjijk} = the adjusted criterion measure, and

with the remaining terms defined as in the previous model.

A summary of the model for each of the stated hypotheses is presented in summary form in Table II.

TABLE II

EXPERIMENTAL MODEL

$$Y_{adjijk} = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \epsilon_{i(jk)}$$

where,

Knowledge Type	Declarative	Procedural
Hypotheses	1 2 3	4 5 6
Variables		
Y_{adjijk}	Number correct Posttest Examination	MAE on Posttest Evaluations
μ	Mean	Mean
α_j	ES Type	ES Type
β_k	ES Placement	ES Placement
$(\alpha\beta)_{jk}$	Type x Placement	Type x Placement
ϵ_{ijk}	Residual	Residual

Summary

This chapter outlined the research method used in the study. A discussion of the subjects and the experimental task was included. The experimental procedure was presented, including a discussion of the research instrument. The study consists of the students being tested on

their knowledge of internal controls prior to being exposed to any of the learning cases. The students then used one of the six ESs, each with a different combination of elaborations embedded in the design, to work through the learning cases. Upon completion of the training, the students were tested for both declarative and procedural knowledge.

The chapter also contained the discussion of the operational definitions of the independent and dependent variables. These variables were then used to develop the hypotheses that were tested. The models used to test the hypotheses were introduced and discussed in detail.

CHAPTER IV

DATA ANALYSIS

Introduction

This chapter contains the results of the data analysis. Preliminary analyses were performed on the experimental groups to evaluate group homogeneity. The results of those analysis are presented first. Main and secondary analyses were performed to test the hypotheses generated in Chapter III. The results of those analyses follow the preliminary.

Preliminary Analyses

Analysis of group homogeneity was performed based on the different treatment groups used in the experiment. The subjects were randomly assigned to one of six different combinations of the two treatments. The two treatments were elaboration type and elaboration placement. Three different elaboration types were studied resulting in each elaboration type being assigned to two of the main treatment groups. Two different elaboration placement types were studied resulting in each being assigned to three of the main treatment groups. Preliminary analysis was performed for

the six different combinations of the two treatments and separately for each of the two treatments.

The data used to evaluate the homogeneity of the groups were collected prior to the treatments being administered. Demographic data, pretest scores, and preevaluation scores were compared across each set of treatment groups. The demographic variables examined were age, academic class, and gender. Bartlett's test for homogeneity of group variances was utilized.

Group Homogeneity - Treatment Combinations

Differences in mean values (age, pretest scores, and preevaluation scores) were tested using an ANOVA F-Test for the six treatment combination groups while differences in frequencies (academic class and gender) were evaluated using a contingency table based chi-square analysis for the groups. The results of the analysis for the treatment combination groups are presented in Table III.

The only variable that was significant at $p = 0.05$ was the pretest examination scores. This variable will be used as a covariate in the remaining analysis, therefore, the significance signifies that the selection of the pretest variable is proper. Based on this preliminary examination, group homogeneity for the six treatment combination groups with respect to the demographic data and preevaluation scores appears to be intact at the

beginning of the experiment.

TABLE III

PRELIMINARY ANALYSIS BY TREATMENT COMBINATIONS

GROUP CHARACTERISTICS - TREATMENT COMBINATIONS								
Panel A - Mean Values								
Variable	Imp x Con	Pre x Con	Prewe x Con	Imp x End	Pre x End	Prewe x End	F	P-Value
N	21	21	21	21	21	21		
Pretest	4.38	3.95	4.23	3.62	4.57	4.91	2.304	.049
Preeval	1.25	1.27	1.31	1.27	1.33	1.35	.102	.992
Age	23.16	21.84	22.89	22.53	22.35	22.10	.469	.798
Panel B - Frequencies								
							χ^2	P-Value
Class							1.678	.892
Soph						1		
Junior	6	8	10	11	9	12		
Senior	15	13	11	10	11	8		
Grad					1			
Gender							.012	1.00
F	9	12	9	12	8	12		
M	12	9	12	9	13	9		

Group Homogeneity - Elaboration Type

Differences in mean values (age, pretest scores, and preevaluation scores) were tested using an ANOVA F-Test for the elaboration type groups

while differences in frequencies (academic class and gender) were evaluated using a contingency table based chi-square analysis for the groups. The results of the analysis for the elaboration type groups is presented in Table IV.

TABLE IV

PRELIMINARY ANALYSIS BY ELABORATION TYPE

GROUP CHARACTERISTICS - TYPE OF ELABORATIONS					
Panel A - Mean Values					
Variable	Imprecise	Precise	Precise w/Example	F	P-Value
N	42	42	42		
Pretest	4.000	4.262	4.571	1.758	.177
Preevaluation	1.262	1.304	1.327	.162	.851
Age	22.842	22.103	22.474	.552	.577
Panel B - Frequencies					
				χ^2	P-Value
Class				.304	.859
Soph			1		
Junior	17	17	22		
Senior	25	24	19		
Grad		1			
Gender				.014	.993
F	21	20	21		
M	21	22	21		

There were no significant differences at $p = 0.05$ between any of the

variables for the elaboration type groups. Based on this preliminary examination, group homogeneity for the three elaboration type groups with respect to the demographic data, pretest scores, and preevaluation scores appears to be intact at the beginning of the experiment.

Group Homogeneity - Elaboration Placement

Differences in mean values (age, pretest scores, and preevaluation scores) were tested using a *t*-test for the elaboration placement groups while differences in frequencies (academic class and gender) were evaluated using a contingency table based chi-square analysis for the groups. The results of the analysis for the elaboration placement groups is presented in Table V.

There were no significant differences at $p = 0.05$ between any of the variables for the two elaboration placement groups. Based on this preliminary examination, group homogeneity for the elaboration placement groups with respect to the demographic data, pretest scores, and preevaluation scores appears to be intact at the beginning of the experiment.

Tests of Hypotheses - Declarative Knowledge

Descriptive Statistics

Prior to testing the hypotheses generated in Chapter III, descriptive statistics were computed and plots of the raw data were completed. Data means and plots of the residuals versus the estimated values were examined

for the combination treatment groups and for each set of groups (elaboration type and elaboration placement) within the combination.

TABLE V

PRELIMINARY ANALYSIS BY ELABORATION PLACEMENT

GROUP CHARACTERISTICS - PLACEMENT OF ELABORATIONS				
Panel A - Mean Values				
Variable	Continuous	End	*t*	P-Value
N	63	63		
Pretest	4.190	4.365	.695	.488
Preevaluation	1.278	1.317	.418	.677
Age	22.625	22.322	.526	.600
Panel B - Frequencies				
			χ^2	P-Value
Class			1.114	.291
Soph		1		
Junior	24	32		
Senior	39	29		
Grad		1		
Gender			.000	.987
F	30	32		
M	33	31		

Aptness of The Model

Treatment Combinations. The data means and standard deviations were computed for the pretest examination scores and for the posttest

examination scores adjusted for the covariate for the six treatment combinations (Table VI).

TABLE VI

MEAN PRETEST AND ADJUSTED MEAN POSTTEST SCORES BY ESs

Treatment Group	Mean Pretest (std. dev.)	Adjusted Mean Posttest (std. dev.)
Imprecise x Continuous	4.38 (1.63)	4.94 (0.41)
Precise x Continuous	3.95 (1.32)	5.28 (0.42)
Precise with Example x Continuous	4.23 (1.30)	4.91 (0.41)
Imprecise x End	3.62 (0.92)	5.56 (0.41)
Precise x End	4.57 (1.29)	4.77 (0.41)
Precise with Example x End	4.91 (1.64)	3.72 (0.40)

It is evident from Table VI that there were differences, between treatment groups, in adjusted mean posttest examination scores. The adjusted mean posttest examination score for the Imprecise x End group is greater than all other groups. However, the three groups with the Continuous placement variable are not far behind, and appear to be bunched together. The other two End placement groups lag behind with the Precise with Example x End being the lowest mean. That group is also the only one where the adjusted posttest mean is lower than the pretest mean.

The plots of the adjusted mean posttest examination scores are shown in Figures 7 and 8. Figure 7 shows the plot of the elaboration placement curves and Figure 8 shows the elaboration type curves.

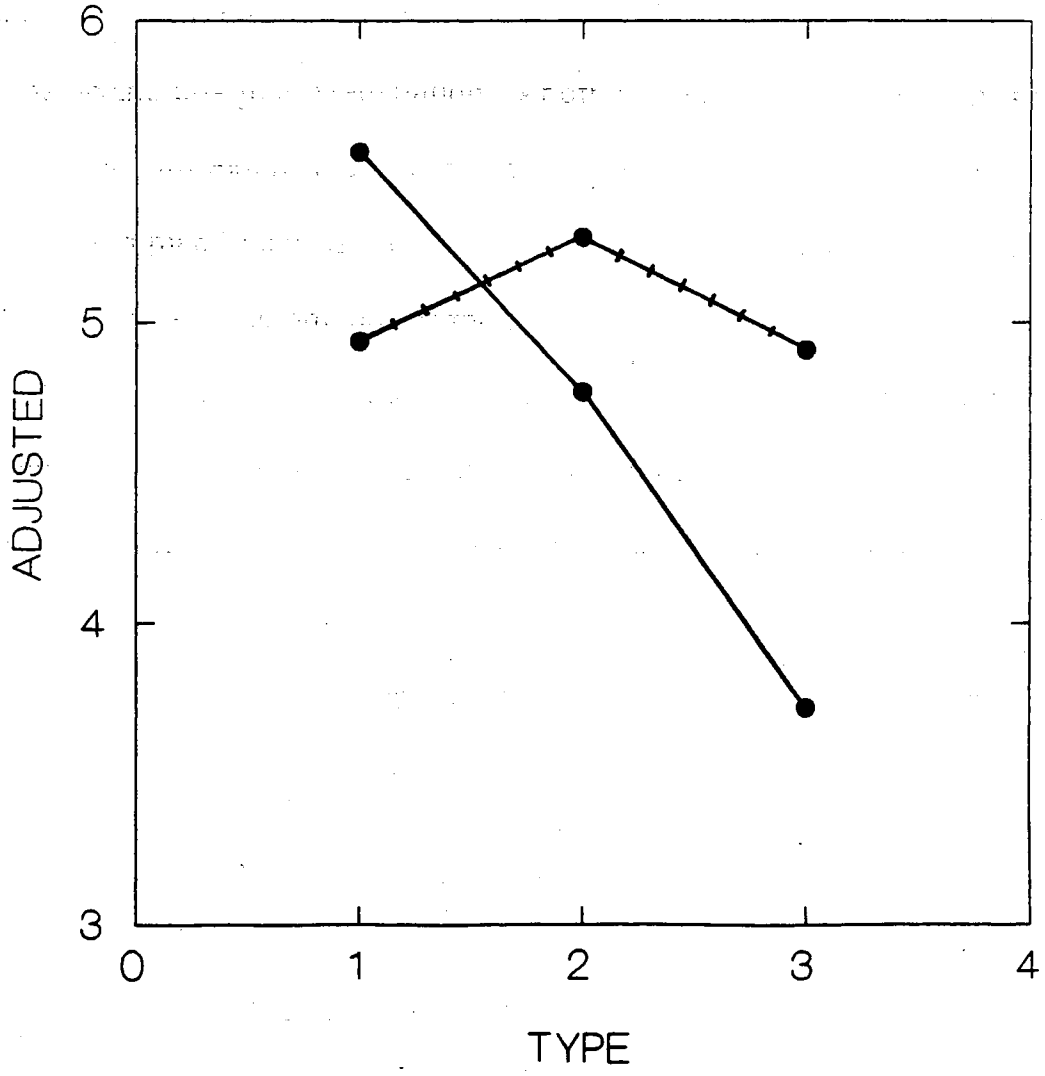
Elaboration Placement. The data means and standard deviations were computed for the pretest examination scores and for the adjusted posttest examination scores for the two elaboration placement groups (Table VII).

TABLE VII

MEAN PRETEST AND ADJUSTED MEAN POSTTEST SCORES BY PLACEMENT

Elaboration Placement	Mean Pretest (std. dev)	Adjusted Mean Posttest (std. dev.)
Continuous	4.190 (1.413)	5.041 (0.236)
End	4.365 (1.406)	4.684 (0.231)

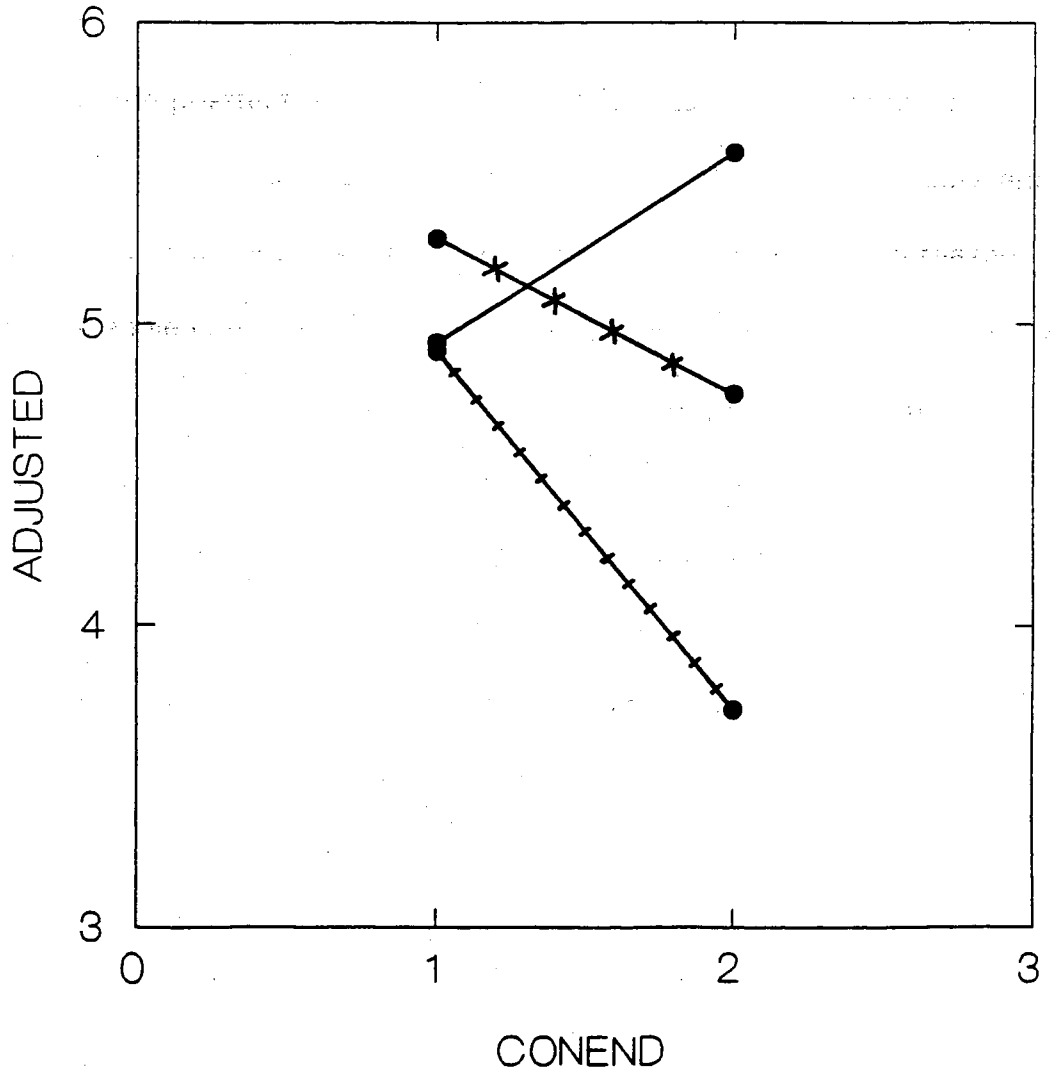
It is evident from Table VII that there were differences, between the elaboration placement groups, in adjusted mean posttest examination scores. The adjusted mean posttest examination score for the Continuous group is greater than the adjusted mean posttest examination score for the End group. Also noticeable is the large increase between pretest mean and the adjusted posttest mean for the Continuous placement group while the End placement group only changed slightly. Another interesting observation concerns the posttest mean for the End group. That adjusted posttest mean



Type 1 - Imprecise
2 - Precise
3 - Precise w/Example

- Continuous
- End

Figure 7. Plots of Adjusted Means - Placement Curves



Conend 1 - Continuous
2 - End

- Imprecise
- Precise
- Precise w/Example

Figure 8. Plots of Adjusted Means - Type Curves

is less than the adjusted posttest mean for the Continuous placement group, even though the pretest means for the two groups were in the opposite direction. The plots of the adjusted mean posttest examination scores for the two elaboration placement groups are shown in Figure 9. In Figure 9, AVGCNEN is the adjusted mean posttest examination score and CONEND is the two elaboration placements.

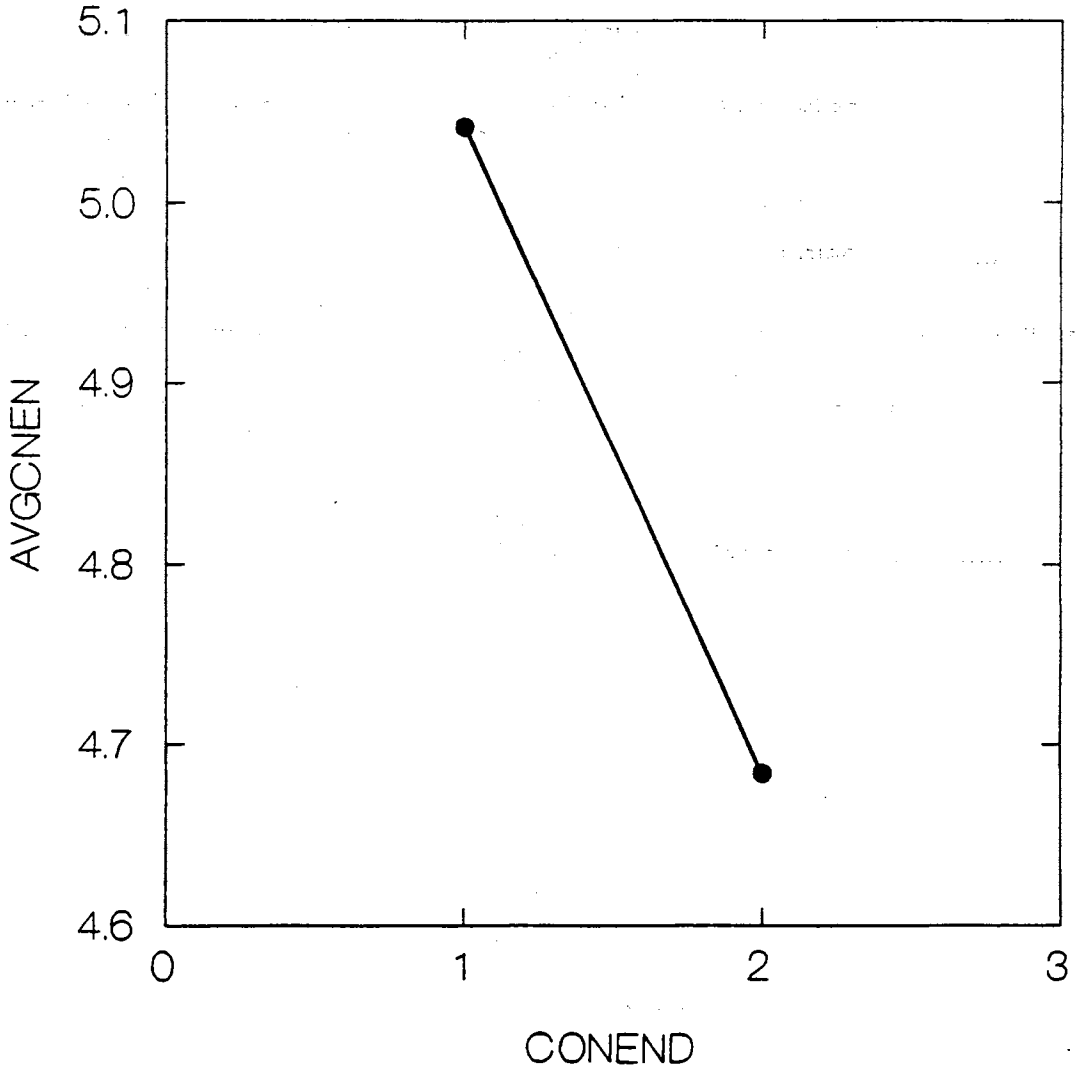
Elaboration Type. The data means and standard deviations were computed for the pretest examination scores and for the adjusted posttest examination scores for the three elaboration type groups and are presented in Table VIII.

TABLE VIII

MEAN PRETEST AND ADJUSTED MEAN POSTTEST SCORES BY TYPE

Elaboration Type	Mean Pretest (std. dev.)	Adjusted Mean Posttest (std. dev.)
Imprecise	4.000 (1.361)	5.250 (0.294)
Precise	4.262 (1.326)	5.024 (0.288)
Precise with Example	4.571 (1.500)	4.315 (0.282)

It is evident from Table VIII that there were differences, between the elaboration type groups, in adjusted mean posttest examination scores. The adjusted mean posttest examination score for the Imprecise group is greater



Conend 1 - Continuous
2 - End

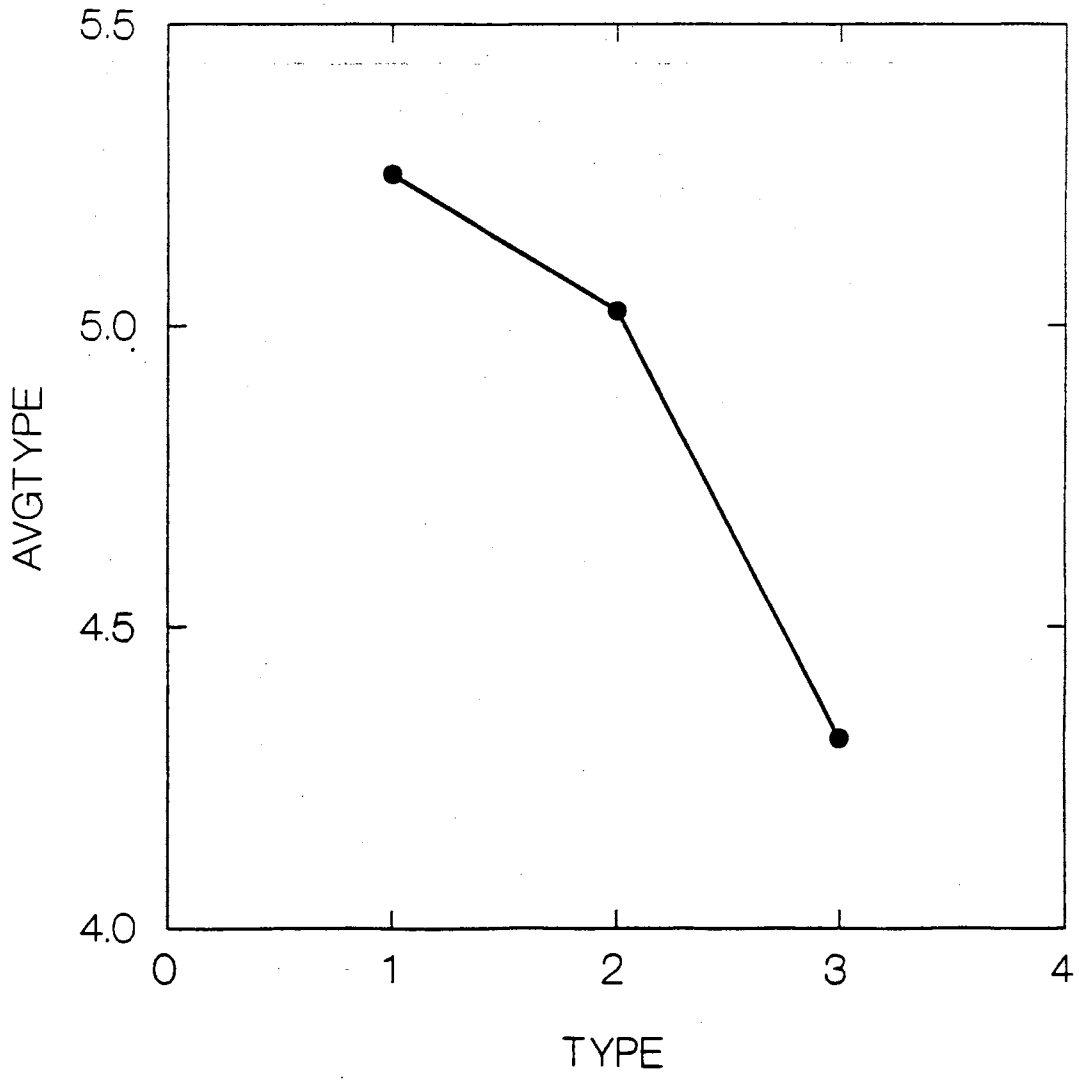
Figure 9. Adjusted Mean Posttest Scores - Placement Groups

than for the other two groups. However, the difference is minimal between the Imprecise group and the Precise group meaning the Precise with Example group must have performed worse than the other two elaboration type groups on the posttest examination. Another interesting observation is that the Precise with Example group decreased between the pretest score and the adjusted mean posttest score while the other two groups increased. Also noticeable is the amount of the increase between the pretest mean and adjusted posttest mean for the Imprecise type group. That mean for the Imprecise group was the lowest on the pretest scores and the highest on the adjusted posttest scores. The plots of the adjusted mean posttest examination scores for the three elaboration type groups are shown in Figure 10. In Figure 10, AVGTYPE is the adjusted mean posttest examination scores for the three elaboration type groups which are plotted as TYPE.

Assumptions of the Model. The ANCOVA model is reasonably robust against some types of departures from the model's basic assumptions, however, the assumptions need to be examined to detect any serious departures that may cause problems (Neter, et al., 1990, 607).
The ANCOVA model assumes that:

1. The probability distributions are normally distributed,
2. The probability distributions have the same variance, and
3. the observations are random and independent. (509)

The normality of the error terms was studied using a normal probability plot of the residuals. The residuals for all treatments were



Type 1 - Imprecise
2 - Precise
3 - Precise w/Example

Figure 10. Adjusted Mean Posttest Scores - Type Groups

combined into one group, since no major differences were found in the error variances for the individual treatments. The normal probability plot in Figure 11 shows that the error terms follow a reasonably straight line. This indicates that there are most probably no serious departures from normality for the error terms.

The constant variance for the error terms was studied from the plots of the residual values against the fitted values. These plots were completed using the six combinations of the treatments and then separately for each of the two treatments. Each of the residual plots show that the residuals are scattered equally around 0 for the overall experiment and for each factor level within the experiment indicating that the error variance is constant for the data collected. These plots are presented as Figures 12, 13, and 14.

The data in this experiment are not time sequenced, therefore, a test for serial correlation was not necessary and was not performed.

In view of the assumptions of the ANCOVA model not being violated, it appears reasonable to continue with the tests of the hypotheses.

Main Analysis

Hypothesis 1

The significance of the differences and the factor effects were tested using the following ANCOVA model:

$$Y_{adjijk} = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \epsilon_{i(jk)}$$

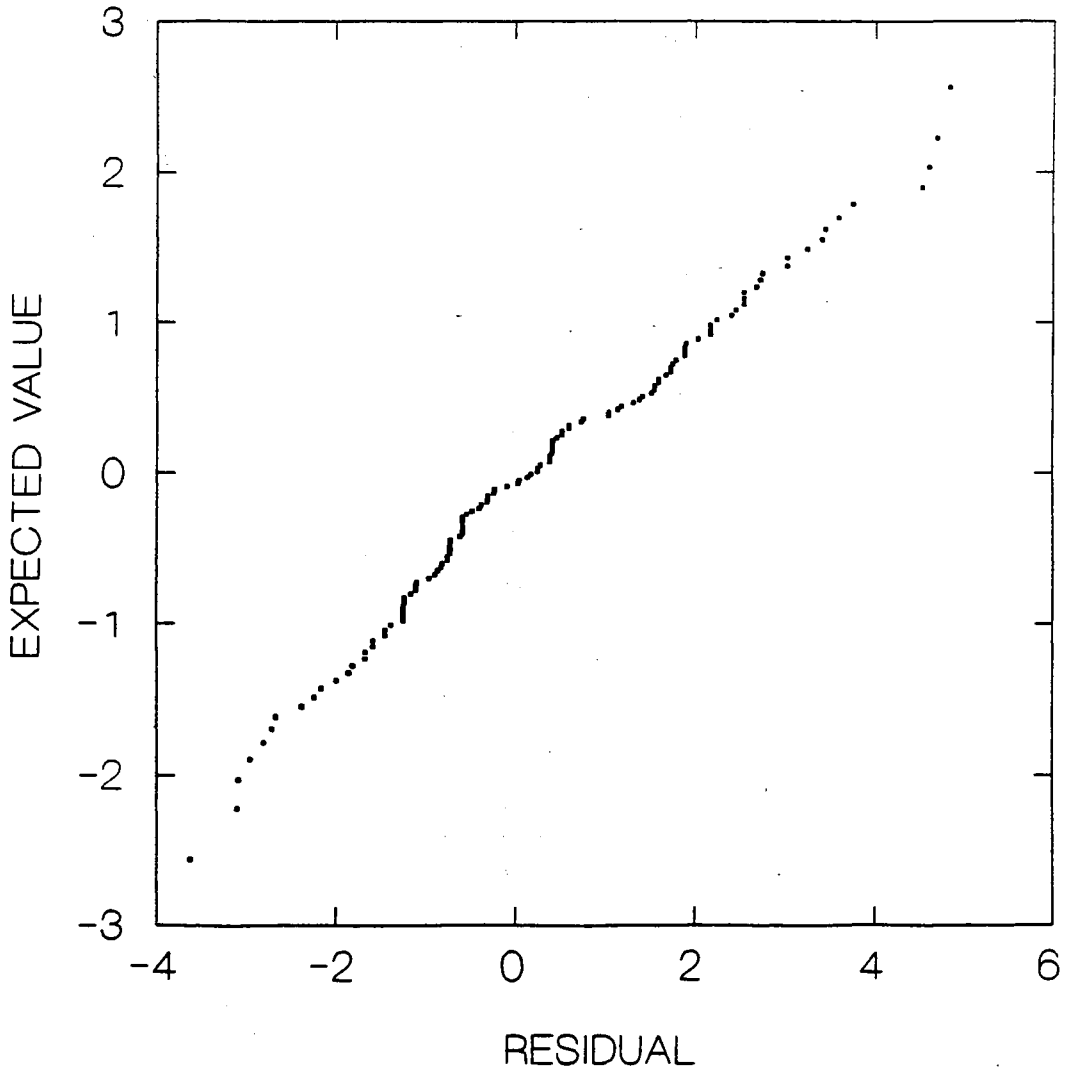


Figure 11. Normal Probability Plot of Residuals

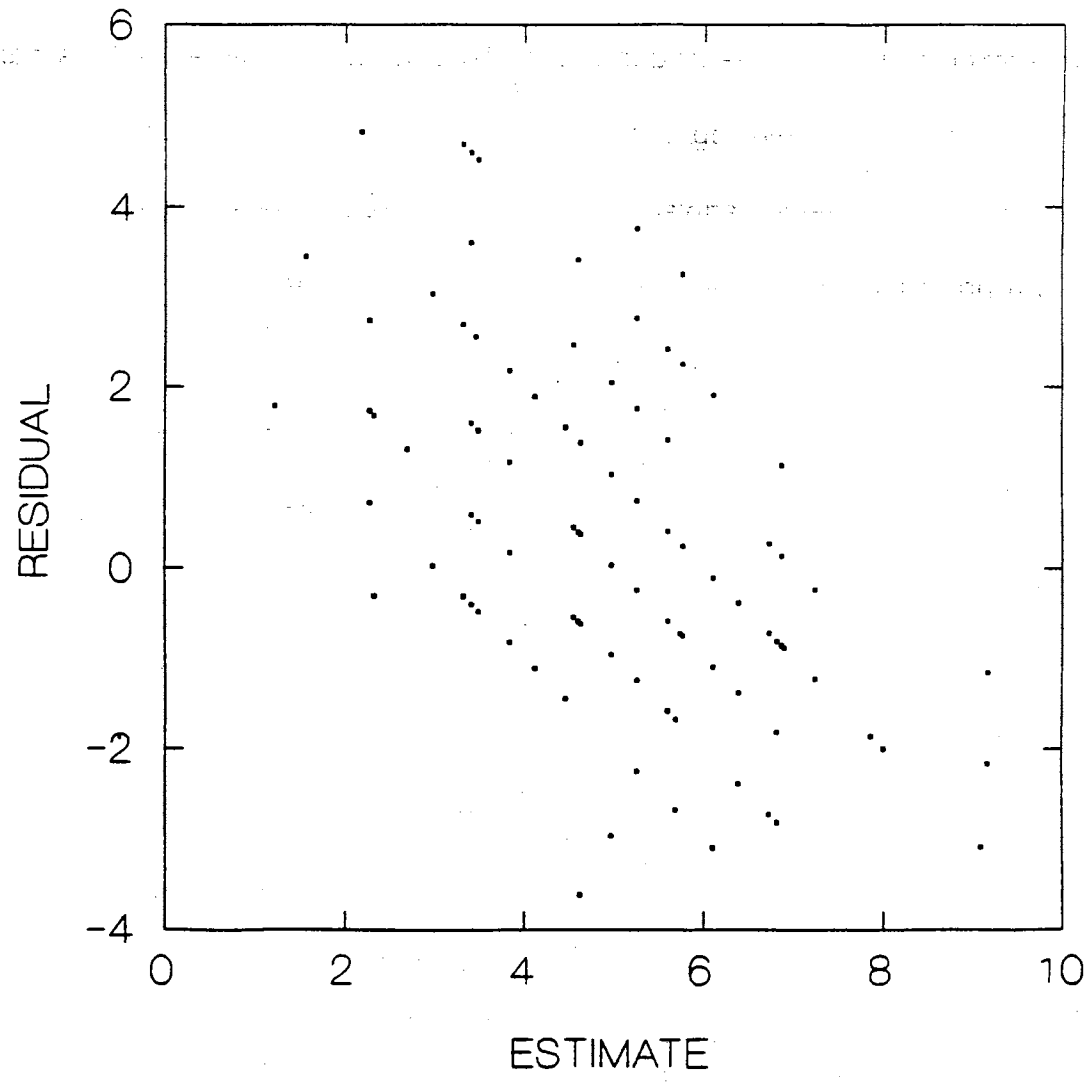
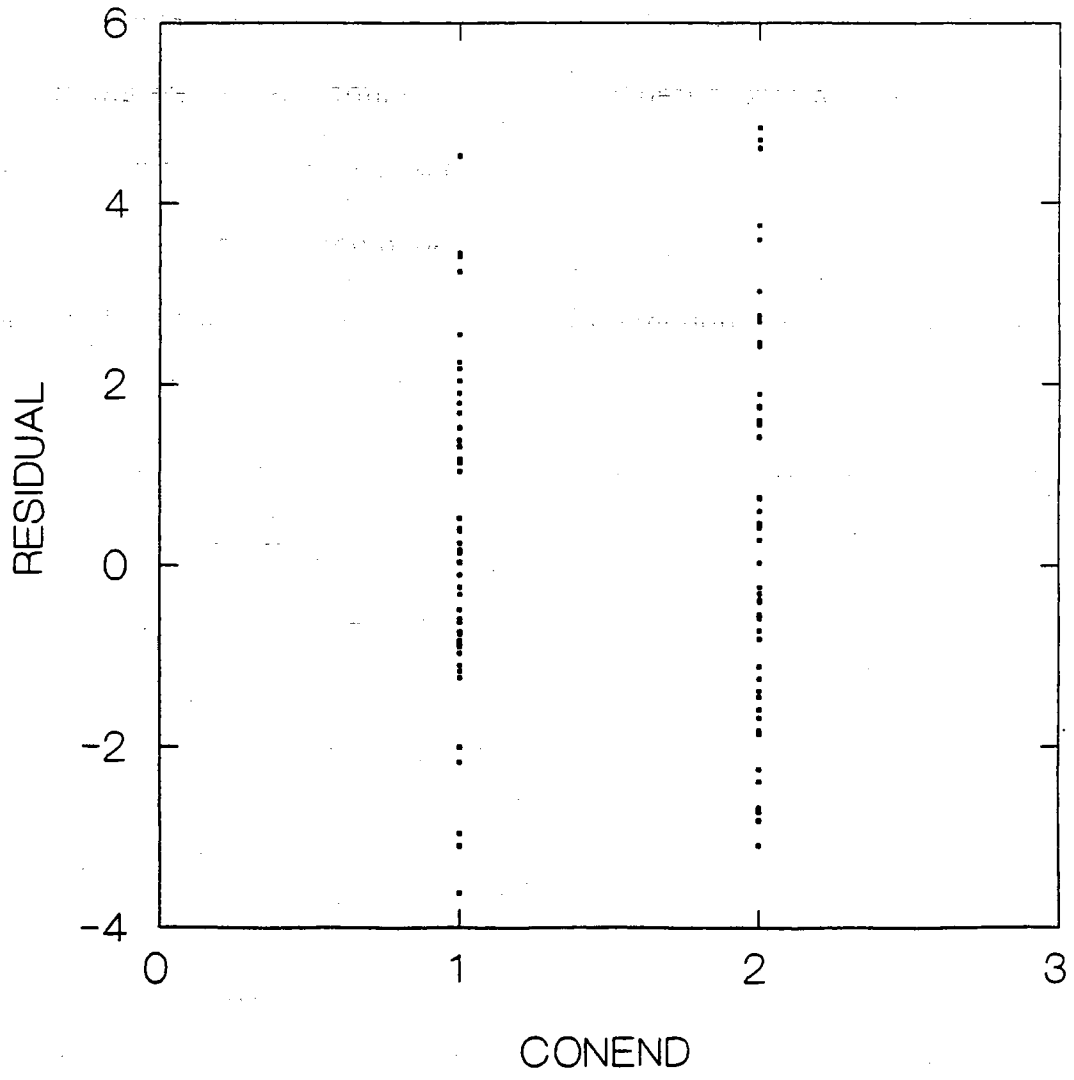
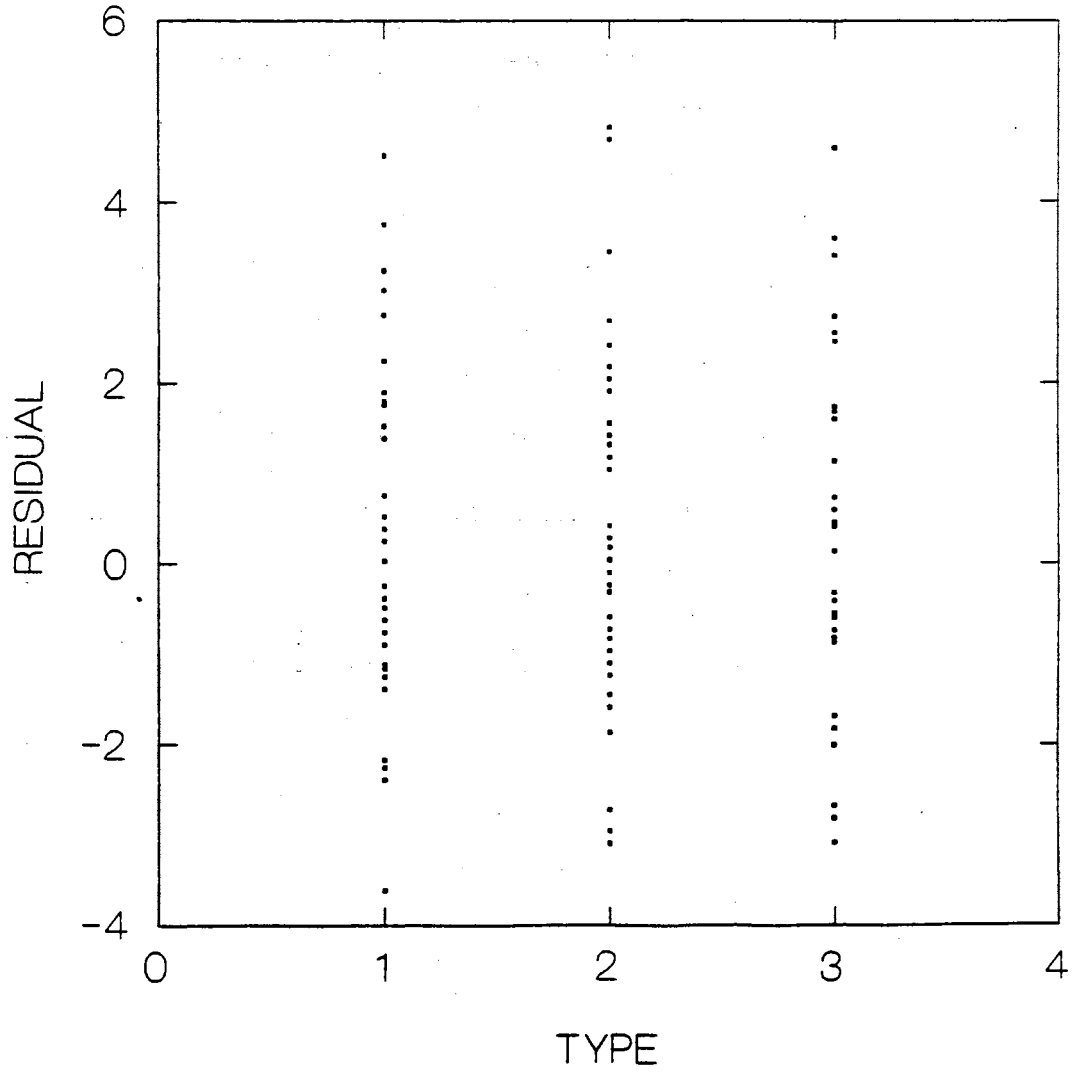


Figure 12. Residual Values Plot - Treatment Combination



Conend 1 - Continuous
2 - End

Figure 13. Residual Values Plot - Placement Groups



Type 1 - Imprecise
2 - Precise
3 - Precise w/Example

Figure 14. Residual Values Plot - Type Groups

In the analysis of a two-factor study, the test of whether or not the two factors interact is completed first. Hypothesis 1 postulated that there would be no difference in the development of declarative knowledge between the groups due to the interaction of the two elaboration control strategies as measured by the subjects' achievement on the posttest examination. It is evident from Table VI and from Figures 7 and 8 that there were differences, between treatment groups, in adjusted mean posttest examination scores.

The results of the ANCOVA model stated above are presented in Table IX. The results indicate a significant interaction effect between elaboration type and elaboration placement on the development of declarative knowledge ($F(2,120) = 2.446$, $p < .091$) resulting in Hypothesis 1 being rejected.

TABLE IX

ANCOVA FOR DECLARATIVE KNOWLEDGE

Source	SS	df	MS	F	p-value
PreMC	3270.833	1	3270.833	910.120	.000
A (Placement)	4.018	1	4.018	1.118	.292
B (Type)	19.949	2	9.975	2.775	.066
AB	17.581	2	8.790	2.446	.091
Error	431.262	120	3.594		
Total	3743.643	126		$R=.940$	$R^2=.884$

Discussion. Figures 7 and 8, previously presented, suggest that the interactions are important, due to the differences in the adjusted mean posttest scores being only minimal between types of elaborations when the elaborations are placed continuously in the expert systems. The differences in the adjusted mean posttest scores is much larger when the elaborations are placed at the end of the expert system sessions. These interactions appear to hide the difference between the continuous placement and the end placement. When interactions are considered important, the main effects of the individual factors should not be discussed in terms of factor level means (Neter, et al., 1990, 687).

One approach to attempt to better understand important interactions is to test hypotheses pertaining to the simple main effects (Kirk, 1982, 365). Hypotheses 2 and 3, as stated previously were concerned with tests of main effects for the two treatments. Due to the finding of important interactions, those hypotheses were not tested as stated, but were restated as tests of the simple main effects.

Hypothesis 2

Hypothesis 2 pertained to the effects of the different placement of the elaborations in the ES designs. The hypotheses to test the simple main effects for the placement treatment breaks Hypothesis 2 into three separate hypotheses; each of the new hypothesis deals with the difference in the

development of declarative knowledge when the two elaboration placements are compared at only one level of elaboration type.

Hypothesis 2A tests the difference between the elaboration placements when imprecise elaborations are used in the ES design. This hypothesis, stated in the null form, is:

> $H_0$2A: There will be no difference in the development of declarative knowledge between the two placement treatment groups when imprecise elaborations are embedded in the design of the ESs as measured by the subjects' achievement on a posttest examination.
>
> $H_0$2A: α_j at $b_1 = 0$ for all j

Hypothesis 2B tests the difference between the elaboration placements when precise elaborations are used in the ES design. This hypothesis, stated in the null form, is:

> $H_0$2B: There will be no difference in the development of declarative knowledge between the two placement treatment groups when precise elaborations are embedded in the design of the ESs as measured by the subjects' achievement on a posttest examination.
>
> $H_0$2B: α_j at $b_2 = 0$ for all j

Hypothesis 2C tests the difference between the elaboration placements when precise with example elaborations are used in the ES design. This hypothesis, stated in the null form, is:

$H_0$2C: There will be no difference in the development of declarative knowledge between the two placement treatment groups when precise with example elaborations are embedded in the design of the ESs as measured by the subjects' achievement on a posttest examination.

$H_0$2C: α_j at $b_3 = 0$ for all j

Hypothesis 3

Hypothesis 3 pertained to the effects of the different types of elaborations in the ES designs. The hypotheses to test the simple main effects for the types treatment breaks Hypothesis 3 into two separate hypotheses; each of the new hypothesis deals with the difference in the development of declarative knowledge when the three elaboration types are compared at only one level of elaboration placement.

Hypothesis 3A tests the difference between the elaboration types when continuous elaborations are used in the ES design. This hypothesis, stated in the null form, is:

$H_0$3A: There will be no difference in the development of declarative knowledge between the three type treatment groups when continuous elaborations are embedded in the design of the ESs as measured by the subjects' achievement on a posttest examination.

$H_0$3A: β_k at $a_1 = 0$ for all k

Hypothesis 3B tests the difference between the elaboration types

when end elaborations are used in the ES design. This hypothesis, stated in the null form, is:

> $H_0$3B: There will be no difference in the development of declarative knowledge between the three type treatment groups when end elaborations are embedded in the design of the ESs as measured by the subjects' achievement on a posttest examination.
>
> $H_0$3B: β_k at $a_2 = 0$ for all k

Discussion. When testing simple main effects, a significant F ratio means that the interaction effect is significantly different or the main effect is significantly different, or both.

The results of the simple main effects analysis are presented in Table X. Two of the simple main effects have a significant F ratio. The two hypotheses that are rejected based on these significant F ratios are Hypothesis 2C: α_j at $b_3 = 0$ for all j; ($F(1,120) = 4.105$, $p < .045$) and Hypothesis 3B: β_k at $a_2 = 0$ for all k; ($F(1,120) = 4.992$, $p < .030$). Hypotheses 2A, 2B, and 3A were not rejected.

The significance of Hypothesis 2C can be interpreted as a significant interaction of elaboration placement with the precise with example elaboration type, or a significant elaboration placement effect, or both. From further analysis of Figures 7 and 8 and Table VI, the difference between the two elaboration placements at the precise with example elaboration type is quite larger than the differences between the elaboration

TABLE X

ANCOVA FOR SIMPLE MAIN EFFECTS

Source	SS	df	MS	F	p-value
PreMC	3270.833	1	3270.833	910.120	.000
A (Placement)	4.018	1	4.018	1.118	.292
B (Type)	19.949	2	9.975	2.775	.066
AB	17.581	2	8.790	2.446	.091
A at b_1	4.131	1	4.131	1.149	.286
A at b_2	2.761	1	2.761	.768	.382
A at b_3	14.752	1	14.752	4.105	.045
B at a_1	1.082	2	.504	.140	.700
B at a_2	35.879	2	17.940	4.992	.030
Error	431.262	120	3.594		
Total	3743.643	126		$R=.940$	$R^2=.884$

placements at the other two elaboration types. Also, in looking further at Figure 9 and Table VII, the difference between the elaboration placements is quite large. These observations in conjunction with the results of the simple main effects analysis shown in Table X, appear to suggest that both the interaction of the elaboration placement with the precise with example elaboration type and the elaboration placement effect are significant. That the significance of the elaboration placement effect did not appear on the ANCOVA shown in Table IX was probably due to the interaction effect.

The significance of Hypothesis 3B can be interpreted as a significant interaction of elaboration type with the end placement of the elaboration, or

a significant elaboration type effect, or both. Again further analysis of Figures 7 and 8 and of Table VI reveals the possibility of both a significant interaction effect between elaboration type and end placement and a significant elaboration type effect. The differences between the three elaboration type adjusted posttest scores are noticeably different when the end placement of the elaboration is used. However, from Figure 10 and Table VIII, the elaboration types appear to be different, especially the precise with example elaboration type. This noticeable difference of the precise with example elaboration type is probably the reason for the overall type significance in the ANCOVA form Table IX.

Summary - Declarative Knowledge

The development of declarative knowledge was originally to be tested based on three hypotheses about the effects of elaboration placements, elaboration types, and the interaction of the two when used in designing ESs. The first hypothesis tested was based on the interaction effect of the two elaborations. This hypothesis was rejected based on the significance of the interactions in the analysis. Once the interactions were found to be important, the interpretation of the main effects had to be qualified and new hypotheses had to be postulated.

To better understand the interaction, hypotheses were postulated and tested on the simple main effects. Five hypotheses were stated based on

the interactions of the two levels of the placement elaborations at the three levels of the elaboration types and the interactions of the three levels of the elaboration types at the two levels of the placement elaborations. The analysis of these five hypotheses resulted in two of the hypotheses being found significant.

The hypothesis dealing with the interaction of the placement elaborations at the precise with example type of elaboration was significant, as was the hypothesis dealing with the interaction of the elaboration types at the end placement. The effects of these significant simple main effects were discussed in the context of the previous findings.

Tests of Hypotheses - Procedural Knowledge

Descriptive Statistics

Prior to testing the hypotheses generated in Chapter III, descriptive statistics were computed and plots of the raw data were completed. Data means and plots of the residuals versus the estimated values were examined for the combination treatment groups and for each set of groups (elaboration type and elaboration placement) within the combination.

Aptness of The Model

Treatment Combinations. The data means and standard deviations were computed for the preevaluation scores and for the postevaluation

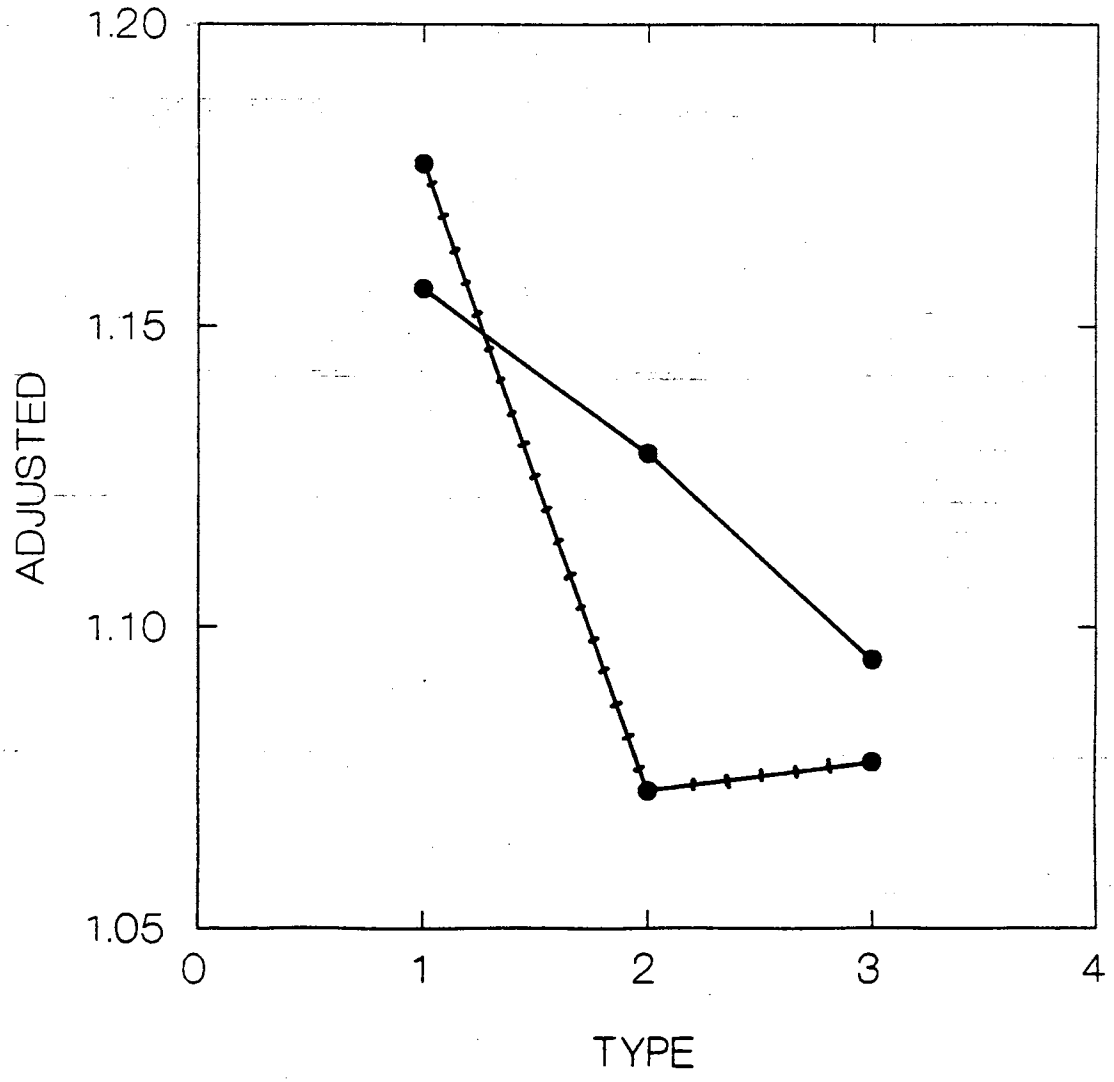
scores adjusted for the covariate for the six treatment combinations (Table XI). It is evident from Table XI that there only very minor differences, between treatment groups, in adjusted mean postevaluation scores. The interesting item is that all scores decreased between pre- and postevaluations.

TABLE XI

MEAN PREEVALUATION AND ADJUSTED MEAN POSTEVALUATION SCORES BY ESs

Treatment Group	Mean Preevaluation (std. dev.)	Adjusted Mean Postevaluation (std. dev.)
Imprecise x Continuous	1.25 (.454)	1.18 (.127)
Precise x Continuous	1.27 (.453)	1.16 (.127)
Precise with Example x Continuous	1.31 (.524)	1.07 (.127)
Imprecise x End	1.27 (.402)	1.13 (.126)
Precise x End	1.33 (.804)	1.08 (.126)
Precise with Example x End	1.35 (.509)	1.10 (.126)

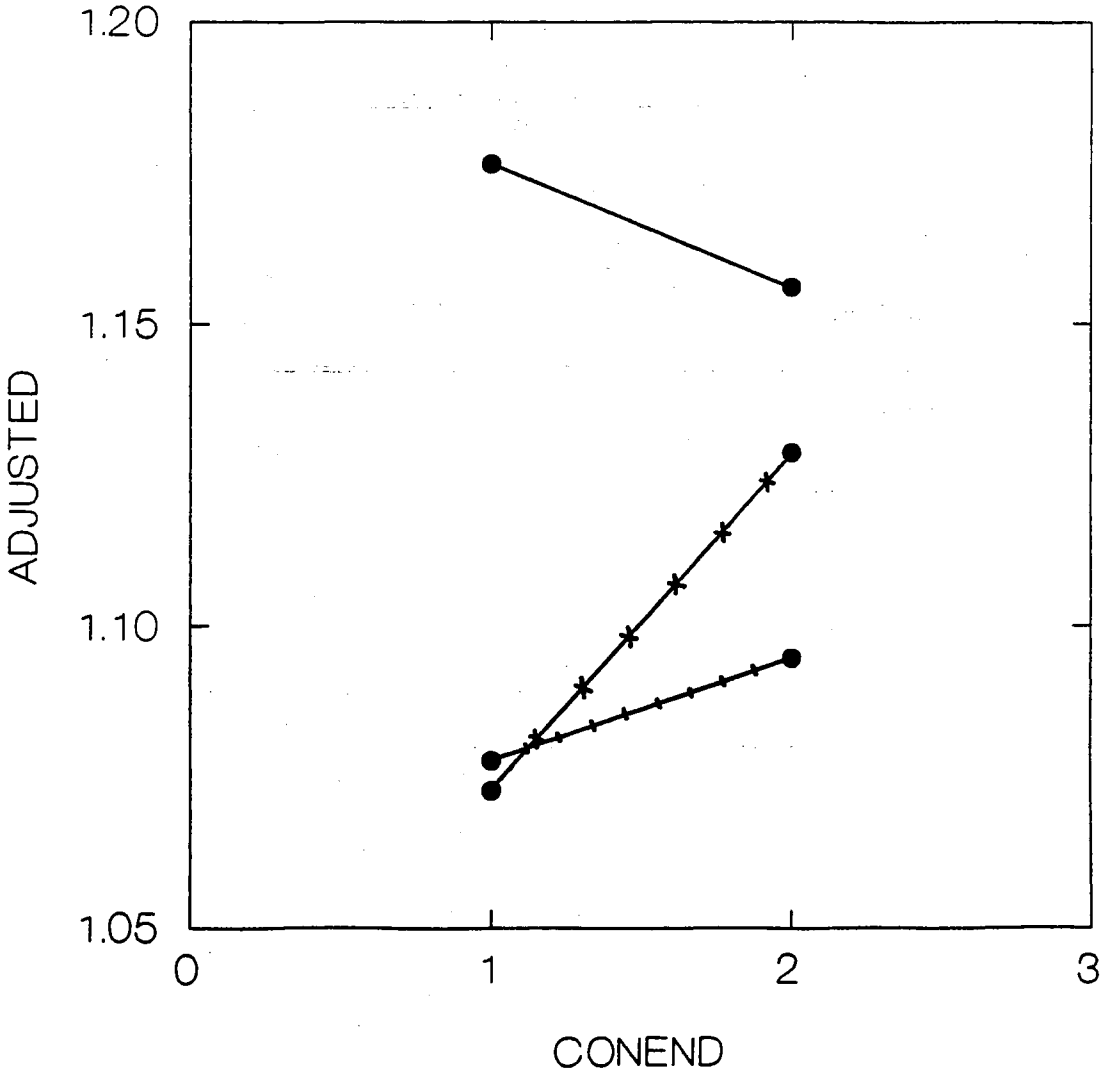
The plots of the adjusted mean postevaluation scores are shown in Figure 15 and Figure 16. Figure 15 shows the plot of the elaboration placement curves and Figure 16 shows the plot of the elaboration type curves.



Type 1 - Imprecise
2 - Precise
3 - Precise w/Example

- Continuous
- End

Figure 15. Plots of Adjusted Means - Placement Curves



Conend 1 - Continuous
2 - End

- Imprecise
- Precise
- Precise w/Example

Figure 16. Plots of Adjusted Means - Type Curves

Elaboration Placement. The data means and standard deviations were computed for the preevaluation scores and for the adjusted postevaluation scores for the two elaboration placement groups (Table XII).

TABLE XII

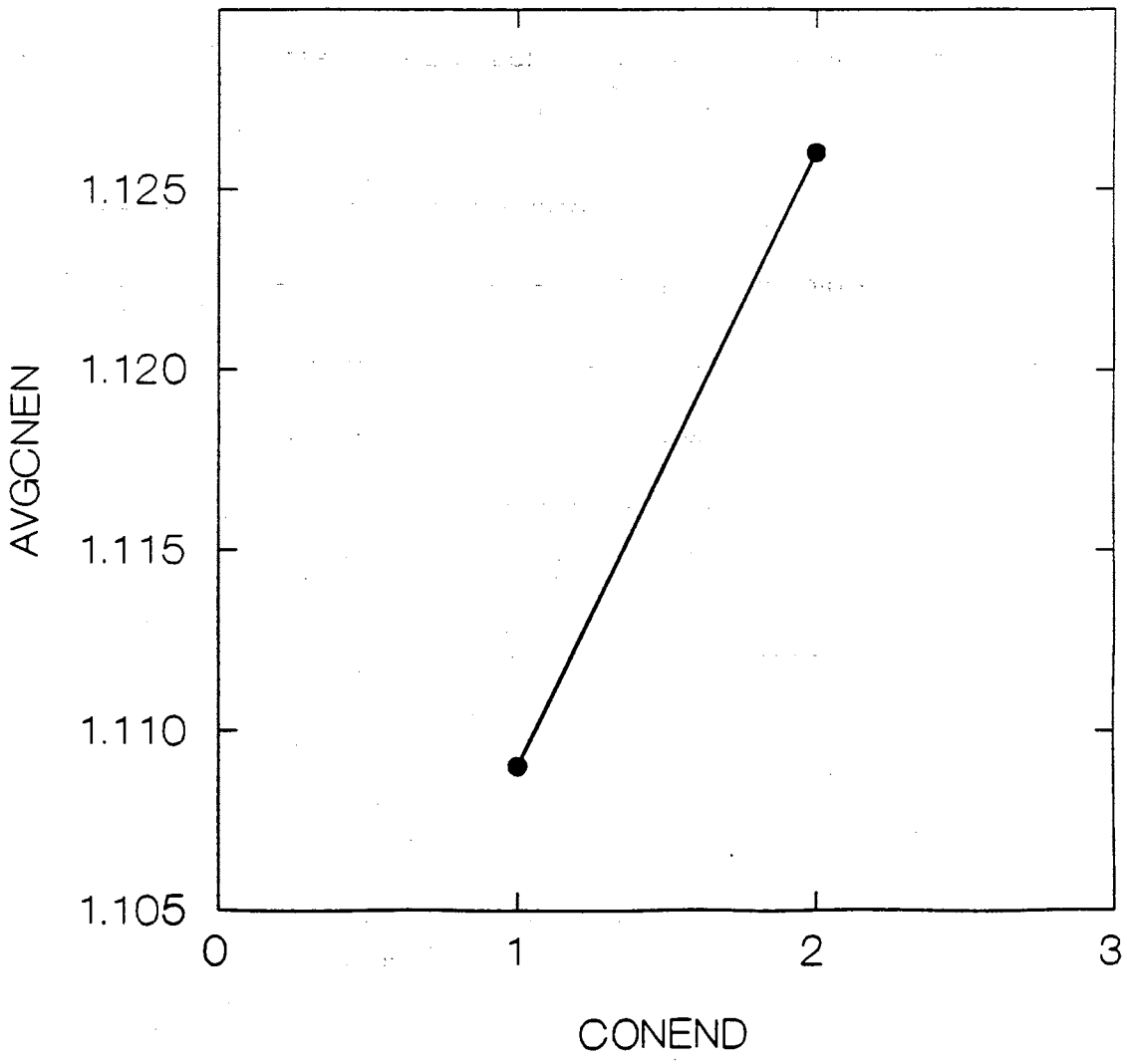
MEAN PREEVALUATION AND ADJUSTED MEAN POSTEVALUATION BY PLACEMENT

Elaboration Placement	Mean Preevaluation (std. dev)	Adjusted Mean Postevaluation (std. dev.)
Continuous	1.278 (0.471)	1.109 (0.072)
End	1.317 (0.588)	1.126 (0.071)

It is evident from Table XII that are only minor differences, between the elaboration placement groups, in adjusted mean postevaluation scores. Again the only item of interest is that all scores decreased between the pre- and postevaluations. Figure 17 displays the plot of the adjusted mean postevaluation scores for the two elaboration placements.

Elaboration Type. The data means and standard deviations were computed for the preevaluation scores and for the adjusted postevaluation scores for the three elaboration type groups and are presented in Table XIII.

It is evident from Table XIII that there are only minor differences, between the elaboration type groups, in adjusted mean postevaluation scores. As discussed previously, the means do show a decrease between



Conend 1 - Continuous
2 - End

Figure 17. Adjusted Mean Postevaluation Scores - Placement Groups

the pre- and postevaluation scores. The plots of the adjusted mean postevaluation scores for the three elaboration type groups are shown in Figure 18. The plots verify the observations made in reference to Table XIII of only minor differences between the type groups.

TABLE XIII

MEAN PREEVALUATION AND ADJUSTED MEAN POSTEVALUATION SCORES BY TYPE

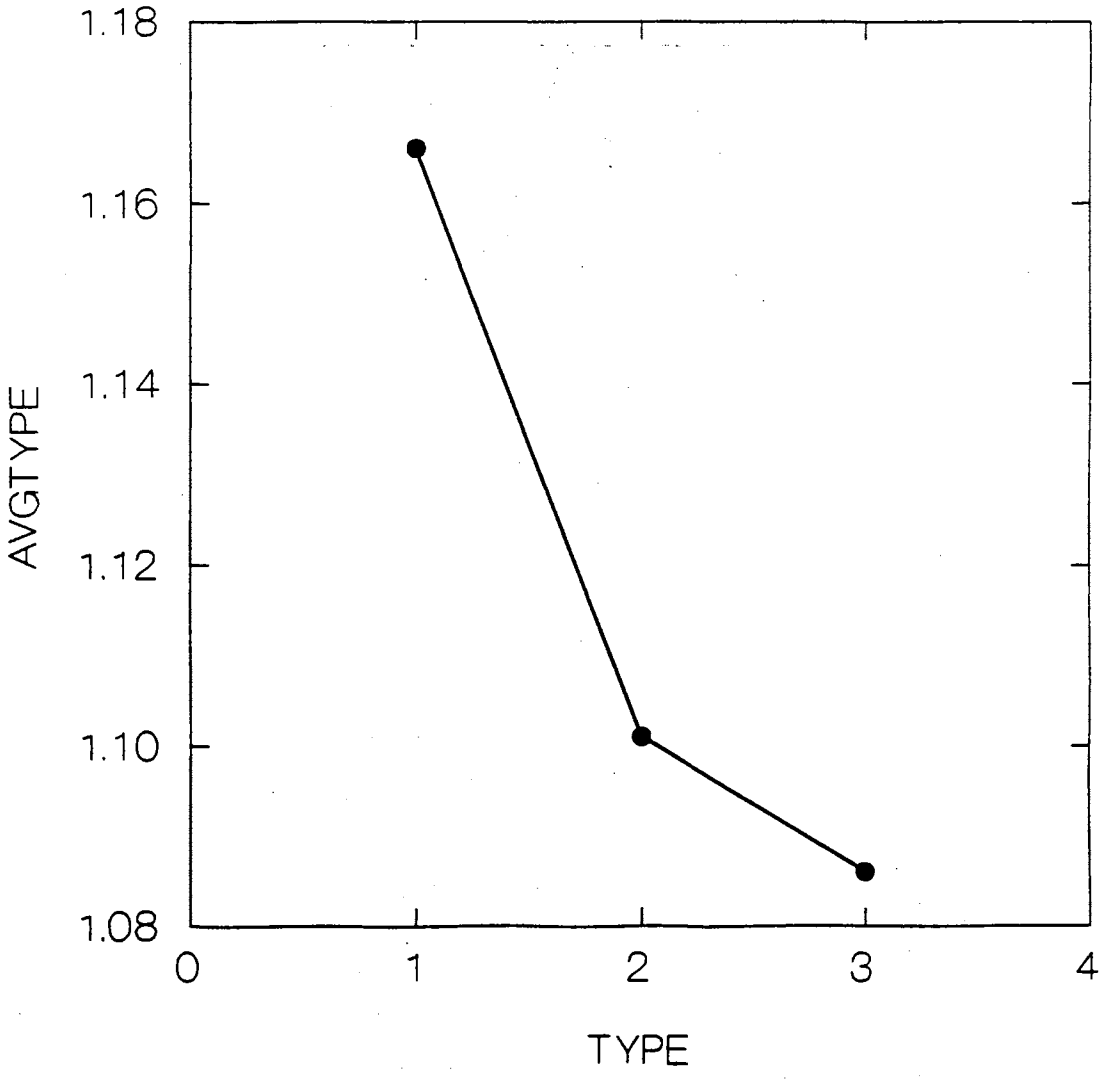
Elaboration Type	Mean Preevaluation (std. dev.)	Adjusted Mean Postevaluation (std. dev.)
Imprecise	1.262 (0.424)	1.166 (0.089)
Precise	1.304 (0.645)	1.101 (0.088)
Precise with Example	1.327 (0.511)	1.086 (0.088)

Assumptions of the Model. The ANCOVA model is reasonably robust against some types of departures from the model's basic assumptions, however, the assumptions need to be examined to detect any serious departures that may cause problems (Neter, et al., 1990, 607).

The ANCOVA model assumes that:

1. The probability distributions are normally distributed,
2. The probability distributions have the same variance, and
3. the observations are random and independent. (509)

The normality of the error terms was studied using a normal probability plot of the residuals. The residuals for all treatments were



Type 1 - Imprecise
2 - Precise
3 - Precise w/Example

Figure 18. Adjusted Mean Postevaluation Scores - Type Groups

combined into one group, since no major differences were found in the error variances for the individual treatments. The normal probability plot in Figure 19 shows that the error terms follow a reasonably straight line. This indicates that there are most probably no serious departures from normality for the error terms.

The constant variance for the error terms was studied from the plots of the residual values against the fitted values. These plots were completed using the six combinations of the treatments and they separately for each of the two treatments. Each of the residual plots show that the residuals are scattered equally around 0 for the overall experiment and for each factor level within the experiment. This indicates that the error variance is constant for the data collected. These plots are presented as Figures 20, 21, and 22.

The data in this experiment are not time sequenced, therefore, a test for serial correlation was not necessary and was not performed.

In view of the assumptions of the ANCOVA model not being violated, it appears reasonable to continue with the tests of the hypotheses.

Main Analysis

Hypothesis 4

The significance of the differences and the factor effects were tested

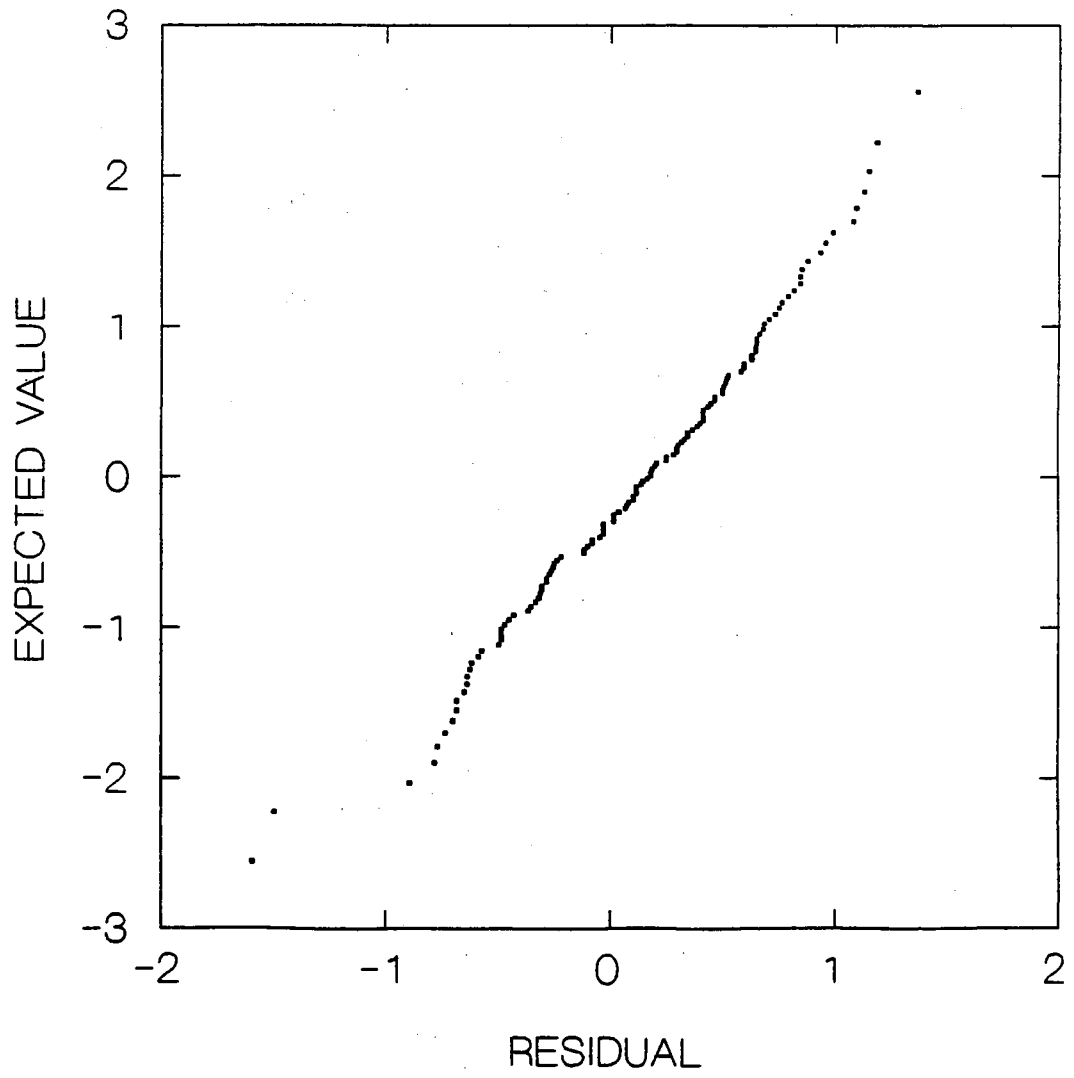


Figure 19. Normal Probability Plot of Residuals

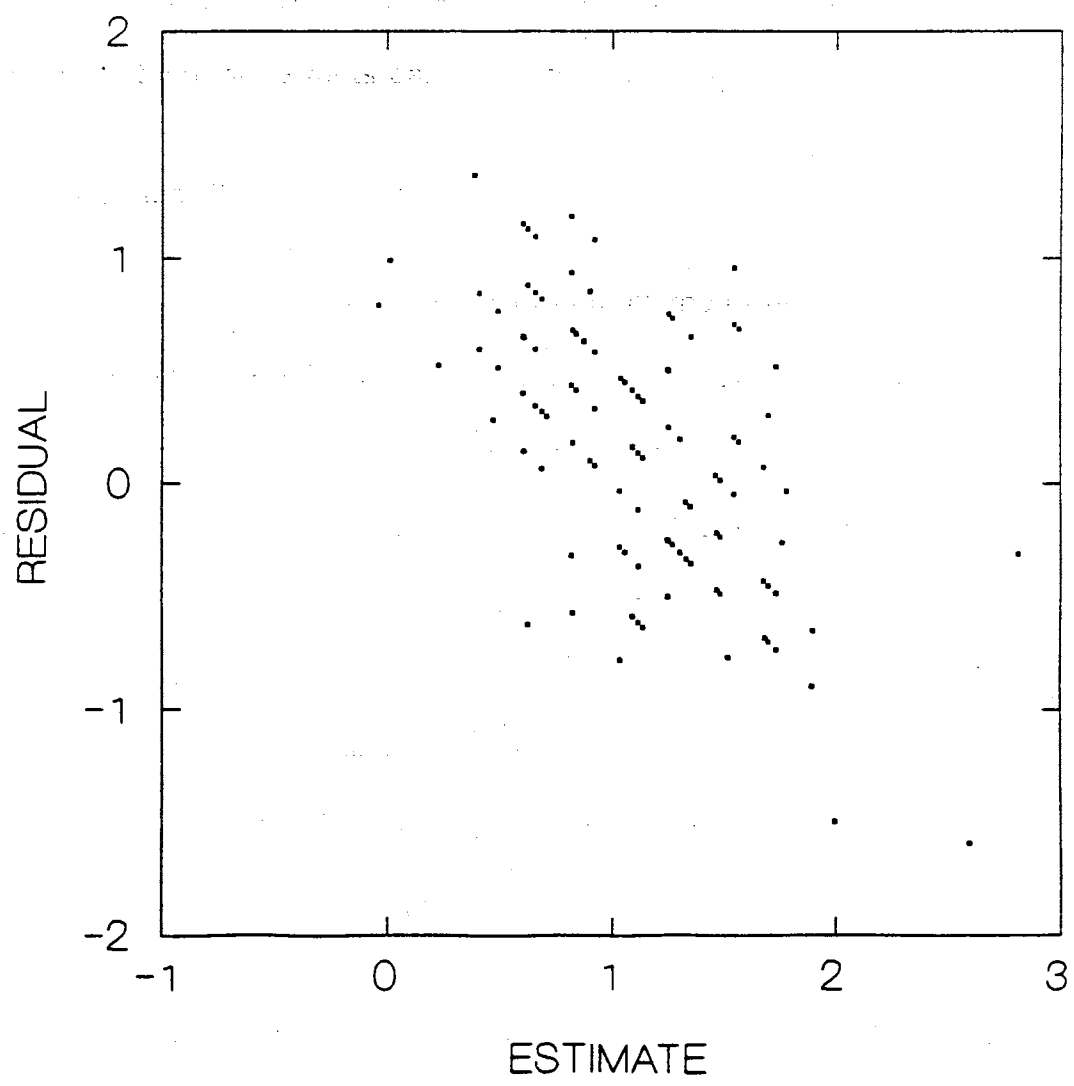
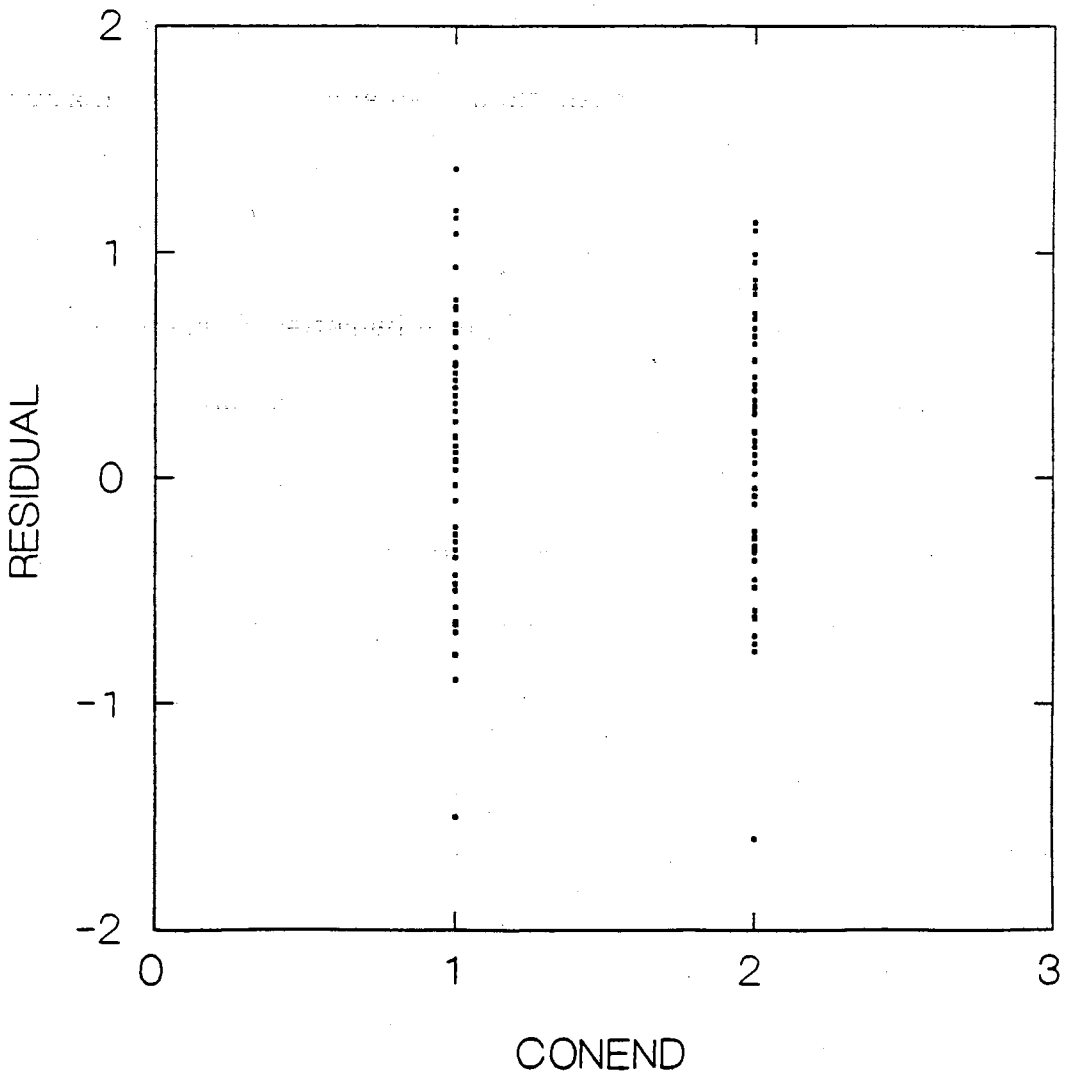
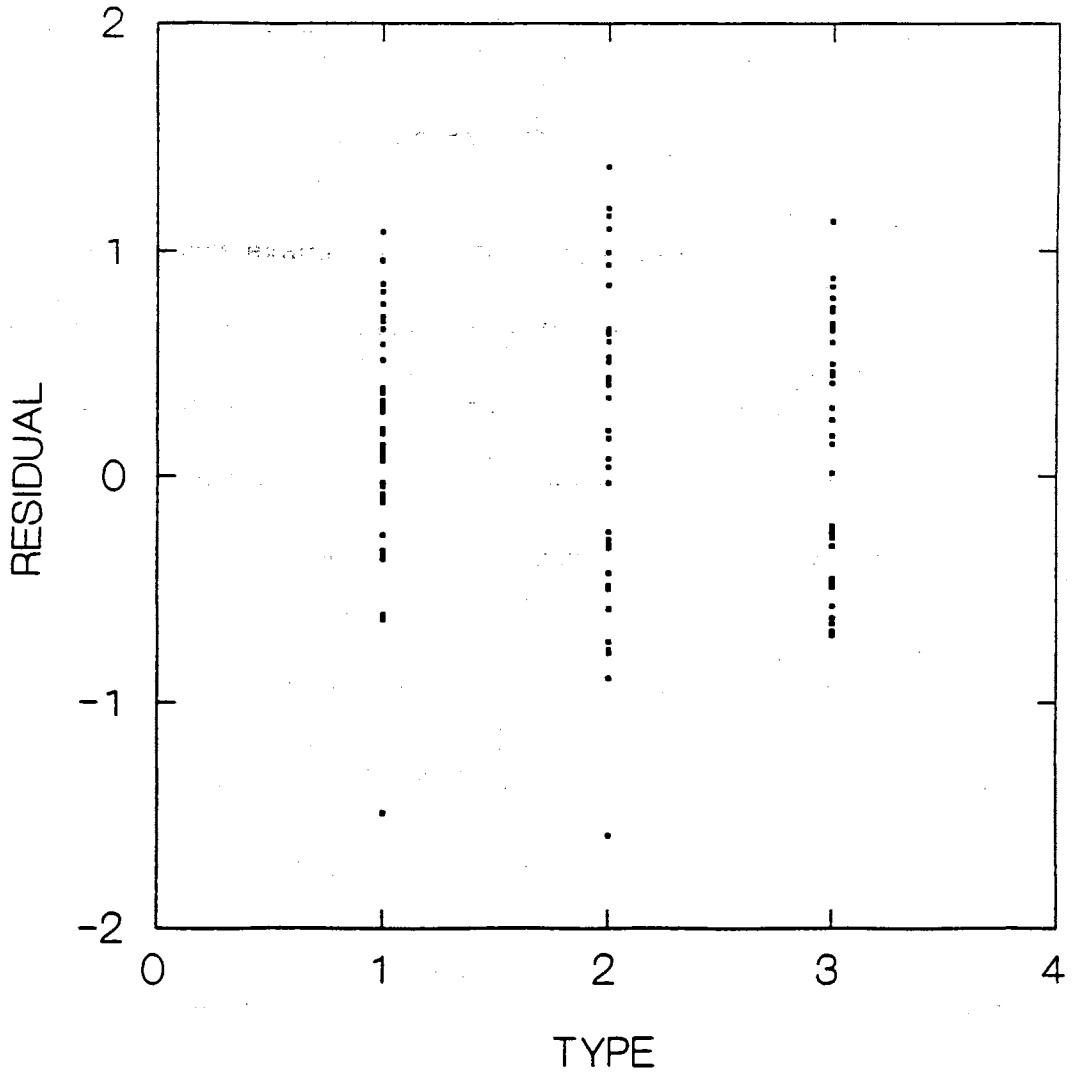


Figure 20. Residual Values Plot - Treatment Combination



Conend 1 - Continuous
2 - End

Figure 21. Residual Values Plot - Placement Groups



Type 1 - Imprecise
2 - Precise
3 - Precise w/Example

Figure 22. Residual Values Plot - Type Groups

using the following ANCOVA model:

$$Y_{adjijk} = \mu + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \epsilon_{i(jk)}$$

In the analysis of a two-factor study, the test of whether or not the two factors interact is completed first. Hypothesis 4 postulated that there would be no difference in the development of procedural knowledge between the groups due to the interaction of the two elaboration control strategies as measured by the subjects' accuracy on the evaluations of the posttest internal control cases. It is evident from Table XII and from Figures 15 and 16 that there were only minor differences, between treatment groups, in adjusted mean postevaluation scores.

The results of the ANCOVA model stated above are presented in Table XIV. No significant effects for the interaction variable were found resulting in Hypothesis 4 not being rejected.

TABLE XIV

ANCOVA FOR PROCEDURAL KNOWLEDGE

Source	SS	df	MS	F	p-value
PreEval	183.430	1	183.430	534.039	.000
A (Placement)	0.010	1	0.010	0.028	.868
B (Type)	0.153	2	0.077	0.223	.800
AB	0.031	2	0.015	0.045	.956
Error	41.217	120	0.343		
Total	224.841	126		$R = .904$	$R^2 = .817$

Discussion. Figures 15 and 16, previously presented, all point to the conclusion of no interaction effect for the elaboration placement variables and the elaboration type variables. With no significant interactions, the analysis of the main effects can be discussed.

Hypothesis 5

Hypothesis 5 pertained to the effects of the different placement of the elaborations in the ES designs. The hypothesis postulated that there would be no difference in the development of procedural knowledge due to the different placement of elaborations in the ES designs. The subjects' accuracy on the evaluations of the posttest internal control cases was used as the measurement device.

The ANCOVA model in Table XIV shows no significance for the placement of elaborations in the ES design. Based on this, Hypothesis 5 cannot be rejected.

Discussion. Figure 17 and Table XII both provided preliminary indication that there would be no significance for the placement of elaborations on the development of procedural knowledge. This preliminary observation was correct as the analysis in Table XIV indicates.

Hypothesis 6

Hypothesis 6 pertained to the effects of the different types of

elaborations in the ES designs. The hypothesis postulated that there would be no difference in the development of procedural knowledge due to the different types of elaborations in the ES designs. The subjects' accuracy on the evaluations of the posttest internal control cases was used as the measurement device.

The ANCOVA model in Table XIV shows no significance for the types of elaborations in the ES design. Based on this, Hypothesis 6 cannot be rejected.

Discussion. Figure 18 and Table XIII both provided preliminary indication that there would be no significance for the types of elaborations on the development of procedural knowledge. This preliminary observation was correct as the analysis in Table XIV indicates.

Summary - Procedural Knowledge

The development of procedural knowledge was originally to be tested based on three hypotheses about the effects of elaboration placements, elaboration types, and the interaction of the two when used in designing ESs. The first hypothesis tested was based on the interaction effect of the two elaborations. This hypothesis was not rejected, resulting in the tests of the main effects hypotheses.

The two main effects hypotheses based on the placement of the elaborations and the type of elaborations were then tested. Neither of the

hypotheses could be rejected. Thus, the development of procedural knowledge was not significantly affected by the placement nor the type of elaborations used in designing the ESs.

Summary and Results for All Hypotheses

The analysis examined the effect on the development of knowledge when using ESs that were designed using elaborations. Two types of knowledge were examined; declarative and procedural. The analysis examined each of these dependent variables separately. To better focus on the overall results, a summary of the results of the tests of the hypotheses for each dependent variable will be discussed.

The first set of hypotheses dealt with the effect of elaboration usage on the development of declarative knowledge. Three hypotheses were postulated based on the two different elaborations used in designing the ESs and on the interactions between the two elaborations. The dependent variable was an accuracy measurement based on the subjects' performance on an examination which tested on factual knowledge about internal control. The dependent variable was adjusted based on the subjects' knowledge of internal controls prior to the experiment. This prior knowledge was measured with a pre-examination on factual information about internal control. The results of the tests of the hypotheses postulated on declarative knowledge are presented in Table XV.

TABLE XV

SUMMARY OF TESTS OF HYPOTHESES ON DECLARATIVE KNOWLEDGE

	Hypotheses	Findings	p-value
$H_0$1:	There will be no difference in the development of declarative knowledge between the treatment groups due to the different types of elaborations interacting with the different placement of the elaborations in the ESs.	**REJECTED** A significant interaction effect was found. Further tests on simple main effects needed.	.091
$H_0$2:	There will be no difference in the development of declarative knowledge between the treatment groups due to the different placements of elaborations embedded in the design of the ESs.	**NOT TESTED** Due to interaction, hypotheses on the simple main effects were tested.	N/A
$H_0$3:	There will be no difference in the development of declarative knowledge between the treatment groups due to the different types of elaborations embedded in the design of the ESs.	**NOT TESTED** Due to interaction, hypotheses on the simple main effects were tested.	N/A

Due to the finding of interaction effects between the elaboration placements and the elaboration types, Hypotheses 2 and 3 could not be tested. To better understand the interactions, hypotheses dealing with the simple main effects were postulated. The results of the tests of the hypotheses postulated on the simple main effects are presented in Table XVI.

Two of the simple main effects hypotheses were rejected based on the findings. The first of these two hypotheses, that were rejected, tested the significance of the two elaboration placements at the precise with example type of elaboration. Further analysis of the descriptive statistics

TABLE XVI

SUMMARY OF TESTS OF HYPOTHESES ON SIMPLE MAIN EFFECTS

Hypotheses	Findings	p-value
H_o2A: There will be no difference in the development of declarative knowledge between the two placement treatment groups when imprecise elaborations are embedded in the design of the ESs.	**NOT REJECTED** There was not a significant interaction between the imprecise elaborations and the elaboration placements.	.286
H_o2B: There will be no difference in the development of declarative knowledge between the two placement treatment groups when precise elaborations are embedded in the design of the ESs.	**NOT REJECTED** There was not a significant interaction between the precise elaborations and the elaboration placements.	.382
H_o2C: There will be no difference in the development of declarative knowledge between the two placement treatment groups when precise with example elaborations are embedded in the design of the ESs.	**REJECTED** There was a significant interaction between the precise with example elaborations and the elaboration placements, or a significant elaboration placement effect, or both.	.045
H_o3A: There will be no difference in the development of declarative knowledge between the three type treatment groups when continuous elaborations are embedded in the design of the ESs.	**NOT REJECTED** There was not a significant interaction between the continuous elaborations and the elaboration types.	.700
H_o3B: There will be no difference in the development of declarative knowledge between the three type treatment groups when end elaborations are embedded in the design of the ESs.	**REJECTED** There was a significant interaction between the end elaborations and the elaboration types, or a significant elaboration type effect, or both.	.030

revealed that the placement elaboration groups were quite different when the elaboration type was precise with example. Also, the continuous elaboration groups mean scores were more consistent, while the end elaboration groups were quite scattered. The second of the two hypotheses, that were rejected, tested the significance of the three elaboration types when the elaborations were placed at the end. Further analysis of the descriptive statistics revealed that the elaboration type groups mean scores were quite different when the elaborations were placed at the end, while they were close when the elaborations were continuous.

The analysis of the simple main effects helps explain the significant interaction found in the main analysis of Hypothesis 1. The interactions between the elaboration types and placements affected the ANCOVA results for the main effects for those two variables.

The second set of hypotheses dealt with the effect of elaboration usage on the development of procedural knowledge. The dependent variable was an accuracy measurement based on the subjects' performance on evaluations of internal control cases. The dependent variable was adjusted based on the subjects' procedural knowledge prior to the experiment. This prior knowledge was measured with evaluations of internal control cases prior to the experiment.

The results of the tests of the hypotheses postulated on procedural knowledge are presented in Table XVII. Neither elaboration type or

placement affected the development of procedural knowledge.

TABLE XVII

SUMMARY OF TESTS OF HYPOTHESES ON PROCEDURAL KNOWLEDGE

	Hypotheses	Findings	p-value
$H_0$4:	There will be no difference in the development of procedural knowledge between the treatment groups due to the different types of elaborations interacting with the different placement of the elaborations in the ESs.	**NOT REJECTED** The interaction effect was found to not be significant. Further tests on main effects were performed.	.956
$H_0$5:	There will be no difference in the development of procedural knowledge between the treatment groups due to the different placements of elaborations embedded in the design of the ESs.	**NOT REJECTED** The placement of elaborations did not affect the development of procedural knowledge.	.868
$H_0$6:	There will be no difference in the development of procedural knowledge between the treatment groups due to the different types of elaborations embedded in the design of the ESs.	**NOT REJECTED** The type of elaborations did not affect the development of procedural knowledge.	.800

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APPENDIXES

APPENDIX A

INSTRUCTIONS FOR CASES

INSTRUCTIONS GIVEN TO SUBJECTS

There are five separate scenarios to evaluate during this session.

Assume you are a staff auditor assigned the task of evaluating the payroll processing cycle. You have collected the data in the attached scenarios. You have available an expert system, called Internal Control Evaluator (ICE), to aid you in your evaluation of the data.

ICE will display a series of questions for you to answer using the data in the scenarios. All questions can and should be answered with the available data. If you make an error during the evaluation session, refer to the instruction sheet provided with your disk.

NOTE: ICE will aid you in your evaluation. You will be required to provide an evaluation of each scenario at the completion of each consultation with ICE. ICE will provide you will additional information during the consultation based on your answers to the questions.

REMEMBER: All sessions are separate situations and should be evaluated separately.

INSTRUCTIONS FOR USING EXPERT SYSTEM ATTACHED TO DISKS

1. Place disk picked up from lab assistant in drive A.
2. Turn on the computer.
3. At the A>, Type VPX.
4. Select choice #4 - Consult, then press Return twice.

NOTE: ALL SCENARIOS WILL BE GIVEN A RATING BY THE EXPERT SYSTEM. IF YOU DO NOT RECEIVE A RATING, YOU MADE A MISTAKE IN ENTERING SOME OF THE DATA AND NEED TO DO THE SCENARIO AGAIN.

TO SELECT AN ANSWER, ARROW OVER TO THE CORRECT ITEM AND PRESS THE RETURN KEY. THEN PRESS THE END KEY TO VERIFY THE SELECTION.

IF YOU SELECT THE WRONG ITEM DURING YOUR CONSULTATION, PRESS THE DELETE KEY BEFORE PRESSING THE END KEY AND THEN SELECT THE CORRECT ANSWER AND CONTINUE AS INSTRUCTED.

ORAL INSTRUCTIONS GIVEN TO SUBJECTS

READ TO STUDENTS PRIOR TO STARTING

This is an individual assignment, stay at your computer and do not discuss your evaluations with your neighbor.

You have five separate scenarios. You will do each one individually. Once you have completed each scenario and have been given an evaluation by the expert system, the expert system will restart and be ready for the next scenario. The scenarios do not depend on each other, they are all individual scenarios.

Read the instructions on the disk sleeve carefully. Those instructions explain how to select an answer for the expert system and how to delete a selection if you make an error. If you do not delete a selection prior to the next question being asked, you will have to quit that one session and start only that one over again. This does not affect any other scenarios, which you may have already completed. To quit in the middle of a session due to a mistake, you type /Q.

All scenarios will be given an evaluation by the expert system. If you do not receive one of the ratings at the bottom of the scenarios (i.e., Weak, Very Weak, Strong, Very Strong, Moderately Weak, Moderately Strong), you have made an error in entering the data and need to redo that one scenario. To help avoid making mistakes, you may want to read through a scenario entirely prior to starting the evaluation for that scenario.

Be sure and circle one of the ratings for each scenario and be sure to write down the major weakness, if any, for that scenario. The expert system will provide you with additional data that may help you determine the major weaknesses. Read the information carefully and thoughtfully. Your evaluation does not have to agree with the evaluation provided by the expert system.

Remember, this is an individual assignment. Keep your eyes on your computer and do not discuss the scenarios with your neighbor. Also, read the instructions carefully.

Any questions?

Okay, write your name on the top of the scenario packet and begin. When you have completed all five scenarios, bring your disk and the scenarios to me so that I can check your name off of the my list. You have 1 hour.

APPENDIX B

BACKGROUND INFORMATION ON COMPANY

Background Information

Assume you are an auditor and have been assigned the task of evaluating the payroll internal control of a company. You have been given a written discription of the payroll internal control by one of your assistants.

The company is a manufacturing operation with a personnel department, a timekeeping department, a payroll department, a cashier, a cost clerk, a general ledger clerk, and an internal auditor.

Evaluate each of the scenarios separately. Each one is to be considered as a different discription of the company's internal control over payroll.

APPENDIX C

DEMOGRAPHIC QUESTIONNAIRE

Questionnaire #1

Name _____

1. What is your classification?

   Freshman Sophomore Junior Senior MBA

2. What is your major?

3. What is your gender?

   Male Female

4. What is your age? ____

APPENDIX D

PRETEST EXAMINATION

Acctg 3603 Name _____

___ 1. The purpose of segregating the duties of hiring personnel and distributing payroll checks is to separate the
a. Operational responsibility from the recordkeeping responsibility.
b. Responsibilities of recording a transaction at its origin from the ultimate posting in the general ledger.
c. Authorization of transactions from the custody of related assets.
d. Human resources function from the controllership function.

___ 2. A factory foreman at Jones Corporation discharged an hourly worker but did not notify the payroll department. The foreman then forged the worker's signature on job cards and time cards and, when giving out the checks, diverted the payroll checks drawn for the discharged worker to his own use. The most effective procedure for preventing this activity is to
a. Require written authorization for all employees added to or removed from the payroll.
b. Have a paymaster who has no other payroll responsibility distribute the payroll checks.
c. Have someone other than persons who prepare or distribute the payroll obtain custody of unclaimed payroll checks.
d. From time to time, rotate persons distributing the payroll.

___ 3. Which of the following ia an effective internal control used to prove that production department employees are properly validating payroll time cards at a time clock??
a. Time cards should be carefully inspected by those persons who distribute pay checks to the employees.
b. One person should be responsible for maintaining records of employee time for which salary payment is not to made.
c. Daily reports showing time charged to jobs should be approved by the foreman and compared to the total hours worked on the employee time cards.
d. Internal auditors should make observations of distribution of paychecks on a surprise basis.

___ 4. An auditor would consider internal control over a client's payroll procedures to be ineffective if the payroll department supervisor is responsible for
a. Hiring subordinate payroll department employees.
b. Approving the employee time cards.
c. Updating employee earnings records.
d. Applying pay rates to time tickets.

___ 5. An auditor would consider internal control over a client's job costing to be ineffective if the cost clerk prepared the labor summary and also is responsible for
a. posting the job cards to the cost records.
b. reconciled the employee job cards and time cards daily.
c. filing the costed time cards into job files.
d. forwarding the labor summary to the general ledger clerk for reconciliation with the payroll register.

___ 6. Proper segregation of duties could include all but:
a. job cards and time cards being reconciled by the timekeeping clerk.
b. paychecks and the payroll register being prepared by the payroll clerk.
c. labor summary and payroll register being reconciled by the general ledger clerk.
d. payroll register and labor summary being prepared by the payroll clerk.

___ 7. If the cashier is responsible for signing employee paychecks, he/she should not:
a. reconcile the payroll register and the pay checks.
b. post the payroll entries into the general ledger.
c. distribute the paychecks.
d. maintain unclaimed paychecks.

___ 8. Proper internal control over the payroll check distribution would require which of the following?
a. Temoporary retention of unclaimed payroll checks by the payroll accounting department.
b. Proper identification provided by the employee at receipt of the paycheck.
c. Approval of employee time records by the payroll accounting department.
d. All of the above.

___ 9. The payroll register is independently verified with all of these but the:
a. paychecks.
b. labor summary.
c. bank statement.
d. costed time cards.

___10. Appropriate segregation of duties requires that the individual preparing the payroll bank account reconciliation should not have any responsibilities for:
a. preparing payroll.
b. paying the payroll to the employees.
c. recording the payroll.
d. all of the above.

APPENDIX E

PRETEST CASES

SCENARIO 1

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record their daily starting and stopping times on timecards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on jobcards which the supervisor approves after making any necessary corrections. At the end of each work week, the timecards and the jobcards are reconciled by the timekeeping clerk.

The payroll register and the paychecks are prepared using the timecards and the current pay rate by the payroll clerk, who then posts this information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions of paychecks are done.

The cost clerk prepares the labor distribution summary using data from the jobcards. The payroll register and the labor distribution summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company's bank account is reconciled by the internal auditor.

Your evaluation of the payroll internal control is:

Very Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

WHAT IS THE PRIMARY CONTROL WEAKNESS, IF ANY?

SCENARIO 2

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record their daily starting and stopping times on timecards using a timeclock. The supervisor approves the time cards and makes any necessary corrections. The employees record the time on each job on jobcards which the supervisor approves after making any necessary corrections. At the end of each work week, the timecards and the jobcards are reconciled by the timekeeping clerk.

The payroll register and the paychecks are prepared using the timecards and the current pay rate by the payroll clerk, who then posts this information to the individual earnings records. The payroll calculations are not verified.

The paychecks are not reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions of paychecks are done.

The cost clerk prepares the labor distribution summary using data from the jobcards. The payroll register and the labor distribution summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company's bank account is reconciled by the internal auditor.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

WHAT IS THE PRIMARY CONTROL WEAKNESS, IF ANY?

SCENARIO 3

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record their daily starting and stopping times on timecards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on jobcards which the supervisor approves after making any necessary corrections. At the end of each work week, the timecards and the jobcards are reconciled by the payroll clerk.

The payroll register and the paychecks are prepared using the timecards and the current pay rate by the payroll clerk, who then posts this information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions of paychecks are not done.

The cost clerk prepares the labor distribution summary using data from the jobcards. The payroll register and the labor distribution summary are not reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company's imprest payroll bank account is reconciled by the internal auditor.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

WHAT IS THE PRIMARY CONTROL WEAKNESS, IF ANY?

SCENARIO 4

Factory employees are hired by the personnel who determines the appropriate pay rate and sends notice of employment and the pay rate to the cashier. Changes in pay rate are authorized by the personnel. Upon termination, employees complete a form and submit it to the personnel which notifies the cashier.

Employees record their daily starting and stopping times on timecards using a timeclock. The payroll clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on jobcards which the payroll clerk approves after making any necessary corrections. At the end of each work week, the timecards and the jobcards are reconciled by the timekeeping clerk.

The payroll register and the paychecks are prepared using the timecards and the current pay rate by the cashier, who then posts this information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The payroll clerk signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the payroll clerk. A record of unclaimed payroll checks is not maintained by an independent party. Periodic surprise distributions of paychecks are done.

The cost clerk prepares the labor distribution summary using data from the jobcards. The payroll register and the labor distribution summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company's bank account is reconciled by the internal auditor.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

WHAT IS THE PRIMARY CONTROL WEAKNESS, IF ANY?

APPENDIX F

LEARNING CASES

SCENARIO A1

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The supervisor approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the timekeeping clerk.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are not verified.

The paychecks are not reconciled with the payroll register for accuracy. The payroll clerk signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the payroll clerk. A record of unclaimed payroll checks is not maintained by an independent party. Periodic surprise distributions are done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does use an imprest payroll bank account. The payroll clerk reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO A2

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by no one.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions are not done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are reconciled prior to the payroll clerk journalizing and posting the payroll information.

The company does not use an imprest payroll bank account. The internal auditor reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO A3

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The supervisor approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the timekeeping clerk.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions are not done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does use an imprest payroll bank account. The internal auditor reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO A4

Factory employees are hired by the supervisor who determines the appropriate pay rate and sends notice of employment and the pay rate to the personnel department. Changes in pay rate are authorized by the supervisor. Upon termination, employees complete a form and submit it to the supervisor which notifies the personnel department.

Employees record daily starting and stopping times on time cards using a timeclock. The personnel department approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the timekeeping approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the personnel department.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the personnel department, who then posts the information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is not maintained by an independent party. Periodic surprise distributions are done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are not reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does use an imprest payroll bank account. The internal auditor reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO A5

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the timekeeping clerk.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions are done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are reconciled prior to the cashier journalizing and posting the payroll information.

The company does not use an imprest payroll bank account. The internal auditor reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO B1

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the personnel department.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions are done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are not reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does not use an imprest payroll bank account. The internal auditor reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO B2

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the cashier. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the cashier.

Employees record daily starting and stopping times on time cards using a timeclock. The payroll clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by no one.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the cashier, who then posts the information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The personnel department signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the personnel department. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions are not done.

The payroll clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does not use an imprest payroll bank account. The internal auditor reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO B3

Factory employees are hired by the supervisor who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the supervisor. Upon termination, employees complete a form and submit it to the supervisor which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the cost clerk approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the supervisor.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions are not done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does use an imprest payroll bank account. The cashier reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO B4

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The supervisor approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the timekeeping clerk.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is not maintained by an independent party. Periodic surprise distributions are done.

The payroll clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does use an imprest payroll bank account. The internal auditor reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO B5

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by no one.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are not verified.

The paychecks are not reconciled with the payroll register for accuracy. The payroll clerk signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the payroll clerk. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions are done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does not use an imprest payroll bank account. The payroll clerk reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO C1

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the timekeeping clerk.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions are done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does use an imprest payroll bank account. The internal auditor reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO C2

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the payroll clerk approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the payroll clerk.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are verified.

The paychecks are reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is not maintained by an independent party. Periodic surprise distributions are done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does use an imprest payroll bank account. The cashier reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO C3

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the payroll clerk.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are not verified.

The paychecks are not reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions are done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are not reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does use an imprest payroll bank account. The cashier reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO C4

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the payroll clerk. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the payroll clerk.

Employees record daily starting and stopping times on time cards using a timeclock. The timekeeping clerk approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the supervisor approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the personnel department.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the payroll clerk, who then posts the information to the individual earnings records. The payroll calculations are not verified.

The paychecks are not reconciled with the payroll register for accuracy. The cashier signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the cashier. A record of unclaimed payroll checks is not maintained by an independent party. Periodic surprise distributions are done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are not reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does use an imprest payroll bank account. The payroll clerk reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

SCENARIO C5

Factory employees are hired by the personnel department who determines the appropriate pay rate and sends notice of employment and the pay rate to the cashier. Changes in pay rate are authorized by the personnel department. Upon termination, employees complete a form and submit it to the personnel department which notifies the cashier.

Employees record daily starting and stopping times on time cards using a timeclock. The personnel department approves the time cards and makes any necessary corrections. The employees record the time on each job on the job cards which the personnel department approves after making any necessary corrections. At the end of each work week, the time cards and the job cards are reconciled by the timekeeping clerk.

The payroll register and the paychecks are prepared using the time cards and the current pay rate by the cashier, who then posts the information to the individual earnings records. The payroll calculations are not verified.

The paychecks are not reconciled with the payroll register for accuracy. The personnel department signs the paychecks and distributes them to the employees. Any unclaimed paychecks are retained by the personnel department. A record of unclaimed payroll checks is maintained by an independent party. Periodic surprise distributions are done.

The cost clerk prepares the labor summary using data from the jobcards. The payroll register and the labor summary are not reconciled prior to the general ledger clerk journalizing and posting the payroll information.

The company does not use an imprest payroll bank account. The cashier reconciles the bank statement.

Your evaluation of the payroll internal control is:

Very Weak	Weak	Moderately Weak	Moderately Strong	Strong	Very Strong

IDENTIFY THE MAJOR WEAKNESS, IF ANY, THAT LEAD TO YOUR EVALUATION.

APPENDIX G

EXAMPLE CONSULTATIONS - QUESTIONS WITH ELABORATIONS

ES with Intra consultation Base comment and Imprecise Elaboration

Q1: Who is responsible for hiring new employees?
R1: Personnel Clerk

Q2: Who approves the employees' jobcards?
R2: Supervisor

Q3: Who approves the employees' time cards?
R3: Supervisor

Elaboration:
A control weakness has been identified. (Segregation of duties)

Authorization and recordkeeping functions should not be handled by the same person.

Q4: Who is responsible for reconciling the jobcards and timecards?
R4: Timekeeping

Q5: Who prepares the employee paychecks and the payroll register?
R5: Payroll clerk

Q6: Are the payroll calculations verified with the paychecks and the payroll register?
R6: Yes

Q7: Who signs and distributes the payroll checks?
R7: Payroll clerk

Q8: Who reconciles the bank statement?
R8: Payroll clerk

Elaboration:
A control weakness has been identified. (Lack of independent check)

Person with a recordkeeping function should not also perform the independent checks of the function.

Q9: Who prepares the labor summary?
R9: Cost clerk

Q10: Who reconciles the labor summary with the payroll register and posts the general ledger?
R10: General ledger clerk

Q11: Is there surprise distributions of payroll by the internal auditor?
R11: Yes

Q12: Is there an imprest payroll bank account?
R12: Yes

Q13: Who maintains unclaimed payroll checks?
R13: Payroll clerk

Q14: Who maintains the record of unclaimed checks?
R14: Internal auditor

ES with Intraconsultation base comment and Precise Elaboration

Q1: Who is responsible for hiring new employees?
R1: Personnel Clerk

Q2: Who approves the employees' jobcards?
R2: Supervisor

Q3: Who approves the employees' time cards?
R3: Supervisor

Elaboration:
A control weakness has been identified. (Segregation of duties)

The supervisor has the authorization function of approving jobcards and the recordkeeping function of approving timecards. One person should not have both of these functions.

Q4: Who is responsible for reconciling the jobcards and timecards?
R4: Timekeeping

Q5: Who prepares the employee paychecks and the payroll register?
R5: Payroll clerk

Q6: Are the payroll calculations verified with the paychecks and the payroll register?
R6: Yes

Q7: Who signs and distributes the payroll checks?
R7: Payroll clerk

Q8: Who reconciles the bank statement?
R8: Payroll clerk

Elaboration:
A control weakness has been identified. (Lack of independent check)

The payroll clerk has the recordkeeping function of preparing the payroll checks and the payroll register, and signing and distributing the checks, while also being responsible for the independent check of reconciling the bank statement.

Q9: Who prepares the labor summary?
R9: Cost clerk

Q10: Who reconciles the labor summary with the payroll register and posts the general ledger?
R10: General ledger clerk

Q11: Is there surprise distributions of payroll by the internal auditor?
R11: Yes

Q12: Is there an imprest payroll bank account?
R12: Yes

Q13: Who maintains unclaimed payroll checks?
R13: Payroll clerk

Q14: Who maintains the record of unclaimed checks?
R14: Internal auditor

ES with Intraconsultation base comment and Precise Elaboration and Example

Q1: Who is responsible for hiring new employees?
R1: Personnel Clerk

Q2: Who approves the employees' jobcards?
R2: Supervisor

Q3: Who approves the employees' time cards?
R3: Supervisor

Elaboration:
A control weakness has been identified. (Segregation of duties)

The supervisor has the authorization function of approving jobcards and the recordkeeping function of approving timecards. One person should not have both of these functions.

If the supervisor has bothe functions, he/she could modify both time records and split the overpayment with the employee involved.

Q4: Who is responsible for reconciling the jobcards and timecards?
R4: Timekeeping

Q5: Who prepares the employee paychecks and the payroll register?
R5: Payroll clerk

Q6: Are the payroll calculations verified with the paychecks and the payroll register?
R6: Yes

Q7: Who signs and distributes the payroll checks?
R7: Payroll clerk

Q8: Who reconciles the bank statement?
R8: Payroll clerk

Elaboration:
A control weakness has been identified. (Lack of independent check)

The payroll clerk has the recordkeeping function of preparing the payroll checks and the payroll register, and signing and distributing the checks, while also being responsible for the independent check of reconciling the bank statement.

If the payroll clerk is not independently checked, he/she could write a fraudulent check and not record it on the payroll register, and subsequently cover his embezzlement on the bank reconciliation.

Q9: Who prepares the labor summary?
R9: Cost clerk

Q10: Who reconciles the labor summary with the payroll register and posts the general ledger?
R10: General ledger clerk

Q11: Is there surprise distributions of payroll by the internal auditor?
R11: Yes

Q12: Is there an imprest payroll bank account?
R12: Yes

Q13: Who maintains unclaimed payroll checks?
R13: Payroll clerk

Q14: Who maintains the record of unclaimed checks?
R14: Internal auditor

ES with End of Session base comment and Imprecise Elaboration

Q1: Who is responsible for hiring new employees?
R1: Personnel Clerk

Q2: Who approves the employees' jobcards?
R2: Supervisor

Q3: Who approves the employees' time cards?
R3: Supervisor

Q4: Who is responsible for reconciling the jobcards and timecards?
R4: Timekeeping

Q5: Who prepares the employee paychecks and the payroll register?
R5: Payroll clerk

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R13: Payroll clerk

Q14: Who maintains the record of unclaimed checks?
R14: Internal auditor

Elaboration:
A control weakness has been identified. (Segregation of duties)

Authorization and recordkeeping functions should not be handled by the same person.

A control weakness has been identified. (Lack of independent check)

Person with a recordkeeping function should not also perform the independent checks of the function.

ES with End of Session base comment and Precise Elaboration

Q1: Who is responsible for hiring new employees?
R1: Personnel Clerk

Q2: Who approves the employees' jobcards?
R2: Supervisor

Q3: Who approves the employees' time cards?
R3: Supervisor

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ES with End of Session base comment and Precise Elaboration and Example

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R1: Personnel Clerk

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Q3: Who approves the employees' time cards?
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VITA

Marcus Dean Odom

Candidate for the Degree of

Doctor of Philosophy

Thesis: AN EXAMINATION OF THE INTERACTION OF ELABORATION ALTERNATIVES AND ELABORATION PLACEMENT ON EXPERT SYSTEM-BASED INCIDENTAL LEARNING

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Minor Field: Accounting

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Personal Data: Born in Newport, Arkansas, September 18, 1961, the son on Marvin Maurice and Virginia Dale Odom; married Shannon Lynne Reid on July 25, 1987; son, Marcus Dean Odom, Jr., born on August 27, 1991.

Educational: Graduated from Newport High School, Newport, Arkansas, in May, 1979; received Bachelor of Science Degree in Accounting from Arkansas State University in May, 1983; received Master of Science in Accountancy from Arkansas State University in May, 1984; completed requirements for Doctor of Philosophy Degree at Oklahoma State University in July, 1993.

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