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The Ohio State University

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EFFECTS OF A CONCEPT ORGANIZER AND INSTRUCTIONAL SCHEMATA ON CONCEPTUAL, PROCEDURAL, AND SKILL LEARNING IN HIGH SCHOOL INDUSTRIAL ARTS CLASSES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Bert Allen Siebold, B.S., M.Ed.

1986

Dissertation Committee:

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Approved by

E. Keith Blankenbaker

College of Education
Dedicated to my wife, Sharon Denise,
for sharing her life and God's gift of eternal love
through Jesus Christ our Lord,
and to Michael Allen,
our beloved son.
ACKNOWLEDGMENTS

This study was completed through the encouragement and assistance of many teachers, colleagues, and friends. The unselfish dedication of each of these has taught me dedication to the profession of teaching and to the assimilation of knowledge and application of wisdom for the intellectual, personal and spiritual growth of our students.

A special thanks to:

Dr. E. Keith Blankenbaker
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CHAPTER I

THE PROBLEM

Introduction

An important problem in the field of education today is the lack of disciplined applications of cognitive-pedagogical theory to the design of instructional strategies and materials which facilitate the learning of school subject matter. Industrial arts teacher educators recognize the need to test the application of theoretically based teaching strategies which appear to hold promise for the improvement of instructional practice. In a 1976 study, Buffer and Campbell identified and rank ordered six categories of research activity and interest among industrial arts professors. Research in instructional strategies was ranked fourth (Buffer, 1979, p. 316). Over the years, industrial arts teacher educators have recognized the need to research techniques which maximize cognitive learning and enactive performance of industrial arts subject matter.
Recently there has been an increase of published instructional materials which employ cognitive-pedagogical techniques in their instructional design. Specifically, publications have used concept organizers in the form of block concept maps as well as subject matter organization principles related to schema theory. The assumption is that these instructional devices may help learners remember cognitive subject matter more accurately and apply it to enactive/skill performance more effectively than traditional organization strategies. The present study attempts to provide empirical knowledge related to the design of instructional strategies which facilitate the cognitive learning and enactive performance of industrial arts subject matter.

**Background of the Problem**

The instructional strategies researched in this study were based on two cognitive-pedagogical theories: the assimilation theory and an information processing theory. Each of these theories has shown merit for teaching a broad range of school subject matter. However, relatively little research has been performed which applies either of these theories to industrial arts subject matter.
Ausubel's Assimilation Theory

Ausubel's assimilation theory focuses on how people learn and retain organized knowledge in a manner which is meaningful to them as individuals. Ausubel's premise is that the primary function of the school is knowledge transmission, and that expository teaching is the most efficient method of transmitting knowledge related to organized bodies of subject matter.

Ausubel named the major innovative component of his strategy an "advance organizer." Ausubel has defined advance organizers to be pre-instructional or introductory materials which are more abstract, more inclusive, or more general than the main body of subject matter content (1978, p. 252). Ausubel has described the function of advance organizers in the following manner:

The function of the organizer is to provide ideational scaffolding for the stable incorporation and retention of the more detailed and differentiated material that follows in the learning passage, as well as to increase discriminability between the latter material and similar or ostensibly conflicting ideas in cognitive structure. (1969, pp. 148-149)

Concept Organizers. An advance organizer is a concept organizer intended to facilitate acquisition of intact concepts in a manner which is relatable to the learner's cognitive structure. Although based on Ausubel's design criteria of being more abstract, more general, and more
inclusive than the subject matter it precedes, the concept organizer in the present study is designed to be meaningful to all four intact classes of students in the study. In addition, the organizer is an iconic concept map supplemented by a brief expository explanation of conceptual relations. Ausubel's organizers are typically comparative or expository texts of three hundred to five hundred words and rarely include iconics.

An Information Processing Approach

Presently, several prominent views of the nature and structure of long-term memory are considered viable. In this study the model first proposed by Rumelhart, Lindsay and Norman (1972) was adopted because of its overall consistency with other semantic-hierarchial long-term memory models and because of the model's specific representation of episodic information within the semantic structure. Rumelhart et al. (1972) viewed long-term memory as a taxonomic order of concepts and events to which associated action sequences are included as elaborations of specific instances or details of those concepts and events. These elaborations are encoded through propositional "then" linkages (i.e., first this, "then" that, etc.). Specifically, he stated:

Conceptual, event, and episodic information is completely intermixed in the memory system, and
all are represented in this same format. The 'then' links are used interchangeably to lead to the next event in an observed action sequence or the next process to be executed by the interpreter. (1972, pp. 210-211)

Since the formation of "then" linkages is cognitive in nature, Rumelhart et al. (1972) theorized that the encoding of episodic sequences are not dependent upon autobiographical reference. This independence from autobiographical reference is particularly well suited to explain the vicarious learning of the sequential processes of industrial arts subject matter through students' observations of teacher demonstrations.

**Schema Theory.** Traditionally the notion of memory schemata has been used to develop strategies for the learning of spatial and temporally organized information. However, schema theory is being applied increasingly to design instructional strategies for the presentation of taxonomically organized knowledge. Calfee (1981, pp. 29-30) has suggested the importance of "organizing frameworks" to the encoding and retrieval of all types of school subject matter--spatial, episodic, conceptual-taxonomic, or any combination thereof. Calfee further suggested that it may be important for the learner to remember the organizing framework of the knowledge itself to facilitate the retrieval of the subject matter content from long-term memory (1981, p. 30).
The presentation of school subject matter formatted into organized frameworks and designed to be compatible with the structure of long-term memory holds promise for helping students encode and retrieve formal school subject matter. The structure of a particular "formal frame" (Calfee, 1981, p. 28) would be dependent on the level of learning of the students, the taxonomic, episodic, or integrated taxonomic-episodic nature of the specific content to be presented and the overall semantic structure of long-term memory.

It is the intent of this study to present industrial arts/technology education subject matter in a schema-ordered format compatible with the structure of human long-term memory theorized by Rumelhart et al. (1972). Further, the possible facilitative effects of a concept organizer are to be studied both in conjunction with the experimental format of instructional presentation and with a more traditional presentation format.

Statement of the Problem

Presently there is a lack of verifiable knowledge which prescribes the design of instructional materials that facilitate cognitive learning and the enactive skill performance of industrial arts subject matter. This study
compares the independent and combined effects of four alternative elements of industrial arts lesson sequences. The purpose of the study is to contribute substantive empirical knowledge to the area of instructional design in industrial arts/technology education.

**Statement of Problem Elements**

The problem elements of the study are:

1. There is a lack of knowledge about the use of iconic-expository concept organizers to facilitate cognitive learning and enactive performance of industrial arts subject matter concepts.

2. Very little is known regarding the application of schema ordered instructional sequences to effect cognitive learning and enactive performance of industrial arts subject matter concepts.

3. There is a lack of knowledge about the combined facilitative effects of instructional sequences containing iconic-expository concept organizers and content organization based on instructional schemata on cognitive learning and the enactive performance of industrial arts subject matter concepts.
Objectives

The objective of this study is to establish empirical knowledge which can be applied to improve the instructional design of industrial arts/technology education subject matter presentations. The specific objectives are to compare the cognitive learning and enactive performance effects of:

1. a concept organizer with a traditional introduction.
2. a schema-formatted instructional presentation sequence with a traditionally organized presentation sequence.
3. a combination of the concept organizer and the schema presentation with any of the other combinations of treatment variables.

Assumptions

The assumptions of the study are as follows:

1. Principal goals of industrial arts instruction are to transmit cognitive knowledge and to facilitate learner enactive performance of industrial arts/technology education concepts.
2. A learner's cognitive structure is organized hierarchically. Further, this structure is a taxonomic order of words or other symbols (information) which have meaning to the learner.

3. Memory schemata can be used by learners to order conceptually-related and sequentially-related data within the classification hierarchy of the taxonomic order.

4. A teacher delivered slide and audio cassette presentation is a suitable medium for the presentation of industrial arts/technology education construction management technology concepts.

5. The taxonomy of construction management concepts developed by the Industrial Arts Curriculum Project (Towers, et al., 1966) is an appropriate source of industrial arts/technology education subject matter.

6. The concept of scaling distances is a suitable sample of industrial arts/technology education construction management technology subject matter to be chosen as the subject matter content for this experiment.

7. A multiple-choice paper and pencil test can be used to measure cognitive learning outcomes of the instructional sequences presentation (Bloom, 1956, pp. 51-53).

8. Subjects in the study will possess adequate hand-eye coordination skills to perform the psychomotor
elements of the enactive performance paper and pencil distance scaling tasks.

9. Enactive performance (scaling distances with an architect's scale) can be measured by using the scale to perform scaling operations on a paper and pencil test.

10. The possible presence of Hawthorne and novelty effects will be equal at all treatment levels. The subjects will not know which treatment is the experimental treatment.

11. The sample size will be suitable for the purposes and statistical procedures of this study.

Definitions

The specialized definitions of concern to the study are as follows:

Cognitive learning - the extent to which the subjects "know, comprehend, and apply" the cognitive subject matter as measured by a researcher-made test designed in accord with the principles of Bloom's evaluation taxonomy of the cognitive domain (1956).

Concept - "A symbol or group of symbols that stand(s) for a class or group of objects or events that possess common properties and may be either verbal or nonverbal" (Houston, 1981 in Hall, 1982, p. 5).
Concept organizer - an iconic concept map of the superordinate, coordinate, and subordinate concepts and conceptual relations of the lesson subject matter. The concepts have been selected to fit the level of learning and the prerequisite skills of the experimental subjects. The organizer also includes a brief motivational and expository explanation of the relationships between the concept levels and each of the coordinate concepts. Ausubel's criteria of abstractness, generality, and inclusiveness for advance organizers have been applied to the design of the concept organizers employed in this study. The concept organizer was presented by a 35mm narrated slide show.

Enactive performance - the extent to which the subjects can use the information and materials of the presentation to enact the scaling sequences presented in the experimental treatments at the "imitation" and "manipulation" levels of Hauenstein's taxonomy of the psychomotor domain (1972, p. 20). Enactive performance was measured by a researcher-made paper and pencil test.

Industrial arts/technology education subject matter - the "knowledgeable doing" of industrial technological processes (Lux, 1981, p. 25). In this study the subject matter was delimited to scaling distances with the one inch per foot and one-half inch per foot scales of a traditional
English architect's scale. This content was selected from the industrial arts construction management taxonomy developed by the Industrial Arts Curriculum Project (Towers, Lux, & Ray, 1966).

**Instructional variable A** - a two-level independent variable incorporated in this study as part of the instructional presentation sequence. Level A1 is a concept organizer for distance scaling concepts and Level A2 is a traditional-motivational/career related introduction to the distance scaling concepts.

**Instructional variable B** - a two-level independent variable used in this study as part of the instructional presentation sequence. Level B1 is a traditionally organized instructional sequence of distance scaling operations with the one inch per foot and one-half inch per foot scales of the architect's scale. Level B2 is a schema-organized instructional sequence of the same scaling concepts.

**Meaningful learning** - learning which is relatable to relevant concepts in the cognitive structures of the particular learners (Ausubel, 1969, p. 225). In this study the concept of measuring distances with an ordinary ruler is assumed to be a critical, relevant concept in the cognitive structure of the subjects. To measure the validity of the assumption, a pretest of the measure of the
subject's ability to measure distances with a standard 12" ruler was administered.

**Memory structure** — the contents of memory that result from learning and the organization that these contents are postulated to have (Gagne & White, 1978).

**Retained learning** — the extent to which subjects can "know," "comprehend," and "apply" the information presented in the instructional treatments seven days following the treatments as measured by a randomly rearranged version of the initial cognitive criterion test. A second measure of retained learning is the extent to which subjects can "imitate and manipulate" the distance scaling sequences of the instructional presentations. An identical version of the enactive test used to measure initial enactive performance was administered concommitantly with the test of retained cognitive learning.

**Schemata** — mental structures (pictorial abstractions or generalized mental outlines) which people develop and use to accept and structure all types of information received by the senses to be encoded into and later retrieved from memory. Schemata direct the search for information and can be modified by the information received. People can develop schemata for information related to common material objects, familiar shapes, situations, sequences, concepts, i.e., a motel room schema

More specifically in terms of memory structure, Minsky states:

We can think of a frame (schema) as a network of nodes and relations. The 'top levels' of a frame are fixed, and represent things that are always true about the supposed situation. The lower levels have many terminals--'slots' that must be filled by specific instances of data. Each terminal can specify conditions its arguments must meet. (1975)

**Traditional introduction** - (instructional variable A2)

an iconic and expository introduction to the specific subject matter of the learning passage. The introduction was designed to motivate student interest in the subject-matter presentation content through career/industry-utilization related information depicting architectural, interior design, and engineering careers dependent on the knowledge of scaling distances with an architect's scale. The introduction was a 35mm narrated slide presentation showing career settings and a professional set of commercially scaled drawings. The introduction does not include higher order concepts or explain the conceptual relationships of the treatment subject matter to superordinate/subsuming subject matter.

**Traditional subject matter sequence** - (independent variable B1) the organization of subject matter content into
an episodic presentation which employs a "utilization related" presentation, a "utilization-procedural" demonstration sequence, and a review of the utilization procedure to show its relationship to the introduction (Posner & Strike, 1976). This presentation is not sequenced taxonomically, nor does it include an abstracted schema outline. However, each procedure was presented with examples of utilization applications (adapted from Wilbur & Pendered, 1967, pp. 107 & 111). The sequence was presented by 35mm slides accompanied by a taped narrative and four planned intervals for learner questions and distance scaling practice.

Schema organized sequence - (independent variable B2) the organization of subject matter content based on the "conceptual, learning related, and utilization" sequencing principles of "class relations," "empirical prerequisites," and "procedure" of Posner and Strike (1976, pp. 674, 677, 678, & 680). The overall taxonomic ordering of the subject matter content is analogous to the overall structure of long-term memory as described by Rumelhart et al. (1980), and Gagne and White (1978). A generalized schema outline of scaling distances with an architect's scale accompanied by the specific scaling sequences to be taught was used to teach the enactive sequence of scaling with the one inch per foot and one-half inch per foot scales. The sequence
was presented via a 35mm narrated slide show with four planned intervals for learner questions and distance scaling practice.

**Vicarious learning** - the learning of factual and procedural cognitive knowledge through the participation in industrial arts lecture-demonstration presentations as an aware observer.

**Delimitations**

The delimitations of the study are as follows:

1. The population of the study was delimited to the students in high school industrial arts classes at the Calloway County High School, Murray, Kentucky.

2. The subject matter content was delimited to scaling distances with the one inch per foot and one-half inch per foot scales of an architect's scale.

3. Criterion measures were delimited to cognitive and enactive performance/skill measures. Scaling knowledge was measured by a cognitive paper and pencil test of the facts, principles, and sequences of reduced scaling with the architect's scale. Enactive performance was measured by a cognitive and psychomotor paper and pencil test of enactive performance/skill distance scaling tasks.
4. The independent variables were delimited to a concept organizer versus a traditional introduction, and a traditionally organized instructional sequence versus a schema organized presentation of the same material.

5. The number of available subjects limited the number of experimental units to four and the number of subjects per experimental unit to twenty-two to twenty-four. The data-producing sample was fourteen to eighteen subjects per unit for a total of sixty-six subjects.

**Limitations**

The limitations of the study are as follows:

1. The instruction was presented over a short period of time. There may have been a positive-cumulative or a negative-saturation effect of any of the treatment variables on learners over extended time periods.

2. The pretest subject matter content involved was selected from the construction management technology section of the taxonomy of industrial arts subject matter as presented in *A Rationale and Structure for Industrial Arts Subject Matter* (Towers, Lux, & Ray, 1966, p. 174).
The results may not be generalizable to all concepts in the taxonomy or subject matter as defined in other descriptions of industrial arts/technology education subject matter.

3. The measures of initial cognitive and enactive performance were taken on the day following the experimental treatments and so may not accurately reflect the actual initial enactive performance.

Statement of Research Hypotheses

Ha 1: Students who receive the concept organizer will perform significantly better on tests of initial and retained cognitive learning at Bloom's comprehension and application classification levels, than will students who receive the traditional introduction.

Ha 2: Students who receive the schema organized subject-matter presentation element will perform significantly better on tests of initial and retained cognitive learning and on measures of enactive performance than will students who receive the traditionally structured presentation element.
Ha 3: Students who receive the concept organizer and the schema organized presentation element will perform significantly better on tests of initial and retained cognitive learning and on measures of enactive performance than will students who receive any of the other treatments.

Ha 4: Students who receive the concept organizer prior to either subject matter presentation will not perform significantly better on the initial and retained tests of cognitive learning at the knowledge classification level of Bloom's taxonomy of cognitive educational objectives than will students who receive the traditional introduction.

Ha 5: Subjects who receive the concept organizer will retain a significantly higher percentage of scaling knowledge than subjects who receive the traditional introduction, as measured by the differences in the initial and retention cognitive criterion test scores at or above Bloom's comprehension level (1956).

Ha 6: Subjects who receive the schema organized instructional element will retain a significantly higher percentage of knowledge and enactive performance than subjects who receive the traditionally organized instructional presentation, as measured by differences in
scores on the initial and retention criterion tests of cognitive knowledge and enactive skill performance, respectively.

Ha 7: Subjects who receive both the concept organizer and the schema organized instructional treatments will retain a significantly higher percentage of knowledge and enactive performance than subjects who receive any of the other experimental treatment combinations, as measured by the respective differences in scores on the initial and retention cognitive and enactive criterion tests.

Summary

Chapter One has been an account of the nature and importance of the study. A brief discussion of supporting theory, the statement of the problem, definition of terms, assumptions, delimitations, limitations, and finally the research hypotheses have been included.

Chapter Two is comprised of a six-section literature review pertinent to the development of the study. In order of presentation, the sections are titled: (a) information processing theories of long-term memory, (b) instructional concept organizers, (c) schema theory, (d) concept organizers an schemata--an integrated approach, (e) instructional sequence design, and (f) instructional media:
narrated slide presentations. An introduction and summary are included as well.
CHAPTER II

REVIEW OF LITERATURE

Chapter two examines the use of concept organizers and the principles of information processing-schema theory as it relates to the design of instructional sequences. In addition, narrated slide show design is discussed to enumerate the principles upon which the instructional presentations of this study were produced.

To aid in the collection and focus of source material, computer searches of the ERIC data base were made for the following descriptors: instructional design and concept teaching or cognitive development, concept map, concept learning, concept development, advance organizers, concept organizers, concept formation, information processing and schema or schema theory. Other key sources included monographs and journals referenced in Dissertation Abstracts International, Jelden's Abstracta, Education.
Index, Psychological Abstracts, and reference lists in works published by David Ausubel, E. V. Tulving, Robert Gagne, D. E. Rumelhart, Robert Calfee, and others.

This chapter is ordered into seven sections. The first section discusses instructional concept organizers. Section two discusses the organization of memory and schema theory. Section three explores areas of commonality between concept organizers and schema theory. The fourth section reviews the design of instructional content sequencing. The fifth section reviews research on narrated 35mm slide-show design and production. A summary constitutes the sixth section.

Prime objectives of industrial arts and technology education programs are to facilitate the learning of organized knowledge essential to the performance of industrial arts activities and the actual performance of those activities. To meet these objectives the learner (according to the cognitive view of learning) must encode the essential procedural steps in long-term memory and then transfer this procedural knowledge (Gagne, 1979) to the operational success of task execution.

Conceptual knowledge is important not only as information relatable to performance, but as valued content
in its own right, necessary to understand the principles which govern technological activity and to communicate knowledge and achievements to others.

The focus of this literature review is to establish a sound base in educational theory for the hypotheses of this study. These hypotheses have been designed to test conceptual and procedural cognitive teaching strategies which may facilitate concept learning, knowledge of procedure and performance of industrial arts activities. If the cognitive elements of the research hypotheses are confirmed, then the question becomes, "Will this increase in cognitive knowledge facilitate the learners' enactive performances? Rejection of the null hypotheses related to this latter question may hold promise for the importance of this study as a basis for additional research in the relationship between cognitive knowledge and enactive performance of industrial arts/technology education activities.

Instructional Concept Organizers

As described in Chapter One, the design of the concept organizer in this study incorporated the logical design criteria enumerated by Ausubel for writing advance organizers (1978, 1982). However, notable distinctions
include: (a) the incorporation of an iconic concept map, (b) that the organizer was designed for use with the broad population of high school students rather than designed for a specific population, and (c) the presentation method is not predominantly an expository text as would have been recommended by Ausubel. Therefore, even though the organizer in this study conforms to advance organizer (AO) design criteria, it bears the more generic descriptor of concept organizer (CO).

The Assimilation Theory

Ausubel's Assimilation Theory is a broad predictive theory predicated on the cognitive view of learning. The concept organizer in this study is based on that portion of the assimilation theory known as the subsumption theory. Through the subsumption theory Ausubel contends that "cognitive structure is hierarchically organized in terms of highly inclusive concepts under which are subsumed less inclusive subconcepts and informational data" (Ausubel, 1960, p. 267). That is, as concepts are presented and learned in formal learning environments, students incorporate new concepts by relating them to more stable, more general concepts already in memory. Each newly learned concept is subsumed under the next higher order concept in the hierarchy. Thus, the new concept has an
anchorage in memory and so becomes more meaningful to the learner than if it were an isolated memory construct (1962, p. 216). As Ausubel states it:

Thus, as new material enters the cognitive field, it interacts with and is appropriately subsumed under a relevant and more inclusive conceptual system. The very fact that it is subsumable (relatable to stable elements in cognitive structure) accounts for its meaningfulness and makes possible the perception of insightful relationships. (1962, p. 216)

Ausubel’s notion was that if the material to be learned is preceded by an introduction which has the potential to help students organize the subject matter and relate it to what they already know about the subject, then this introduction has the potential to provide an ideational scaffolding which will facilitate the encoding of subject matter content in long-term memory. Moreover, Ausubel suggests that the newly presented material will be encoded in the taxonomic structure of memory more reliably because the material will be encoded with a subsuming concept already existent in the learner’s long-term memory. Consider Ausubel’s explanation:

Advance organizers are helpful only because it is seldom the case that unmodified existing relevant subsumers in cognitive structure are targeted at the particular learning task at hand, are proximately relevant and inclusive in relation to the latter, and that the learner is invariably aware of the relevance of existing subsumers for the new learning materials. (1980, p. 402)
Most of Ausubel's organizers are expository or comparative texts of three hundred to five hundred words in length. In the present study, however, the format of the concept organizer is an iconic-taxonomic concept map and a brief expository text. The use of the concept map/expository organizer may have advantages over strictly textual organizers. The first possible advantage is parsimony. The organizer concept map, with its expository explanation, does not exceed one hundred fifty words. The second projected advantage is organizational clarity. Ausubel's textual organizers are designed to show relationships, but they can be viewed as a whole only after the inspection of the component parts. Even then, some of these relationships are implicit. The concept map organizer with its brief textual explanation can be viewed holistically, analytically, or both. In addition, the lines of a taxonomy are formal and sharply reduce the reliance on implicit interpretation of the content. The expository text may serve to: (a) increase student interest in the concept map, (b) reinforce student understanding of the subsuming relationship between the superordinate and coordinate concepts, and (c) assist the student in forming or activating the proper concept schemata for the encoding of the subject matter in the presentation section of the lesson. The concept organizer
sequence includes a slide presentation and narrated discussion of the concept map, its component concepts and conceptual relations, the potential usefulness of the ability to read an architect's scale to the students, and a statement concerning the organizer's usefulness in helping the student learn about and use the architect's scale.

Advance organizer research. Research on the effectiveness of advance organizers during the last two decades has led to mixed results. To date, several meta-analyses of organizer research have been conducted. The first and most critical review was conducted by Barnes and Clawson in 1975. Barnes and Clawson concluded that "Advance organizers, as presently constructed, generally do not facilitate learning" (1975, p. 657). Evaluation of three primary elements illuminate the value of Barnes and Clawson's conclusion: (1) What criteria were used to select the included studies? (2) What was the meta-analyses techniques employed and how did it influence the outcomes? And (3) What design criteria were used in the "as presently constructed" organizers and what design criteria should have been used?

First, Barnes and Clawson give no explanation of any criteria for the inclusion of particular studies in their review (1975). Thirty-two studies were selected, twelve of which reported a statistically significant increase in
learning presumably attributable to the advance organizer, and twenty which reported no statistically significant benefit. Second, the technique employed by Barnes and Clawson was a voting technique which grouped the results of studies showing positive but statistically nonsignificant gains with studies showing negative results. The effect of the voting technique on Barnes and Clawson's analyses was to skew the measures of effectiveness of several studies from slightly positive to negative. In 1978, Glass proposed that such evaluations be made by an analysis of effect size such that all effects (statistically significant or not, positive or negative) would be weighted according to their actual measured worth. Third, the design criteria applied by researchers other than Ausubel and his colleagues generally did not accurately represent the premises of the subsumption theory, if only because Ausubel's definition of an advance organizer was misinterpreted. Researchers in the Barnes and Clawson study had to develop their own interpretations of Ausubel's definition. The breadth of these interpretations led to inconsistent application of Ausubel's theory and predictably inconsistent results.

Ausubel (1980) argues logically and Mayer (1979) enumerates conditions in which it would be inconsistent with the subsumption theory for an advance organizer to
facilitate learning. These inconsistent conditions include: (1) the learners are already adept at organizing new conceptual content, and (2) the learning objective(s) and criterion test(s) are concerned only with recall or rote memorization of the content. The failure of an advance organizer to facilitate learning is therefore not necessarily inconsistent with the subsumption theory. The subsumption theory can be applied to predict the failure of advance organizer effects (Mayer, 1979).

Luiten, Ames and Ackerson (1980) performed a meta-analyses of 135 advance organizer studies. The same three-step evaluation applied to the Barnes and Clawson study was applied here. First, no selection criteria were listed except that both published and unpublished studies were included and that initially 176 studies were identified and the number was reduced to 135 through the elimination of duplication. Luiten, et al. (1980) studied slightly more than four times the number of studies than Barnes and Clawson's earlier work. Second, Luiten, et al. (1980) employed the effect size technique introduced by Glass (1978) which divides the difference between the mean criterion scores of the treatment and control groups by the standard deviation of the control group. This statistic does not bias the influence of small positive or negative effect sizes or diminish the effect of strongly positive or
negative effect size results. The large number of studies analyzed reduced the impact of extreme effect size statistics in the field of 135 studies. Third, the design criteria of the organizers were not discussed.

Luiten, et al. (1980) concluded that, "The average advance organizer study showed a small but facilitative effect on learning and retention." The study notes that effect size might be increased by administering treatments of longer duration or by aural presentation of the advance organizer. The main influence of Luiten's research on the present study was to present the organizer aurally.

Richard Mayer reviewed 44 advanced organizer studies in 1979. His selection criteria began with an extensive literature search to locate all advance organizer studies since 1960. He then applied two acceptance criteria for the study. First, the report had to have been published in a book or journal. Second, studies which contained a minimum of one advance organizer group and one control group were accepted as standard advance organizer studies and studies which tested a minimum of one advance organizer group and one post organizer group were accepted as modified advance organizer studies. The literature yielded 50 papers published in a book or journal. Six of the 50, however, failed to meet the control group criteria. Papers were not scrutinized on the basis of advance organizer
design or the accuracy with which the advance organizers reflected Ausubel's definition, however, 12 studies were rejected categorically because their advance organizers were limited to either the passage title or topical sentence (Mayer, 1979, p. 138). These selection criteria may yield the bulk of the well-designed studies, but certainly skews the results by loading the meta-analyses with studies reporting positive results.

Mayer's analysis (1979) like Barnes and Clawson's (1975) rested on tests of statistical significance. However, Mayer clearly intended to refute the Barnes and Clawson report and so loaded the study under the guise of legitimate selection criteria to result in glowing positive effects for Ausubel's advance organizers. Therefore, this researcher has chosen not to belabor Mayer's glowing positives, but move to the more worthwhile aspect of Mayer's work.

In his analysis of the predictive worth of the subsumption theory with regard to advance organizer design, Mayer offered the following insights:

It should be noted the assimilation theory predicts that AOs should have an effect mainly in situations where a learner either does not possess relevant subsumers or would not normally use them during learning. Thus AOs should have their strongest effects: (1) for materials which are technical or unfamiliar or not well-organized, (2) for learners who have not had previous experience or ability with respect to the to-be-taught material, and (3) for test items
that measure transfer to novel situations. In addition, AOs will have an effect only when the AO actually presents a useful assimilative context for the general ideas in the to-be-learned materials. (1979, p. 139)

The present study has incorporated many of Mayer's recommendations. First, the subject matter included in this study has a technical-conceptual structure in both the definitive—(what) and procedural—(how to) aspects of concept classification. Second, it was assumed that the experimental population does not have a developed notion of the subsumer "measuring scaled distances," but does have the superordinate concept of "distance measuring" and therefore the organizer may help the learner assimilate this more specialized or technically correct subsumer. This assumption is tested by the cognitive pretest. Third, the assumption that the learners have limited experience with respect to the instructional content (distance scaling with the one-inch and one-and-one-half inch scales of the architect's scale) is tested by an enactive pretest. And fourth, the criterion tests measured the breadth and depth of the students ability to recall/recognize and to transfer the content material to novel situations. And finally, Mayer's recommendation that criterion tests measure both initial and retained learning was employed.

Noel (1980) suggested the inclusion of instructions to tell learners how to use an advance organizer. Noel's
confirmed hypothesis was founded on four of Gagne's instructional events (1979). The instructional events are informing the learner of the objective, directing attention, stimulating recall, and providing learning guidance (Gagne, 1979). In accordance with Noel's recommendations, brief remarks were presented with the concept organizer in this study which directed attention to the organizer and stated its purpose and instructed the learners in the use of the organizer in studying the distance scaling content. Similar brief remarks were presented in conjunction with the traditional introduction to emphasize the importance of career awareness and to guide students to associate the learning of distance scaling with learning a career skill essential to many professionals.

Four studies were identified which concerned the application of Ausubel's theory to industrial arts instruction. Two of these studies (Darrow, 1980 & Kirkwood, 1971) showed no significant difference between treatment groups receiving advance organizers or comparison treatments. Dawson (1966), however, demonstrated a significant increase in initial learning and three week retention learning of industrial arts subject matter with eighth-grade male students. Burse (1969) also demonstrated the significant facilitative effect of organizers for
initial learning, retained learning, and the performance of selected psychomotor tasks between an organizer treatment group and a teaching method which did not contain such a preorganizer. Each of these studies was to compare the effects of the presence, absence, or comparison of an advance organizer preceding the main body of subject matter. No industrial arts related studies were found which analyzed the combined effects of organizers and other treatment variables.

A review of these studies has aided in the design of this study. Burse (1969) and Dawson (1966) performed essentially identical experiments. Both studies used a control group, pre-organizer group, normal group, and experimental group (Burse used precisely the same group names and treatment structures as Dawson, but Burse's study did not fully replicate Dawson's work). In each case the pre-organizer group received the advance organizer and criterion measures; the normal group received the instructional passage and the criterion measures but received no pre-instructional material of any nature; and the experimental group received an advance organizer, the instructional passage, and the criterion measures. In short, neither Burse nor Darrow truly tested the effectiveness of the advance organizer as coupled with the instructional passage because any form of pre-instructional
material may have had an equally facilitative effect. The main impact of Burse's and Dawson's studies on this study was the inclusion of a traditional introduction as a comparison treatment for the concept organizer.

Two features of Darrow's organizer study (1980) have influenced this study. First, his organizers were in an iconic format. Relatively few iconic organizers have been tested experimentally and though Darrow described studies in which iconic organizers have had a facilitative effect on learning, most studies have shown mixed or negative results (Darrow, 1980, pp. 67-70). Darrow's results were also nonsignificant. Darrow's organizers were quite long by Ausubel's standards (ten minute video tapes) and they incorporated a broad range of material-processing concepts. Furthermore, the distinctive feature between Darrow's organizers and overviews was organization. Darrow's organizer was arranged hierarchically but included the subject matter content. The concepts in the overview were arranged randomly. Ausubel clearly denotes level of conceptual structures and increased generality as organizer design criteria. The present study includes iconic and expository elements and contains more abstract (subsuming) concepts and coordinate concepts, as prescribed by Ausubel's criteria of abstraction, generality, and inclusiveness. Additionally, the facilitative effect of
the organizer is compared to a motivational-career-related introduction common in traditional industrial arts instructional sequences.

Kirkwood (1971) tested the effects of expository and comparative organizers in three classes of undergraduate elementary education majors enrolled in undergraduate industrial arts classes. The results were not significant nor was there a difference in relation to the subjects' verbal ability levels. Kirkwood's study had no direct influence on the present study.

**Information Processing Theories**

**Schema Theory**

The information processing theories are a category of theories which, according to Woolfolk and Nicolich, comprises "perhaps the most important current view of learning from the cognitive perspective" (1980, p. 221). As described by Gagne and White (1978, p. 187), information processing theories are based on the three-element paradigm "stimulus memory response." Information processing theorists propose that subject-matter content should be organized in a manner which facilitates cognitive processing and storage in the learner's long term memory. These theorists view the structure of the instructional
sequence to be a critical link between the knowledge structure of the discipline and the memory structure of the learner.

The Organization of Memory

Presently, an unsettled debate exists between theorists who propose different structures for the organization of information within long-term memory (LTM). Separate episodic and semantic memories are proposed by Tulving. In reference to episodic memory, Tulving states:

Episodic memory receives and stores information about temporally dated episodes or events, and temporal-spatial relations among these events. A perceptual event can be stored in the episodic system solely in terms of its perceptible properties or attributes, and it is always stored in terms of its autobiographical reference to the already existing contents of the episodic memory store. (1972, pp. 385-386)

...Most, if not all, episodic memory claims a person makes can be translated into the form: 'I did such and such, in such and such a place, at such and such a time'. (1972, p. 389)

Tulving (1972) described episodic memory as a temporal record of autobiographical experience.

Semantic memory, however, is a cognitive reference; a store of symbolic/verbal knowledge which though gained through temporal sequences consists of symbolic information concerning language symbols, other types of symbols and the interrelations between these symbols:
Semantic memory is the memory necessary for the use of language. It is a mental thesaurus, organized knowledge a person possesses about words and other verbal symbols, their meanings and referents, about relations among them, and about rules, formulas and algorithms for the manipulation of these symbols, concepts and relations. Semantic memory does not register perceptible properties of inputs, but rather cognitive referents of input signals. (1972, p. 386)

Inputs into the semantic memory system are always referred to an existing cognitive structure, and information they contain is information about the referent they signify rather than information about the input signal as such. Information stored in the semantic memory system represents objects—general and specific, living and dead, past and present, simple and complex—concepts, relations, quantities, events, facts, propositions, and so on, detached from autobiographical reference. (p. 389)

Though Tulving (1972) clearly delineated the episodic-semantic distinction as a communicative devise for the convenience of researchers, his work does imply functional differences between episodic and semantic memories.

I refer to both kinds of memory as two stores or as two systems, but I do this primarily for the convenience of communication rather than as an expression of any profound belief about structural or functional separation of the two. The distinction between episodic and semantic memory systems should not be considered as representing the beginning of some new theory of memory. (p. 384)

Tulving has discussed episodic memory as a register of temporal sequences which are encoded through
autobiographical reference and semantic memory as a hierarchical/logical order of symbols, concepts and relations (1972). However, Tulving does not suggest that these conceptual/functional distinctions are indicative of a physical or structural presence of two physically separate memories.

Tulving's view of memory has been an important notion to the growth of cognitive—information processing theories of Long Term Memory (LTM) structure. This researcher agrees with Tulving that the semantic-episodic distinction is not a new theory of memory structure. Moreover, its focus on strictly interpreted autobiographical sequences and linguistic-semantic orders of data does not adequately accommodate or explain the vicarious learning of cognitive-procedural knowledge which is central to task performance in industrial arts learning environments.

Vicarious task learning in industrial arts comprises the learning of the sequential steps of the task as learners actively observe the task being performed by a skilled demonstrator. This knowledge is largely a cognitive knowledge of the procedure required for task completion. If the learner already possesses the component skills of the sequence, then this cognitive knowledge of procedure can be readily transferred into task performance. A more subtle aspect of vicarious task learning is that
students who do not possess the skills being demonstrated frequently are able to perform the task skills by learning the steps of the procedure and imitating the skill performance of the demonstrator. These students have learned the essentials of skilled task performance through cognitive processing rather than through autobiographical experience. Clearly, these vicariously learned skills are rudimentary and improve with experience and practice. The literature is replete with acknowledgement that all learning has the temporal element of the interval in which the learner received the stimulus. The distinction is that initial skill learning can take place in industrial arts/technology education laboratories through cognitive processing rather than through direct experiential/autobiographical reference.

Anderson and Ross (1980) also argued against an episodic-semantic distinction, and proposed a unified computer simulation model of long-term memory named ACT. Anderson and Ross state that:

Long-term memory in ACT is represented by a network of propositional interconnecting concepts. . . . All information, semantic and episodic, is stored together. (p. 442)

Anderson's ACT theory is premised on the importance of parallel processing to cognition, with a clear distinction between declarative and procedural knowledge (1976).
Clarification of the latter premise is necessary here. Declarative knowledge, the knowing of truths or facts, is represented in memory in terms of propositions which are abstract, have truth values, have rules of formation, and are nonambiguous (Anderson, 1976). In contrast, Anderson describes procedural knowledge to be of a behavioral stimulus-response nature which is autobiographical in nature and is best gained by doing. The primary distinction made between the ACT theory and behaviorism is that the selection of the proper sequence is responsive to data in the propositional network of the memory's declarative structure (1976, pp. 122-124). Anderson's model, though unified, represents procedural knowledge in neobehavioralistic terms and again does not adequately explain the cognitive processing involved in vicarious task learning.

Rumelhart, Lindsay, and Norman (1972) view episodic information to be stored in memory as a component of an overall taxonomic/semantic network. Rumelhart et al. (1972) theorize a single process-oriented model of LTM comprised of discrete nodes (concepts, events, or episodes) interconnected by relations (action, declaration, and the propositions then and while) to explain the storage and process functions of all memory activities. Further, in contrast to Tulving, Rumelhart et al. (1972) proposed that
memory of episodes can be independent of autobiographical reference (in Gagne & White, 1978, p. 194). The vicarious learning of enactive sequences as included in industrial arts demonstrations is thus accounted for:

Conceptual, event, and episodic information is completely intermixed in the memory system, and all are represented in this same format. The then links are used interchangeably to lead to the next event in an observed action sequence or the next process to be executed by the interpreter. (Rumelhart et al., 1972, pp. 210-211) (Emphasis added)

In this study, the structure of long-term memory will be defined as an overall semantic hierarchy of concepts and conceptual relations. As argued by Rumelhart et al. (1972), episodic information will be assumed to be temporally organized sequences of information stored as related through active propositional linkages (then or while) to any appropriate concepts within the overall semantic structure. From this concept of an overall semantic processing system Rumelhart and Ortony (1977) and Rumelhart (1980) have described a schema theory which emphasizes cognitive structure as an active processor of held schemata and so de-emphasize the importance of creating more specific models of memory structure.
Schema Theory

Kant described a rudimentary schema theory (1781) as a rule for the delineation of a concept— not limited to any experiential example or concrete instance of that concept. Bartlett (1932) built on that concept, but concluded that people form "schemata" based on experience. Bartlett also believed that encountering new information which was related to an existing schema modified or elaborated upon that schema. Though these early descriptions of schemata were rudimentary and not focused on the learning of school subject matter, they did lay the foundation for current educational schema research. This section reviews the varied positions offered by researchers on the types and applications of instructional schemata for teaching school subject matter.

For the past 15 years or so, the bulk of schema research has been focused on the facilitation of reading comprehension. As described by B. J. Meyer (1978) knowledge gained through formal schooling is largely communicated through written prose. Moreover, Rumelhart and Ortony (1977) proposed a schema based model of reading comprehension which posited that comprehension of a written text occurs when the reader selects, verifies and uses appropriate conceptual schemata to organize and relate this new material in its perceived relationship to prior
knowledge. A notion central to schema theory is that learners are active processors who give meaning to potentially meaningful information when they organize it and associate it with related information they know already or with which they are already familiar.

Rumelhart and Ortony (1977) have contributed greatly to our conceptualization of schema theory and the function of schema processing in reading comprehension. Schemata are described as concepts in generalized form which include the interrelationships generally held between individual cases of any given concept (p. 101). Schemata are encyclopedic in character incorporating the range of specific cases and their relationships (p. 110). They are abstractions of knowledge we employ language to describe. They represent knowledge associated with concepts, but are not definitions of the concepts they describe, i.e. schemata are "...abstract symbolic representations of knowledge which we express and describe in language, and which may be used for understanding language, but which nevertheless are not themselves linguistic" (pp. 110-111). Schemata, then, are abstract knowledge structures which people use to organize, interpret and encode information in long term memory such that it is meaningful to them.

As an abstracted or generalized case of a type of event, story, or knowledge structure, a schema cannot be
equated with any particular event, story, or specific knowledge substructure which it encompasses. A schema is used to interpret a specific event, story or knowledge structure, and the details of the individual case fill the "variable slots" and so flesh out the generalized schematic framework and give it specific meaning to the learner (Rumelhart & Ortony, 1977). These variables can be assigned by environmental/sensory input, by memory, or by default from the schema itself. Upon satisfying all variable slots with specifics, the schema is said to be instantiated or complete (Rumelhart & Ortony, 1977; Rumelhart, 1980; Anderson, Spiro, & Anderson, 1978). In his description of a story schema, Rand stated:

The schema helps the reader attend to certain aspects of the incoming material while keeping track of what has gone on before. The schema lets the reader know when a part of the story is complete and can be stored in memory, or whether the information should be held until more is added. (1984)

Schemata are also embedded within other schemata in a superordinate—subordinate relationship, a higher order schema may have several "subschemata" embedded within it (Brooks & Dansereau, 1983; Rumelhart, 1980). Consider Tuinman's hotel room schema:
Traveling much I have a well developed hotel room schema: I know the general layout of even new rooms; I know to expect a TV, a telephone, a specific kind of furnishings, a notion of room rates, a heating/cooling control, etc. (1980, p. 416).

Subschemata would certainly include: a hotel room layout schema, types and sizes of TVs—cable and pay movie offerings, bathing and grooming facilities—their provision for sauna and whirlpool and details such as whether tissues, shampoo and shoeshine cloths are supplied, etc. We hold subschemata for each constituent in this class of hotel rooms details as well; just as we do for the setting, theme, plot, and resolution subschemata embedded within a story schema (Gordon & Braun, 1983). Similarly, the starter event, inner response, action, the success or failure of the action, and the reaction are subschemata within the plot subschemata delineated within the story schema (Gordon & Braun, 1983). Though we often think of investigating a single isolated schema for research investigation, most schema whether temporal, taxonomical, or both, are instantiated at least partially by subschemata each with its own variable set.

In the early to mid-seventies research with schemata concentrated on relatively simplistic items such as stories or descriptions of casual situations (Anderson et al., 1977; Rumelhart, 1980; Rumelhart & Ortony, 1977). However, in
the late seventies and eighties, the literature is replete with more complex schemata taken directly from learning situations to answer pedagogical questions. Most of these, however, are representative of temporal action sequences, stories, or spatial relationships rather than the more formal \textit{a priori} relations of taxonomically ordered subject matter or instructional content with both temporal and taxonomic components.

Calfee uses the term frame as synonymous with schema (1981, p. 22) and distinguishes frames as abstractions of temporal experience from formal frames which are products of school learning (p. 28). Frames are generally described as inductive abstractions of personal experience, while formal frames are more likely to be stored in memory in their own right and to be used deductively to interpret, classify, and encode school subject matter (pp. 28-29). Calfee proposes that learners need schemata to interpret and encode subject matter which has temporal, taxonomic, or both taxonomic and temporal components. Calfee, then enlarges our concept of schemata:

I suspect that the importance of frames is even more important in studying school subjects such as biology, physics, geology, and so on. A precise knowledge of the subject matter content is probably an essential prerequisite to formulating organizing frameworks in such instances. . . . In addition, it may be important for the student to remember also the organizing framework itself, so that this structure is automatically called forth when he
is being tested on the knowledge. (1981, pp. 29-30)

If the structure of LTM is a single functional entity as described by Rumelhart et al. (1972), then the structure of a "formal frame" should be compatible with a single semantic cognitive structure in which declarative relationships and temporal sequences are stored to delineate attributes and instances of the concepts which they encompass in cognitive structure. Armbruster (1976) equated concept acquisition and storage of schemata in memory:

In schema terminology, we can say that a student has learned a concept when he has stored in memory a data structure bearing the appropriate constant relationships among the attributes or dimensions of the concept as well as the range of possible values these dimensions can assume. (1976, pp. 15-16)

B. J. Meyer (1976) posited that the hierarchical or "top-level" schema structure used by authors to organize textual discourse can markedly improve a reader's information processing, if the reader but abstracts and uses the author's structure. She further suggested this strategy to be most useful for learning school subject matter when the learner is to retain the material intact (if the learner is scanning for a particular item or has some other purpose then, naturally, other strategies apply) (1976, p. 3). The burden for the student then becomes to
discern the type of material being presented and to select from memory, or to abstract from the subject matter structure an appropriate schema to organize and encode the novel information. Abstracting common characteristics of diverse inputs, cases or attributes is a high level intellectual talent. Tuinman (1980) proposed that therefore, learners with high IQs and diverse experience will excel in the development of appropriate schemata and so outperform their classmates. An observation on which most educators might agree.

To interpret different types of school subject matter learners can activate existent schemata in either of two ways. First, they might find the schema which best fits the specifics of an episode, event, or conceptual information presented (bottom-up processing). Alternately, they might select an appropriate schema by evaluating and choosing from the range of subschemata of a higher order schema under which the novel information falls (top-down processing) (Rumelhart, 1980). A person's speed and accuracy in identifying appropriate memory schemata to process incoming subject matter, then can influence the amount of content which can be processed from any one lecture/presentation and the person's ability to accurately replicate that information.
With the advent of mainstreaming, educators need to apply new strategies to enhance the learning of all students— to learn the cognitive processing patterns of the intellectually gifted, and apply them to the benefit of all. This researcher proposes to present learners with organizing schemata at the outset, describe the potential usefulness of each schema, and direct students to use them to organize and remember both the scaling concepts and the procedural knowledge of scaling skills.

We develop or can be presented with schemata for business letters, baseball parks, the taxonomy of the animal kingdom, and skilled processes such as preparing a souffle. In short, our memory is a store of innumerable schemata which range from formally organized taxonomies to temporally ordered stories or action sequences to simpler items such as sawdust or egg yolk. Truly some set of criteria are needed to categorize types of schemata for efficiency of research communication. To date no such complete delineation has been universally adopted. Anderson, Pichert and Shirey (1983) described two classes: textual schemata and content schemata. A textual schema being an abstraction of discourse-level conventions such as typical structures for: short stories, business letters, newspaper articles, research reports, etc. (1983, p. 271). A content schema is then a person's topical context for the
content being introduced—what the person already knows or believes about the topic under consideration and the effect of this prior conception on the processing and interpreting of the content in question (1983, p. 271). As applicable as the textual-content distinction may be for processing temporal discourse, the convention as described is not suitable for organizing both the taxonomic/conceptual and temporal/sequential components of industrial arts/technology education subject matter.

A similar, if more complete categorization set consisting of content schemata and form schemata has been proposed by Rigney and Monro (1977). Rigney and Monro considered content and form schemata to be opposite ends of a continuum with their degree of abstraction as the organizing principle. Form or structural schemata are relatively abstract schemata which might delineate a type of knowledge structure or type of event in terms of abstracted generalizations such as Anderson, Spiro, and Anderson's (1978) nation schema where the authors speculate that an adult's nation schema may be a complex hierarchy of subschemata like: type of political organization, economy, individual rights, topography, etc. On the opposing end of the spectrum, content schemata are described as relatively specific or concrete entities such as the specific facts or episodes which might instantiate a structural or form
schema. Brooks and Dansereau (1983) laud Rigney and Monro's notion that form or structural schemata include not only the temporally oriented textual schemata described by Anderson et al. (1983), but also encompass more abstract academic materials for which the learner may hold only limited relevant schemata.

The present research employed three structural schemata. The first was a concept map which showed the coordinate bodies of cognitive knowledge (knowledge of parts and principles of the architect's scale and the knowledge of sequential procedures) to be subordinate concepts to reduced scaling with the architect's scale. The second structural schema orders the knowledge of the cognitive knowledge of parts and principles of the architect's scale. The final structural schema presents the four steps of the generalized procedure for drawing reduced scale lines and measuring reduced scale distances with the architect's scale. These structural schemata were presented intact with instructions for use just prior to their respective portions of the instructional content presentation.

Content schemata were also employed to organize the specific procedures of reduced scaling with the architect's scale, e.g. drawing reduced scaled lines with the one inch scale, measuring reduced scale distances with the one inch
scale, etc. The content schemata were not abstracted from the instructional script or presented to the learners intact. The purpose of the content schemata was to organize and present the specific scaling parts, principles and procedures in a format compatible with the higher level structural schemata. The assumption was that subjects would use the respective structural schemata while learning the specific content of the content schemata. In addition to reinforcing the embedded organization of the instruction, the structural schemata might also help learners transfer the lesson scaling content to scaling procedures which were not included in the instructional presentation, e.g. scaling distances with the 1/4" or 1/8" scales. Indeed, novel instructional content can be ordered into valid, reliable schema structures at the appropriate level of learning, and these schemata can be presented to learners with instructions to help students use the schemata to comprehend, encode and recall the specific instructional content.

Concept Organizer and Schemata
The Common Ground

The literature is relatively silent on the compatibility of Ausubel's organizers and instructional
schemata. Clearly, the pedagogical intent of an organizer is to activate relevant schemata in the learner's cognitive structure to enhance the reception of novel content. Organizers are not schemata at the same level of abstraction as the instructional content, but Ausubel's logical criteria do describe them to include superordinate schemata at a higher level of generality and abstraction than the more differentiated, specific, concrete subject matter to follow.

R. C. Anderson (1978) was prominent among schema theorists who believed it vital to differentiate their work from Ausubel's "hopelessly vague" organizer research. In fact, schema theory is a refinement of the subsumption theory just as the subsumption theory was built upon earlier cognitive learning theory. The observation should not be missed that schema notions of the early and mid-seventies are also rather vague in light of Rigney and Monro's (1977) differentiation between structural and content schemata and the application of schema theory to the teaching of the whole range of school subject matter. Further, as refinement continues it is likely that today's notions of cognitive processing and schema mechanisms may also seem a bit elemental or vague in the future.

The concept organizer in the present study is in fact a structural schema of a higher order than the schemata
employed to organize the instructional content. The organizer is a taxonomy of distance scaling concepts which includes measuring scaled distances with the architect's scale as a subconcept or subschema. The distinction between the organizer schema and the more specific instructional schemata is that of purpose. The organizer schema is not intended to direct the encoding and recall processing, but to help the learner recall appropriate existent concepts to serve as anchors for the novel material. An appropriate place in the learner's cognitive structures is thereby isolated to encode the new concepts and help the learner interpret and place meaning on the incoming material in relation to whatever he or she might already know about the subject. The purpose of the instructional schemata is to present an organizing framework (a concept organizer if you will) which is instantiated with the specific subject matter. This organizer can be used by the learner to direct the encoding and retrieval of the novel material (Anderson et al., 1983; Brooks & Dansereau, 1983).

Just as very few advance organizers have been designed to be hierarchical, iconic concept maps, the notion of formally presenting structural and content schemata to learners is also novel. Hypothetically, it could be beneficial to some learners (possibly those not gifted with
higher IQ's) to present the introductory concept organizer, the structural schemata and organize the instructional content into content schemata. Alternative hypotheses might include: (a) that this triple organizing is unnecessarily redundant and that schemata form their own conceptual anchorage in memory (Rumelhart, 1980), or (b) that due to the broad range of learning styles typically held in intact classes of students that the approach is too narrowly focused on specific students' needs (possibly only a portion of slow learners). These alternate hypotheses may well be credible, but it is intuitively attractive to this researcher to hypothesize that the combination of the concept organizer and the schema-organized instructional content will prove to facilitate learning more than any other treatment combination. To the extent that concept organizers and schemata both inspire deeper cognitive processing of subject matter by learners they may have a combined facilitative effect.

Instructional Sequence Design

In this section the subject matter content is ordered into four distinct instructional treatments (A1, A2, B1, B2). Each of the instructional treatments is an ordered sequence of instructional elements. The selection and
arrangement of these instructional elements was determined by the objectives of each and the application of an ordered set of instructional design criteria. Posner and Strike's (1976) instructional sequence design principles were employed herein to insure uniformity of instructional design criteria and to objectively quantify instructional design distinctions between the four instructional treatments. The level of learning of the instructional content is also treated in this section.

Subject Matter Content Sequencing

The organization of subject-matter content into instructional sequences requires the use of an ordered set of sequencing principles. Posner and Strike (1976) have enumerated a set of five sequencing principles for the design of instructional sequences. Logically speaking, the sequencing set is relatively mutually exclusive and operationally adequate. Even though no single principle of organization was identified for selecting or ordering the elements, the sequencing set is useful for identifying alternative content sequences for instructional design.

Three of Posner and Strike's five major types of sequencing principles are presented here (1976, pp. 672-681). The concept-related, learning-related, and utilization-related principles were selected on the basis
of their ability to clarify and distinguish the instructional design sequences used in the four treatments of the present study.

Concept-related sequences are based on the relationships of the conceptual-logical properties of knowledge within a subject matter area. Sub-types described by Posner and Strike (1976) are: class relations, propositional relations, sophistication, and logical prerequisites. Class relations refers to the common properties shared by a set of things or events (i.e. the shared critical attributes of coordinate concepts) or the grouping of concepts into superordinate and subordinate levels on the basis of the logical-hierarchical structure of the concepts in the discipline. Propositional relations refers to relationships between propositions such as: contradictions, premise-conclusion, theory application, rule-example, etc.; Sophistication refers to the level of precision, conceptual complexity, abstractness, vagueness, range and level of refinement (through statements of qualification); Logical prerequisites refers to the necessary a priori relationship of understanding one or more prerequisite concept(s) as a condition for understanding another related concept.

Learning-related sequences are organized on the principles of learning psychology. In this category Posner
and Strike include both curriculum and instructional content sequencing sub-elements (1976, p. 677). This discussion, however, is restricted to the sequencing of instruction. The sub-types of learning-related sequences applicable to instructional design are empirical prerequisites, familiarity, difficulty, interest, and internalization. Empirical prerequisites are skills which facilitate or make possible the learning of additional skills. Skills in this case refers to the wide range of empirical prerequisite cognitive, affective, and psychomotor skills. Familiarity refers to the sequencing of content based on the learners' past experiences or the frequency of the learners' contact with the subject matter elements. Difficulty sequencing is the presentation of less difficult content prior to more difficult content. Sequencing according to interest is the presentation of content which is more likely to be intrinsically interesting to the learners prior to less motivating material. The use of internalization sequencing is meant to induce students to internalize attitudes or values.

Utilization-related content can be sequenced to facilitate usage in social, personal, and career contexts. Although utilization-related principles can be broadly applied to all three contexts, they directly address the performance of enactive sequences. The sub-types of this
principle are: procedure and anticipated frequency of utilization. Procedure sequencing is the organization of content into the sequential steps of a process. The process can then be performed by following the sequence of steps and possibly by adapting the steps to meet individual performance needs. Anticipated frequency of utilization refers to curriculum design and so is not described here (p. 681).

**Sequence Design of Instructional Variables**

In the following discussion, Posner and Strike's principles of content sequencing are employed to clarify and distinguish the design of instructional sequences used in each of the four experimental treatments. The treatments are grouped within their instructional variable classification, e.g. Instructional Variables A (the concept organizer versus traditional introduction) or Instructional Variable B (the schema-organized versus traditional presentation).

**Sequencing the experimental instruction.**

Instructional Variable A1, the concept organizer is an adaptation of Ausubel's notion of the advance organizer. In the subsumption theory, Ausubel proposes that both the principles of learning psychology and the shared events or attributes of a specific set of concepts are tantamount in
importance to the overall content structure of the discipline of subject matter for the design of sequences (Posner & Strike, p. 683). Through the application of the concept-related principle of class relations the concept organizer reflects the logical superordinate-coordinate structure of a taxonomy of the subject matter concepts and exhibits the common properties between the coordinate concepts. The content within the organizer is compatible with the level of learning of the experimental population. The learning-related principle of familiarity was employed in the design of the organizer to help the learner recall associated material already in long-term memory and thereby relate the new material and the existent material in the student's cognitive structure. Finally, the principle of interest was employed to attempt to write an intrinsically interesting script for the learners in the experimental population.

Instructional Variable A2, the traditional introduction, was designed to present career related applications for the knowledge of and ability to scale distances with an architect's scale. Through the utilization-related portrayal of distance scaling activities by architects, interior designers, and engineers, distance scaling is shown to be an important, useful skill with widely varied applications in the world
of work. The learning-related principles of familiarity and interest are employed to select career examples with which the learners are likely to be familiar. The introduction sequence includes the slide presentation and discussion of examples of professional architectural or engineering drawings; architects, designers, and engineers at work; and buildings, interiors, and industrial products. The design of the traditional introduction is modeled after recommendations by Wilbur and Pendered in *Industrial Arts in General Education* (1967).

The design of the traditional presentation, Instructional Variable B1, was based on a utilization related presentation to define the subject matter concepts and explain what they will be used for by the subjects. A utilization related-procedural sequence was employed to present the demonstration sequence to show how to use the one-inch per foot scale of an architect's scale. Finally, a brief review was used to summarize the instructional material and procedural sequences. The learning related principle of empirical prerequisites was employed to select a level of learning compatible with the subject's prior ability to measure distances with a ruler--accurately to the nearest one-sixteenth of an inch.

The traditional sequence was presented via 35mm slide and audio tape narration of the specific concepts and
enactive tasks of the subject matter. At four separate intervals between the sequence presentations the projector was turned off and the subjects each completed a practice performance worksheet on the skill sequence just shown. Altogether, these practice worksheets covered scaling with both the one inch per foot and one-half inch per foot scales of the architect's scale; and the worksheets were identical to the practice worksheets administered in the schema-ordered treatment groups.

Instructional Variable B2, the schema-organized subject-matter presentation, utilizes the sequencing principles of conceptual-class relations, learning related-empirical prerequisites, and utilization-procedure as described by Posner and Strike (1976, pp. 674, 677, 678, & 680). The subject matter concepts were presented in the context of their coordinate class relations and to the main (superordinate) concept of measuring scaled distances. This ordering principle was selected because it orders the subject matter in a taxonomic structure compatible with the view of long-term memory structure described by Rumelhart et al. (1972), and provides an overall structure for the organization of the subject matter in the format of a formal frame or schema. The "learning related-empirical prerequisites" principle was employed to select and structure the specific subject matter to be taught from the
more complex discipline-related subject matter taxonomy of measuring scaled distances. The utilization-procedural principle was used to organize a scaling schema compatible with scaling distances with any of the scales of the architect's scale and organize the specific procedural steps for scaling distances with the one inch per foot and the one-half inch per foot scales. Finally, a brief review was included to summarize the schemata outlines and scaling procedures for the 1" per foot and 1/2" per foot scales.

Hypothetically, the two specific how-to sequences for the two specified scales were stored more efficiently and recalled more accurately because they were presented in a framework compatible with the structure of the subjects' long-term memories. In addition, the generalized schemata were available intact to be applied to the scaling of distances with scales other than the two specifically presented.

The schema-organized sequence was presented by a 35mm slide-tape show as was the traditional instructional sequence. Finally, the same four practice worksheets were employed to record the subjects' enactive performance abilities during the subject matter presentation that were administered during the traditional instructional sequence.
Level of Learning

The discipline-related structure of subject matter was reordered to fit the specific learning requirements of the instructional presentation and to match the level of complexity suitable for the learners. The subject matter of the study was delimited to the scaling of distance with the one inch scale and the one-half inch scale of the architect's scale. Bloom's taxonomy of educational objectives was used as the standard for specifying the level of cognitive learning objectives (Bloom, et al., 1956). Cognitive objectives and criterion test measures were written at the levels of knowledge, comprehension, and application (Bloom, et al., 1956, pp. 201-205). The three levels chosen reflect the introductory nature of the experimental presentations and are consistent with the exploratory nature of the secondary industrial arts program of the Calloway County High School, in which the experiment was conducted.

Hauenstein's taxonomy of the psychomotor domain (1972, p. 20) was employed for the selection of the level of enactive performance sequences utilized. Adequate learner hand-eye coordination constituted a necessary but not sufficient prerequisite for the performance of paper and pencil scaling tasks. The levels of subjects' enactive performances were dependent upon cognitive knowledge of the
enactive sequences of scaling distances and the ability to apply that cognitive knowledge at specified levels of psychomotor skill.

The hand-eye coordination required for scaling tasks is an ability which is also prerequisite for many other active performance tasks. The measure of neuromuscular movement is not of interest in this study as reflected by assumption number eight from chapter one. The interest here is to measure the learners' abilities to employ enactive sequences to perform skilled scaling tasks at specified levels. The levels of imitation and manipulation (Hauenstein, 1972, p. 20) were used to design enactive performance instructional objectives and to measure the enactive performance skills as exhibited by subjects on the enactive performance pretest and criterion tests.

Eight major elements of instructional design were employed in this study. The first element was the organization of a discipline-related taxonomy of the specific subject matter concepts to be learned. The second component was the writing of cognitive and psychomotor learning and performance objectives at the specified levels. The third step entailed the outlining and defining of the subject-matter concepts in a taxonomic format appropriate to the specific learning requirements. The fourth step was outlining the four instructional elements:
(a) the schema presentation, (b) the concept organizer, (c) the traditional introduction, and (d) the traditional presentation. The fifth step was the writing of the actual instruction for each of the four instructional elements. Sixth was the development of the cognitive and enactive performance tests. The seventh step was to produce the four instructional slide series. Eighth was the field testing, evaluating and revising of the instruction and tests.

Instructional Media

Narrated Slide Presentations

This section discusses the media selection for the delivery of the four instructional treatments and reviews the design criteria relevant to that media. The mode and quality of an instructional presentation can affect student attitudes and efficiency in learning the subject matter content. The following criteria were applied to minimize an experimental atmosphere and assure unbiased delivery of treatments. The presentation mode must: (a) allow replication of normal classroom procedures, (b) control instructional content in order to maximize intentional distinctions between treatments and ensure uniformity of delivery, and (c) allow students the opportunity to
practice the scaling skills and ask questions related to the instructional content and practice exercises.

The narrated slide presentation was selected with the provision for question slides to be inserted in the presentation at key points to provide the opportunity for students' questions and to administer practice worksheets. Video tape recordings and computer-aided instruction were also considered. Video tape recordings were not selected because the extreme close-ups of scale detail would be difficult to show on conventional monitors or large screens. The computer was dismissed because students' lack of familiarity with microcomputer usage would confound experimental results with computer familiarity, require instruction in computer use and introduce a novelty factor which did not represent conventional classroom management at Calloway County High School.

**Slide Show Design**

Since 1950, there has been considerable research in the broad area of audio-visual material design. Kemp (1975) offered a compilation of findings abstracted from several research summaries. In addition, Kueter (1981), Wright (1970), Ryan (1980) and The Eastman Kodak Company (1983) offer a wide range of design recommendations for the
planning of effective narrated slide productions. The following four categories of research recommendations formed the media design base employed in this research. The first comprises general design recommendations for slide-tape shows. The second category deals with the design of the visual message. The third set deals with the audio message, and category four treats the value and incorporation of questions and practice in slide-tape programs.

**General Recommendations**

Several research recommendations apply across all of slide show design and development. The following were incorporated to produce a professional quality presentation. First, as recommended by Ryan (p. 8), the subject matter was focused to avoid the inclusion of too many concepts. Second, the audience was identified and learning outcomes were written at the desired level of learning (Kueter, pp. 31-33). And third, instructional content was broken into its essential components to ensure the completeness of the presentation yet avoid nonessential or confusing details (Kemp, p. 26).
The Visual Script

The visual and audio scripts are both essential to effective narrated slide shows. In the design of the visual script, Ryan's recommendation (p. 8) that at least one visual be used for each step to be learned was incorporated to pace the presentation and be certain each learning step was individually described. As suggested by Wright (p. 68) repetition of colored tags and key slides was used to focus learning. Arrows were used to show change in position and add variety (Wright, p. 68), and the human hand was incorporated as a pointer to add interest and variety. Finally, title slides, questions and cuing devices were used to direct the learner's attention and stimulate thinking (Kemp, p. 23).

The Narrative

The narrative scripts in this study not only clarify and emphasize the visual message, but frequently carry the dominant instructional message. Therefore, the narrations were written prior to visual scripting and were revised concomitantly with the visuals. As recommended by Kemp (p. 24) the script was kept as concise as possible and pauses were incorporated to avoid verbal saturation and allow for "reading the visual." The script was written in the second person active voice to be dynamic and involve
its audience (Kemp, p. 22). Finally, Lewman (p. 17) and Kueter (p. 25) caution to avoid strict adherence to formal grammatical punctuation as these may sound stilted when read. Therefore, an enthusiastic conversational narrator was employed.

Practices and Questions

As questions can be employed to motivate and stimulate thinking, skilled practice spaced within a presentation can facilitate performance of skill techniques (Kemp, p. 22). As recommended by Ryan (p. 8), questions were employed to increase the students' involvement in the learning process, and as recommended by Kemp (p. 24), solutions to scale reading questions were provided to reinforce learning. Four distinct practice worksheets were incorporated within the instructional presentation. Each worksheet was completed following a discrete unit of instruction and related directly to that unit of instruction; students were encouraged to ask questions prior to and during practice intervals. And finally, the solutions to each practice worksheet item were given in the slide show immediately following each practice period.

NOTE: The original scripts and slides may be obtained from: Bert Siebold, Department of Industrial Education and Technology, Murray State University, Murray, Kentucky 42071.
Chapter two provides the theoretical context to support the research hypotheses of the study. Both Ausubel's subsumption theory and schema theory are predicated on the cognitive view of learning. Cognitive psychology posits that school learning comprises: stimulus presentation, interpretation of the stimulus by the learner, encoding in memory, and immediate or delayed recall-response outputs. First Ausubel and later schema theorists describe meaningful knowledge acquisition as knowledge which learners have related to what they already know about the subject. Schema theorists, however, refine Ausubel's theory of subsumption to specifically suggest that the instructional materials can be learned more accurately and reliably if learners can recall or abstract an appropriate memory schema to structure the novel material for encoding in LTM.

The topic of instructional content sequencing is addressed to objectively qualify and maximize the distinctions between treatment variable levels. Narrated slide-tape show design and production is also reviewed to aid in the design and production of effective instructional presentations.
CHAPTER III

EXPERIMENTAL AND STATISTICAL DESIGN

Chapter Three presents the experimental research design, procedures, and statistical design of the study. The chapter is organized into the following presentations: (a) instructional treatment variables, (b) pretest measures, (c) a third potential covariate, (d) criterion measures, (e) instrumentation reliability and testing, (f) research design, (g) null hypotheses, (h) ecological setting, (i) population and sample description, (j) experimental procedures, (k) pre-pilot and pilot studies, (l) statistical design, and (m) summary.

Instructional Treatment Variables

Two distinct types of instructional treatment variables were employed. The first was a two-level independent variable, Instructional Variable A (IVA). IVA—level one (IVA 1) is a concept organizer to arouse
students' interests, to provide subsuming and coordinate concepts and to clarify the immediate realm of knowledge into which the concept of scaling distances belongs taxonomically. The concept organizer design is based on Ausubel's criteria for advance organizer design.

IVA—level two (IVA 2) is a traditional introduction to arouse students' interests, and to show how the scaling of distances may apply to careers in business and industry or to the avocational interests of students.

The traditional introduction is designed to reflect the criteria for subject matter lesson introductions as described by Wilbur and Pondered (1967, pp. 107, 111).

The second instructional treatment variable is also a two-level independent variable, Instructional Variable B (IVB). IVB—level one (IVB 1) is a traditional presentation of distance scaling concepts and sequences as organized with the format described by Wilbur and Pondered (1967, p. 109). IVB—level two (IVB 2) is the experimental presentation of the identical subject matter employed in IVB 1. IVB 2 is a schema organized presentation designed to provide suitable long-term memory schemata which may aid in the encoding and retrieval of the concepts, conceptual relations, and enactive sequences related to the concepts.
The schema design has been based on information processing-schema theory as compatible with Rumelhart et al.'s model (1972) of human long-term memory.

The two types of treatment variables were then crossed with one another to produce four distinct experimental treatments as illustrated in Table 1.

Table 1
Identification of Experimental Treatments

<table>
<thead>
<tr>
<th>Treatment Group No.</th>
<th>Instructional Variable A</th>
<th>Instructional Variable B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concept Organizer</td>
<td>Traditional Sequence</td>
</tr>
<tr>
<td>2</td>
<td>Traditional Introduction</td>
<td>Traditional Sequence</td>
</tr>
<tr>
<td>3</td>
<td>Concept Organizer</td>
<td>Schema Ordered Sequence</td>
</tr>
<tr>
<td>4</td>
<td>Traditional Introduction</td>
<td>Schema Ordered Sequence</td>
</tr>
</tbody>
</table>

Pretest Measures

Two distinct pretests were developed to provide covariate data and describe any initial variance between the experimental units. The first pretest was a researcher-made test of skill with a standard twelve inch English ruler (Appendix A). The second covariate measure (Appendix B) was a measure of the subjects' abilities to
perform distance scaling task sequences with an architect's scale at the imitation and manipulation levels of Hauenstein's taxonomy of the psychomotor domain (1972, p. 21).

A Third Covariate

Due to the breadth of the concrete to conceptual levels of the cognitive content and the apparent potential for manipulative confusion while learning to perform scaling tasks, the hypothesis was made that intelligence as measured by subjects' intelligence quotient (IQ) scores might have a meaningful bearing on experimental results. Therefore, IQ scores were recorded for the data producing sample in each cell (though not relateable to subjects by name) and the hypothesis of no difference was tested at an alpha level of .05. Rejection of the null was considered sufficient justification to sacrifice a statistical degree of freedom and IQ scores were therefore installed as a third covariate.

Criterion Measures

Two separate criterion instruments were developed by the researcher to measure treatment effects. These
instruments were: (a) an objective paper and pencil test of enactive performance skill consisting of multiple-choice items and scaling problems (Appendix C), and (b) an objective cognitive paper and pencil test consisting of multiple-choice questions (Appendix D).

The cognitive paper and pencil posttest was designed to measure each subject's cognitive ability to recall-recognize, comprehend-classify, and to apply the concepts and usage sequences of the subject matter as classified in Bloom, et al. (1956, pp. 78-184). This test does not include any items which require the procedural performance of any of the subject-matter content. The cognitive posttest of retained learning is a randomly rearranged version of the initial cognitive posttest.

Additionally, the specification table used in the design of this test required that test items be classified by level of complexity. Two categories or levels of questions were established to satisfy the requirements of research hypotheses one, four, and five. Category One comprised knowledge level questions, while Category Two included comprehension and application (Bloom, et al., 1956) level questions. Each category contained fourteen of the total twenty-eight test items, and each category of 14 questions was treated as a separate subtest in the statistical analysis. The cognitive criterion test was used
to measure the effect of treatments on overall cognitive learning and to test for differential effects between low level and higher level cognitive learning.

The initial and retained criterion measures of enactive performance were identical to the pretest of scaling with the architect's scale. Like the pretest, the enactive criterion test was designed to measure each subject's ability to imitate and manipulate (Hauenstein, 1972, pp. 20-21) the knowledge of the subject matter sequences by performing scaling tasks using the architect's scale on a paper and pencil test. The tasks required subjects to imitate the demonstrated sequence by: (a) scaling a given line with a specified scale, and (b) drawing a specified line to scale when given a specified scale and scaled length. The enactive test also required subjects to manipulate the scaling sequences by: (a) reducing given scaled lines to other reduced scale representations (this required the use of scales which were analogous to using the one inch per foot scale, but which were not included in the instructional lesson), (b) enlarging a one-half inch per foot scaled triangle to double its original size, and (c) by determining which scale had been used to perform a series of scaling tasks as detailed in Appendices C and I. The enactive performance test was not designed to require performance at the
performance or perfecting levels of Hauenstein's taxonomy (1972, p. 21). No questions were included in any criterion measure directly related to career utilization, subsuming concepts, or any material which was the exclusive content of either the concept organizer or the traditional introduction.

Tests were evaluated by blind scoring. The multiple-choice items were scored with a standardized key and the reduced and enlarged scale drawings were scored with a standardized key which made no partial credit allowances. An error tolerance of + or - 1/32 inch was made to allow for minor discrepancies in scale readings or marking distances to scale by subjects.

Tests of Instrumentation
Reliability and Validity

The Kruder Richardson Formula 20 Test was used to measure the reliability of all testing instruments in this study. The split-half and KR 21 tests were considered but rejected for the more rigorous and accurate KR 20 Formula. The KR 20 Formula is a relationship of the proportions of subjects answering each particular test item correctly and the standard deviation of the total scores.
All criterion instruments were written, evaluated and revised by the researcher. The tests were revised again after each of two sets of pre-pilot study administrations of the experiment. In each of these pre-pilot administrations, students marked the hardest, easiest and most confusing questions. Finally, the tests were reviewed by Dr. E. K. Blankenbaker of The Ohio State University (Columbus, Ohio) and Dr. Edward Adams of Murray State University (Murray, Kentucky). Their reviews were incorporated and the final instruments were printed.

The series of practice worksheets administered during the instructional treatments were also scored and analyzed. The practice exercises were identical for all treatment groups and consisted of four practice sheets. Each of the four worksheets related to a specific sub-sequence of instruction and each was administered during a planned break in the instruction as marked by a specialized question slide in the slide presentation. The separate practice worksheet scores were then analyzed as separate measures to test for significant differences between groups during the instructional sequences. Kennedy recommended a one-between-group and one-within design and a one-way ANOVA as the appropriate statistical design for the worksheet data (in conversation, 1983). The practice session scores were not analyzed as posttest scores.
The research design employed was a quasi-experimental Campbell and Stanley "nonequivalent control group design" (1966, p. 47). By virtue of the dual administration of the cognitive and enactive dependent measures, the design herein is also properly labeled a repeated measures design and so is eligible to be analyzed by a repeated measures statistical design. Four experimental groups arranged in a 2 x 2 factorial matrix as shown in Table 2. The schematic of the experimental sequence is given in Table 3.

### Table 2

<table>
<thead>
<tr>
<th></th>
<th>A 1</th>
<th>A 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cell No. 1</td>
<td>Cell No. 2</td>
</tr>
<tr>
<td>B 1</td>
<td>Concept Organizer and Traditional</td>
<td>Traditional Introduction and</td>
</tr>
<tr>
<td></td>
<td>Sequence</td>
<td>Traditional Sequence</td>
</tr>
<tr>
<td></td>
<td>Cell No. 3</td>
<td>Cell No. 4</td>
</tr>
<tr>
<td>B 2</td>
<td>Concept Organizer and Schema</td>
<td>Traditional Introduction and</td>
</tr>
<tr>
<td></td>
<td>Organized Sequence</td>
<td>Schema Organized Sequence</td>
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Table 3
The Schematic Design of Experimental Sequence

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 10</th>
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<tr>
<td>01</td>
<td>02</td>
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<td>09</td>
<td>X2-010</td>
<td>011</td>
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<td>015</td>
<td>016</td>
<td>X3-017</td>
<td>018</td>
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<tr>
<td>022</td>
<td>023</td>
<td>X4-024</td>
<td>025</td>
</tr>
</tbody>
</table>

NOTES: X1 - Concept organizer and traditional content presentation.
X2 - Traditional introduction and traditional content presentation.
X3 - Concept organizer and schema organized presentation.
X4 - Traditional introduction and schema organized presentation.

01, 08, 015, and 022 are administrations of the pretest of skill with the 12 inch ruler.
02, 09, 016, and 023 are administrations of the scaling enactive performance pretest.
03, 010, 017, and 024 are the enactive performance practice worksheet measures made during the instructional treatments. The measures were administered as four brief exercises.
04, 011, 018, and 025 are occurrences of the enactive scaling posttest. This test is identical to the enactive performance pretest.
05, 012, 019, and 026 are occurrences of the paper and pencil cognitive test of initial scaling knowledge.
06, 013, 020, and 027 are occurrences of the enactive retention scaling posttest. This test is identical to both the enactive performance pretest and initial enactive scaling posttest.
07, 014, 021, and 028 are administrations of the measure of retained cognitive scaling knowledge, a randomly rearranged version of the initial cognitive posttest.
Experimental units were individual students within the intact classes. The data producing sample of the four intact classes consisted of 14 to 18 subjects each and all experimental treatments were randomly assigned to intact groups as illustrated in Table 4. All treatments were administered via slide and audio tape presentations by the same instructor in a manner as nearly identical to normal classroom procedure as possible. The presenting instructor was "blind" to the research goals of the experiment, and to the relationship of the experimental treatments and treatment groups to those goals. An audio tape recording of each treatment presentation was made. All objective criterion tests were administered by the regular classroom teacher and scored by two blind scorers from standardized answer keys. A Kruder Richardson 20 reliability measure was made for each version of each test.
Table 4
Identification of Cells by Randomly Assigned Treatments

<table>
<thead>
<tr>
<th>Cell #</th>
<th>Matrix Name</th>
<th>Cell Treatment Name</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A 1 B 1</td>
<td>Concept Organizer &amp; Traditional Instruction</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>A 2 B 1</td>
<td>Traditional Introduction &amp; Traditional Instruction</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>A 1 B 2</td>
<td>Concept Organizer &amp; Schema Instruction</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>A 2 B 2</td>
<td>Traditional Introduction &amp; Schema Instruction</td>
<td>17</td>
</tr>
</tbody>
</table>

TL. 66

Control of Internal Extraneous Variables

Campbell and Stanley's nonequivalent control group design does not control for the combined effects of selection and testing. To assess the variance due to selection and testing interaction, the means and standard deviations of each group's scores were compared. Pearson Product Moment Correlation calculations were not necessary since between-group variables in pretest and IQ data were corrected for by the covariate statistical methods. In addition, the design does not necessarily control for statistical regression toward the mean of extreme test scores.
Since only one group was used for each treatment, the variance due to group error was confounded with the variance due to each group's respective treatment. A strong linear relationship was found between both pretest measure's IQ and the two criterion measures. Therefore, MANCOVA and univariate ANCOVA tests were used to statistically compensate group variance effects due to knowledge of measuring and the ability to measure and draw to scale.

Finally, intrasession history also posed a threat to internal validity. Consistent presentation of the treatment variables, consistent classroom control, and the absence of external factors such as fire alarm drills were the key factors here. The following precautions were taken to minimize or record intrasession effects: (a) the research dates were scheduled with both Mr. Nix and the school principal to minimize external school interferences; (b) the experimenter and regular classroom teacher were present throughout all phases of testing and treatment periods; and (c) an audio recording was made of the entire experimental sequence to allow for review of classroom events by interested parties.
Null Hypotheses

The null hypotheses tested that:

Ho 1: No significant difference in initial cognitive learning at or above Bloom's "comprehension" level (1956, p. 89) would exist between the concept organizer groups ($H_1, H_3$) and the groups which received the traditional introduction ($H_2, H_4$) as measured by the initial cognitive criterion test. Ho 1: $H_1, H_3 = H_2, H_4$.

Ho 2: No significant difference in retained cognitive learning at or above Bloom's "comprehension" level (1956, p. 89) would be found between the concept organizer groups ($H_1, H_3$) and the groups which received the traditional introduction ($H_2, H_4$) as measured by the cognitive retention criterion test. Ho 2: $H_1, H_3 = H_2, H_4$.

Ho 3: The treatment groups which received the traditional introduction ($H_2, H_4$) performed equal to or significantly better on initial cognitive learning at the knowledge level of Bloom's taxonomy (Bloom, 1956) than the treatment groups which received the concept organizer ($H_1, H_3$) as measured by the initial cognitive posttest. Ho 3: $H_2, H_4 > H_1, H_3$.

Ho 4: The traditional introduction treatment groups ($H_2, H_4$) performed equal to or significantly better on retained cognitive learning at the knowledge level of
Bloom's taxonomy (Bloom, 1956) than the treatment groups which received the concept organizer ($M_1, M_3$) as measured by the cognitive posttest of retained learning. Ho 4: $M_2, M_4 \geq M_1, M_3$.

Ho 5: No significant difference would be found in initial measures of cognitive learning between the treatment groups which received the traditionally structured presentation ($M_1, M_2$) and the schema instructional treatment groups ($M_3, M_4$) as measured by the initial cognitive criterion test. Ho 5: $M_1, M_2 = M_3, M_4$.

Ho 6: No significant difference would be found in initial measures of enactive performance between treatment groups which received the traditionally structured presentation ($M_1, M_2$) and the schema instructional treatment groups ($M_3, M_4$) as measured by the initial enactive criterion test. Ho 6: $M_1, M_2 = M_3, M_4$.

Ho 7: No significant difference would be found in retained measures of cognitive learning between the treatment groups which received the traditionally structured presentation ($M_1, M_2$) and the schema instructional treatments groups ($M_3, M_4$) as measured by the cognitive retention criterion test. Ho 7: $M_1, M_2 = M_3, M_4$.

Ho 8: No significant difference would be found in retained measures of enactive performance between the
groups which received the traditionally structured presentation (H1, H2) and the schema instructional treatment groups (H3, H4) as measured by the enactive retention criterion test. Ho 8: $H_1, H_2 \neq H_3, H_4$.

Ho 9: No significant difference in measures of initial cognitive learning would be found between the treatment group which received the concept organizer and the schema structured presentation (H3) and any of the other treatment groups (H1, H2, H4) as measured by the initial cognitive criterion test. Ho 9: $H_3 = H_1, H_2, H_4$.

Ho 10: No significant difference in measures of initial enactive performance would be found between the treatment group which received the concept organizer and the schema structured presentation (H3) and any of the other treatment groups (H1, H2, H4) as measured by the initial enactive criterion test. Ho 10: $H_3 = H_1, H_2, H_4$.

Ho 11: No significant difference in measures of retained cognitive learning would be found between the treatment group which received the concept organizer and the schema structured presentation (H3) and any of the other treatment groups (H1, H2, H4) as measured by the retention posttest of cognitive learning. Ho 11: $H_3 = H_1, H_2, H_4$.

Ho 12: No significant difference in measures of retained enactive performance would be found between the
treatment group which received the concept organizer and the schema structured presentation ($M_3$) and any of the other treatment groups ($M_1, M_2, M_4$) as measured by the enactive performance retention test. Ho 12: $U_3 = U_1, U_2, U_4$.

Ho 13: No significant differences in the retention of cognitive knowledge at or above the "comprehension" level (Bloom, 1956) would be found between treatment groups which receive the concept organizer ($M_1, M_3$) and the traditional introduction ($M_2, M_4$) as measured by the differences between initial and retention scores on the cognitive criterion tests. Ho 13: $M_1, M_3 = M_2, M_4$.

Ho 14: No significant differences in retention of cognitive knowledge would be found between treatment groups who received the traditionally organized instructional element ($M_1, M_2$) and the schema organized instructional element ($M_3, M_4$) as measured by differences in scores on the initial and retained cognitive criterion tests. Ho 14: $M_2, M_4 = M_1, M_3$.

Ho 15: No significant differences in retention of enactive knowledge would be found between treatment groups who received the traditionally organized instructional
element ($\mu_1, \mu_2$) and the schema organized instructional element ($\mu_3, \mu_4$) as measured by differences in scores on the initial and retained enactive criterion tests. Ho 15 = $\mu_2, \mu_4 = \mu_1, \mu_3$.

Ho 16: No significant differences in retention of cognitive knowledge would be found between treatment groups which received both the concept organizer and the schematically organized instructional elements ($\mu_3$) and treatment groups which received any of the other three experimental treatment combinations ($\mu_1, \mu_2, \mu_4$) as measured by differences in scores on the initial and retention cognitive criterion tests. Ho 16 = $\mu_3 = \mu_1, \mu_2, \mu_4$.

Ho 17: No significant differences in retention of enactive knowledge would be found between treatment groups which received both the concept organizer and the schematically organized instructional elements ($\mu_3$) and treatment groups which received any of the other three experimental treatment combinations ($\mu_1, \mu_2, \mu_4$) as measured by differences in scores on the initial and retention enactive criterion tests. Ho 17 = $\mu_3 = \mu_1, \mu_2, \mu_4$. 
Ecological Setting

The Calloway County High School is a modern central facility which houses about 1,200 students. Calloway County is a rural agricultural county of 30,000 residents. Most families depend on truck farming, tobacco farming, dairy or beef farming or factory work for their income. The school is located in the northwest corner of the city of Murray, Kentucky. Murray is a small city of 14,200 residents which hosts a state university of 7,500 full-time equivalent students.

The industrial arts faculty at Calloway County High consists of one and one-half full-time instructors. Mr. William Nix, the full-time instructor, has taught industrial arts for twelve years. During the years from 1976-1983, however, he served as assistant principal of Calloway County High School. Mr. Nix's Fall 1985 classes consisted of two classes of basic woods, two general industrial arts classes, and a drafting communication course. The first four classes were chosen as the experimental population to minimize the influence of prior scaling knowledge on the experimental results. At Calloway County High School, classes are scheduled in a student's high school program so that normally the drafting course is taken in the 11th or 12th year. Therefore, students in the
basic materials processing courses were not likely to have taken the drafting class.

Control of Ecological Extraneous Variables

Possible ecological extraneous variables such as compensatory rivalry, resentful demoralization, and diffusion were minimized by the equal treatment of all groups through: treatment preparation quality, anonymity of the experimental groups' identities, and minimum deviation from normal classroom procedures for all groups.

Population and Sample Description

The population was the students in four of the five intact industrial arts classes taught by Mr. William Nix, the industrial arts teacher at Calloway County High School, Murray, Kentucky. The invited sample was the population. The data producing sample contained sixty-six students, 14 to 18 students from each of the four classes. Differential mortality was the primary cause for the unequal cell sizes of the data producing sample.
Experimental Procedures

Each experimental subject participated in the following sequence: (a) enactive/skill pretest of measuring with a standard 12" ruler, (b) enactive/skill scaling pretest, (c) treatment and enactive scaling worksheets, (d) enactive performance posttest, (e) cognitive scaling posttest, (f) cognitive scaling retention test, and (g) enactive performance scaling retention test.

Steps A through E of the experimental sequence were completed during the subjects' regularly scheduled industrial arts class periods on three consecutive days. On the first day, the enactive pretest of measuring with a ruler and enactive scaling pretests were given. The second day began with the presentation of treatment variables and enactive scaling practice worksheets. The enactive scaling and initial cognitive posttests were administered on the third day at the start of each class. The enactive performance retention test was administered seven days following the initial cognitive posttest. The posttest of cognitive retention was given immediately following the cognitive-retention posttest.
Pre-pilot and Pilot Study

A pre-pilot study was held at the East Carter County High School with six students as a dress rehearsal of all tests and instructional slide sequences. Minor changes were made in the slide and scripts, and several test items were rewritten. A pilot study was then conducted to test and refine the instructional materials and experimental procedures still further. The pretests and criterion tests were also tested and refined through student responses and Kruder-Richardson 20 reliability measures. The KR 20 rating for the enactive test of architect's scale usage was .85, while the KR 20 rating for the cognitive posttest yielded a .68. The pilot study was conducted with industrial arts students at the Murray (City) High School, Murray, Kentucky.

Statistical Design

The statistical design accounts for variance due to: (a) the main effect of either Instructional Variable A and/or Instructional Variable B, (b) any possible interactions between the instructional variables, and
(c) the individual differences of subjects within the experimental groups. A repeated measures two-factor fixed effects design was chosen for two effects between (the independent variables) and one effect nested within (the subjects). See Table 5.

Table 5
Repeated Measures Two Factor Fixed Effects Design

<table>
<thead>
<tr>
<th>Type of Introduction</th>
<th>Type of Introduction</th>
<th>DV₁ Time One</th>
<th>DV₁ Time Two</th>
<th>DV₂ Time One</th>
<th>DV₂ Time Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₁</td>
<td>A₁</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td></td>
</tr>
<tr>
<td>B₁</td>
<td>B₁</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td></td>
</tr>
<tr>
<td>A₂</td>
<td>A₂</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td></td>
</tr>
<tr>
<td>B₂</td>
<td>B₂</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td>(S₁...S₁₈)(S₁...S₁₈)</td>
<td></td>
</tr>
</tbody>
</table>

The summary table recommended by Kennedy (1972, p. 269) for the two factor fixed effects design is outlined in Table 6.
Table 6

General Summary Table for Two Factor Fixed-Effects Designs

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS*</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>a-1</td>
<td>SS(A)/a-1</td>
<td>MS(A)/MS(S/AB)</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>b-1</td>
<td>SS(B)/b-1</td>
<td>MS(B)/MS(S/AB)</td>
<td></td>
</tr>
<tr>
<td>AB</td>
<td>(a-1)(b-1)</td>
<td>SS(AB)/(a-1)(b-1)</td>
<td>MS(AB)/MS(S/AB)</td>
<td></td>
</tr>
<tr>
<td>S/AB</td>
<td>ab(n-1)</td>
<td>SS(S/AB)/ab(n-1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>abn-1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* sums of squares formulas found in Kennedy, 1972, pp. 264-265.

Both descriptive and inferential statistical analyses were executed. The SAS program was used to calculate all statistics (SAS Institute, Inc., 1985).

Descriptive Analyses

Prior to the execution of the inferential analyses, the following data were computed for each experimental group independently and for the population as a whole: mean pretest and posttest scores, standard deviations of pre-posttest scores, and intelligence quotient scores.

Since the two pretest measures and IQ scores were used as covariates, Pearson Product Moment Correlation
Coefficients were not calculated between treatment groups on pretest descriptive measures. IQ scores were compiled only for the data producing sample, and at no time were the names of specific subjects relatable to their personal set of descriptive data.

**Inferential Analyses**

A repeated measures multivariate analysis of covariance (MANCOVA) was the first choice for the calculation of inferential statistics. The choice of the MANCOVA was based on satisfaction of the following requisites: a repeated measures research design (both dependent variables were repeated), multiple dependent variables which were correlated (the enactive performance and cognitive knowledge posttests), and the presence of covariates (the ruler pretest, the scale reading enactive pretest and IQ). The tactical advantage of a repeated measures MANCOVA is that the procedure performs a two-way MANCOVA of the difference between subjects' scores on the initial and retention instances of each dependent variable without requiring additional statistical procedures. The repeated measures MANCOVA, then, simplifies the analysis of "change score" variance between groups. The testing of change score variance is necessary to test null hypotheses 13 through 17.
A MANCOVA (non-repeated measures) was the second choice for inferential testing. The MANCOVA was to be employed if the variance of difference between any two dependent variables did not hold the relationship of sphericity (conversation with Malec, 1986). The repeated-measures MANCOVA assumes that a mathematical relationship of sphericity exists between dependent variables. If this assumption is rejected by a significant F test (alpha = .05), then the repeated measures design would not be appropriate and a regular MANCOVA must be run.

Summary

In chapter three the ground work has been laid for the experimental and statistical designs of the study. The chapter presented the following topics: instructional treatment variables, pretest measures, a third covariate, criterion measures, instrumentation, reliability and testing, research design, null hypotheses, ecological setting, population and sample description, experimental procedures, pre-pilot and pilot studies, statistical design, and summary.

Chapter four presents the descriptive and inferential analyses of the study. The reliability and descriptive results of both covariate and criterion tests are reported.
The inferential statistical procedures are described and results are reported in summary tables. The research and null hypotheses are tested; and finally, an ANCOVA analysis of the practice worksheets is included.
CHAPTER IV

DATA ANALYSIS

This chapter is a presentation and analysis of the experimental data. Summary tables derived from the SAS statistical program (SAS Institute, Inc., 1985) were employed to provide a concise display of the statistical results. The chapter includes the following sections: (a) instrumentation and descriptive statistics, (b) statistical procedures and results, (c) hypothesis testing and results, and (d) analysis of practice worksheets.

Instrumentation and Descriptive Statistics

Three distinct categories of instrumentation were employed: pretests, initial criterion tests, and retention tests. Pretest measures comprised (a) a test of skill with a standard twelve inch English ruler (Appendix A), and (b) a test of enactive performance/skill with the architect's scale (Appendix B). Both tests were used as covariates.
The two initial criterion tests were given the day following the instruction. First, a test of enactive performance/skill with the architect's scale was administered (Appendix C). This test was identical to the architect's scale pretest. Second, a test of cognitive knowledge was employed to measure each student's factual and procedural knowledge of scaling with an architect's scale (Appendix D). This test of cognitive knowledge was then split into two separate measures: (a) a measure of knowledge memorization/recall level learning (Appendix E), and (b) a measure of comprehension and application levels of learning (Bloom, et al., 1956) (Appendix F).

Two tests of retained learning were also administered. The first of these was identical to the pretest and initial criterion test of enactive performance (Appendix G). The second retention test was a randomly rearranged version of the initial measure of cognitive knowledge (Appendix H). Like the initial cognitive posttest, this second retention test was divided further into measure of knowledge level learning (Appendix I) and a composite comprehension and application level of learning (Appendix J).

A Third Covariate

Intelligence Quotient scores were recorded for experimental subjects (though not relatable to subjects by
name) and a two-way analysis of variance (ANOVA) was performed to test for significant differences between cells. The statistical results were $F(1, 59) = 4.911$, $p = .031$ for the main effect of $B$. With alpha set at the .05 level the null hypothesis of no difference was rejected and it was assumed that for the main effect of instruction a significant difference existed between the mean group I.Q.'s ($\mu_1, \mu_2 = \mu_3, \mu_4$). Therefore, a statistical degree of freedom was sacrificed to establish an apparently valuable covariate. No significant difference was found in differences in I.Q. scores over the main effect of $A$ (types of introduction) $F(1, 59) = .000$, $p = .989$ or for the interaction of $A$ and $B$, $F(1, 59) = .753$, $p = .389$.

Summary Tables

The summary tables to follow, Tables 7 to 14, are a condensation of the descriptive statistics of all covariate and criterion measures, the Kruder Richardson 20 reliability measures of pretest and criterion measures, and cell identification information.

These summary tables reveal several characteristics of the data producing sample and give overall indications of the effects of the treatments on both cognitive and skill learning. Salient observations are noted here; some of which may illuminate the report of inferential statistics.
First, the pretest measures show noteworthy though nonsignificant differences in subjects' abilities to read a twelve inch ruler and to use an architect's scale. Statistically significant differences are shown in mean intelligence (Table 7). Therefore, their value as covariates was accepted at the cost of three degrees of freedom to the inferential analyses. Second, the variability of standard deviation values does not appear to hold a linear relationship to mean values on any pretest or posttest measures. The test of homogeneity of variance is met and analysis of variance statistics can be appropriately applied for the inferential analysis. Third, as shown by the pretest of scaling skill, all groups possessed very limited prior ability to perform scaling tasks (Table 7).

Experimental subjects in all groups showed strong gains in scaling skill after the instructional treatments. The overall scaling pretest mean of 22.42 rose to 64.02 on the initial scaling skill posttest. This nearly threefold increase and its relative consistency across groups might indicate a practice effect of testing. However, since the scaling retention posttest yielded an overall mean of 67.05, only 5.02% higher than the 64.02 overall mean of the initial scaling posttest, the practice effect of testing would not appear to be the dominant influence. A high
degree of effectiveness of all treatment combinations is shown here, especially when it is noted that some of the tested items were generally more difficult or complex than the instructional treatment examples.

The experimental subjects who received the traditional introduction combined with the traditional instruction held the second highest I.Q. scores (104.21) and the lowest scaling pretest mean (18.92). The combination may have been a factor in their attainment of the highest initial scaling criterion scores (68.21 from Table 8), but notably they achieved the lowest scaling skill retention scores (62.14 from Table 9) and were the only group whose scaling retention scores were lower than their initial scaling posttest scores. This may indicate uncharacteristically high initial scaling scores and regression on the posttest or may truly reflect an instance of high initial learning with rapid attenuation.

Finally, the subjects who received the treatment combination of the traditional introduction and the schema presentation showed the highest retention scores of all subjects on scaling skill and overall cognitive knowledge (including the highest retention test scores on both the knowledge level and the comprehension/application level cognitive subtests). The students who received the combined traditional introduction and schema instruction
also had the highest differential retention on both skill and cognitive measures (except for the comprehension/application level of cognitive knowledge where they were a close second) (Tables 11-14). The statistical implications of these data patterns are discussed in the section of Hypothesis Testing and Results.

**Instrumentation Reliability Testing**

As discussed in Chapter III, the Kruder Richardson Formula 20 was chosen for its rigor and accuracy as the test for instrumentation reliability. This test is essentially a ratio of the internal consistency divided by the variance, which is then multiplied by $\frac{n}{n-1}$ where $n$ is the number of items on the test. Due to the nature of this formula, tests which have a high measure of internal consistency and large variances (which are then multiplied by a number slightly greater than 1.00) may indeed yield KR 20 measures which approach or exceed unity (Gronlund, 1976, p. 118). Additionally, the tests were quite homogeneous in content which also contributes to high reliability coefficients. These high measures of reliability did indeed occur on some measures as noted in Tables 7 to 10. The reliability coefficients were confirmed by a second and third administration of the scaling skill test and an administration of a randomly rearranged version of the
### Table 7

**INSTRUMENTATION AND DESCRIPTIVE STATISTICS SUMMARY TABLE**

#### Covariate Measures

<table>
<thead>
<tr>
<th>Covariate Measure</th>
<th>KR 20</th>
<th>Treatment Name</th>
<th>Cell #</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ruler</strong></td>
<td></td>
<td></td>
<td></td>
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<td>Concept Organizer and Traditional Instruction</td>
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<td>18</td>
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Table 7 (continued)

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<th>SD</th>
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<td>12.58</td>
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Table 8
INSTRUMENTATION AND DESCRIPTIVE
STATISTICS SUMMARY TABLE

Initial Criterion Measures

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<th>Initial Criterion Measures</th>
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1.0526 T1 66 64.02 23.11

| Cognitive Knowledge Initial Posttest |       | Concept Organizer and Traditional Instruction       | 1      | 18  | 43.06  | 16.05 |
|                                     |       | Traditional Introduction & Traditional Instruction  | 2      | 14  | 40.79  | 10.23 |
|                                     |       | Concept Organizer and Schema Instruction            | 3      | 17  | 40.00  | 12.82 |
|                                     |       | Traditional Introduction and Schema Instruction     | 4      | 17  | 40.29  | 14.71 |
|                                     |       |                                                     |        |     | 0.9911 |       |

0.9911 T1 66 41.08 13.55
Table 8 (continued)

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Table 10
INSTRUMENTATION AND DESCRIPTIVE
STATISTICS SUMMARY TABLE

Retention Criterion Measures--Subtest by Cognitive Level

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<th>Mean %</th>
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<td>16.78</td>
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Table 11
INSTRUMENTATION AND DESCRIPTIVE STATISTICS SUMMARY TABLE

Enactive Performance (Initial Minus Retention) Change Scores

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<th>Measure</th>
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<th>Cell #</th>
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<td>-6.47</td>
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Table 12

INSTRUMENTATION AND DESCRIPTIVE
STATISTICS SUMMARY TABLE

Cognitive Knowledge (Initial Minus Retention) Change Scores

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<tr>
<th>Measure</th>
<th>KR 20</th>
<th>Treatment Name</th>
<th>Cell #</th>
<th>n</th>
<th>Mean % Change</th>
<th>SD</th>
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Table 13
INSTRUMENTATION AND DESCRIPTIVE
STATISTICS SUMMARY TABLE

Cognitive Knowledge Change Scores for "Knowledge Level Subtest"

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<th>Measure</th>
<th>KR 20</th>
<th>Treatment Name</th>
<th>Cell #</th>
<th>n</th>
<th>Mean % Change</th>
<th>SD</th>
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<td></td>
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<td>17</td>
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<td>14.37</td>
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### Table 14

**INSTRUMENTATION AND DESCRIPTIVE STATISTICAL SUMMARY TABLE**

Cognitive Knowledge Change Scores for "Comprehension/Application" Level Subtest

<table>
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<tr>
<th>Measure</th>
<th>KR 20</th>
<th>Treatment Name</th>
<th>Cell #</th>
<th>n</th>
<th>Mean % Change</th>
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</table>
initial cognitive tests as retention measures. Finally, the calculations were computed to eight decimal places to mitigate any effect to rounding error.

**Statistical Procedures**

The first statistical procedure employed was a repeated measures multivariate analysis of covariance (repeated measures MANCOVA). The dual administration of every dependent variable lent itself nicely to this analysis, and its advantage of increased efficiency was not lost on the researcher. Additionally, the repeated measures MANCOVA allows testing for differences in scores on the same test, as they vary from the initial posttest administration to the retention test instance. This testing of effects over time would satisfy the testing of Ho 13 through Ho 17 without a separate analysis of change scores to measure differential group retention.

The repeated measures MANCOVA procedure, however, is predicated on the assumption of passing Bartlett's test of sphericity, which is a mathematical relationship of the variance of differences between any two dependent variables (conversation with Malec, 1986). Since, in each of the repeated measures MANCOVA analyses in this study, Bartlett's test assumption was rejected by a wide margin $F$
(3,62) = 11.42, p = .01, and F (3.59) = 68.93, p = .000, the replacement of the repeated measure MANCOVA analysis with conventional MANCOVA appeared wise. In one final attempt to revive the repeated measures MANCOVA, the output data were transformed into two forms of residual plots. The first transformed each datum instance to 100 minus the datum value to test for positively skewed data curves. The second transformation plotted the logarithm of each point of output data to test for a negatively skewed data curve and to yield fewer error residuals. However, neither transformation yielded fruitful results, and therefore the conventional MANCOVA strategy was adopted.

Two sets of MANCOVA analyses were needed, each of which comprised two separate analyses. The first set included one MANCOVA analysis to test for the main effects of independent variables A and B and any interactions between A and B, taking all initial dependent variable measures simultaneously. The second analysis in set one tested for main and interaction effects of the independent variables on cell variances for all criterion retention tests.

The second set of MANCOVA analyses tested for significant variances in the change scores of each respective set of dependent variables, e.g. the change score of enactive performance was derived for each subject.
by subtracting the subject's enactive retention test score from his or her initial enactive criterion measure (initial score minus retention score equals change score). The first analysis ran MANCOVA probabilities on change scores of the enactive performance tests (subject's initial enactive score minus subject's enactive retention score equals subject's enactive performance change score) and change scores of the cognitive posttests (initial cognitive posttest score minus cognitive retention score equals subject's cognitive change score). The second run in the set tested change score variances for each subtest of the cognitive criterion measures taken separately, i.e. (a) each subject's knowledge level subtest score on the initial cognitive posttest minus each subject's knowledge level subtest score on the cognitive posttest of retained learning, and (b) subject's comprehension and application level subtest score on the initial cognitive criterion test minus that subject's comprehension and application level subtest scores on the cognitive retention test.

Significant MANCOVA results from either the main or interaction effects of the independent variables would have allowed hypotheses to be treated in groups and would have streamlined the discussion of results. However, the MANCOVA analysis produced no significant results at Alpha = .05. The summary data, therefore, as reported later in
Chapter IV, will concentrate on univariate ANCOVA results. The presentation of MANCOVA results will be limited to the interaction effects of the treatments on both cognitive knowledge and skill retention change scores, which produced interesting, though nonsignificant results.

**Hypothesis Testing and Results**

The overall findings from the analyses of data related to the 17 null hypotheses are summarized in Table 15. Additionally, Table 15 reports tests of alternate hypotheses (Hₐ) and records other descriptive information to clarify the relationships between null, independent variables effects, dependent variables and research hypotheses. A full presentation of statistical results follows in the discussion of Tables 15 through 28.

A study of Table 15 reveals that only H₀ 3 end H₀ 4 were rejected, and therefore only Hₐ 4 was not rejected. Further, Hₐ 4 states only that students who receive the concept organizer would not out-perform students who received the traditional introduction as measured by scores on "knowledge" level items on either the initial or retained cognitive posttests.

The focus of Hₐ 4 was to sharpen the discrimination of Hₐ 5. Hₐ 5 focused on the theorized strength of the
<table>
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<th>Statement of Null</th>
<th>Independent Variable</th>
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<td>Initial Cognitive Learning</td>
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<td>Initial Cognitive Learning</td>
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<td>Retained Enactive Performance</td>
<td>#</td>
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Note: For testing of Ho and Ha: * = Reject; # = Not Reject
Table 15 (continued)

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<td>Concept Organizer and Schema Instruction vs. All Other Treatments</td>
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<td>Ha 3</td>
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<td></td>
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<td></td>
<td>Initial Enactive Performance</td>
<td></td>
<td>Ha 3</td>
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<td></td>
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<td>Retained Cognitive Learning</td>
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<td>Ha 3</td>
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<td>Ho 17</td>
<td></td>
<td></td>
<td></td>
<td>Enactive Performance Change Score</td>
<td></td>
<td>Ha 7</td>
<td>*</td>
</tr>
</tbody>
</table>

Note: For testing of Ho and Ha: * = Reject; # = Not Reject; ** succeeded by A, B interactions
concept organizer to improve higher level learning (comprehension and application), but not to improve rote knowledge retention. Since Ha 5 was rejected, then the failure to reject Ha 4 means only that the concept organizer and traditional introduction performed equally well in this regard.

Summary of MANCOVA Results

None of the MANCOVA tests produced significant results. Therefore, the analysis of inferential statistics will center on the analysis of covariate ANCOVA results reported in the next section.

There was, however, one noteworthy MANCOVA finding. The interaction effects of treatments on scaling skill change scores and overall cognitive knowledge change scores produced the following Telling-Lawley Trace Test $F$ Ratio: $F(2, 58) = 2.74, p = .073$. Therefore, a 92.7% ($\mu_1$, $\mu_2$, $\mu_3$, $\mu_4$) on skill and cognitive learning were not due to chance as measured by change scores. Though not significant at the .05 level, a clearly positive overall effect was shown for groups which received the concept organizer with traditional instruction and the traditional introduction with schema instruction over the groups which received the traditional introduction and traditional instruction and the concept organizer and schema
presentation. The ANCOVA summary tables and ensuing discussion center on the significant univariate ANCOVA components of this MANCOVA interaction.

**Significant ANCOVA Results—Change Scores**

A significant interaction occurred which showed differential retention of scaling skill between intact groups as measured by change scores. Table 16 is a matrix of change score means and Figure 1 is a plot of the A, B interaction. The specific interaction tested was $\bar{M}_1 + \bar{M}_4 = \bar{M}_3 + \bar{M}_2$. Substituting the values from Table 16 ($-6.60 + -6.47 = -13.07$; and $-3.23 + 6.07 = 2.48$) reveals that the composite mean of $-13.07$ is statistically different from $+2.48$. In terms of independent variables, both the effects of the concept organizer combined with the traditional instruction and the effects of the traditional introduction combined with the schema ordered instruction produced significantly higher values of skill retention than either the concept organizer combined with the schema ordered instruction or the traditional introduction combined with the traditional instruction. Table 17 describes the interaction statistically: $F(1,59) = 5.33, p = .024$. Since this interaction is significant at alpha = .05, the null hypothesis $H_0$ is neither accepted nor rejected, but superceded.
Table 16
Enactive Performance Mean Change Scores

<table>
<thead>
<tr>
<th>Level</th>
<th>A 1</th>
<th>A 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CELL 1</td>
<td>CELL 2</td>
</tr>
<tr>
<td>B 1</td>
<td>Initial 60.56</td>
<td>Initial 68.21</td>
</tr>
<tr>
<td></td>
<td>Retained 67.22</td>
<td>Retained 62.14</td>
</tr>
<tr>
<td>Change Score</td>
<td>-6.66</td>
<td>Change Score</td>
</tr>
</tbody>
</table>

|       | CELL 3 | CELL 4 |
| B 2   | Initial 63.53 | Initial 64.71 |
|       | Retained 66.76 | Retained 71.18 |
| Change Score | -3.23 | Change Score | -6.47 |

Figure 1
Skill Change Score-- A, B Interaction
To probe the A x B interaction more thoroughly, Tukey's HSD Test of All Multiple Comparisons was run at alpha = .05 and alpha = .10. At alpha = .05 no comparisons provided significant results. However, at alpha = .10 two comparisons proved significant. First, the mean of group one minus the mean of group two yielded a difference of \(-12.7381\) which suggests that the combination of the concept organizer and traditionally organized instruction may be more effective than the traditional introduction with the traditional instruction. Similarly, the mean of group four minus the group two mean produced a difference of \(-12.5452\). The students who received the traditional introduction and the schema instructional presentation performed somewhat better than students who received the traditional introduction and traditionally organized instruction.

Notably at alpha = .10, Tukey's HSD Test does not find the CO plus the traditional instruction or the traditional introduction with the schema presentation to be superior to the CO plus the schema presentation.

Figure 2 is a correlation chart of this same interaction. The initial posttest means of each treatment group are plotted on the abscissa while retention test means are on the ordinate axis. The scatter of points does
not reveal a positive linear correlation and therefore regression of skill change scores toward the mean was not a contributing factor in the statistical results.

A second A × B interaction occurred which involved treatment effects on "knowledge" level cognitive change scores (Table 18). Though not statistically significant at alpha = .05, $F (1,59) = 3.49$, $p = .067$, this change score
interaction does parallel the significant skill retention interaction and indicates a 93.3% probability that chance was not the determining factor which contributed to improved retention of knowledge of the parts, principles, and procedures of the architect's scale. Change score results were not significant in either the subtest of comprehension and application level of cognitive knowledge (Table 19), or in the change score results from the test of cognitive knowledge taken as a whole (Table 20).
Table 17
ANCova Summary Table

Architect's Scale Performance Change Score

<table>
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<tr>
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<td>B</td>
<td>1</td>
<td>382.50</td>
<td>446.33</td>
<td>1.89</td>
<td>0.174</td>
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<tr>
<td>AB</td>
<td>1</td>
<td>1,077.15</td>
<td>5.33</td>
<td>0.0244</td>
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</tr>
<tr>
<td>S/AB</td>
<td>59</td>
<td>11,915.93</td>
<td>201.96</td>
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</tr>
<tr>
<td>Ruler Covariate</td>
<td>1</td>
<td>322.14</td>
<td>1.60</td>
<td>0.212</td>
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<tr>
<td>Scale Covariate</td>
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<td>213.76</td>
<td>1.06</td>
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<td>IQ Covariate</td>
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<td>254.84</td>
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<td>0.266</td>
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<tr>
<td>Total (abn-1)</td>
<td>65</td>
<td>14,593.93</td>
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</tr>
</tbody>
</table>


Table 18

ANCOVA SUMMARY TABLE

Cognitive Subtest Change Scores at "Knowledge Level"

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<td>20.57</td>
<td>418.50</td>
<td>0.08</td>
<td>0.781</td>
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<tr>
<td>AB</td>
<td>1</td>
<td>914.54</td>
<td>3.49</td>
<td>0.067</td>
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<tr>
<td>S/AB</td>
<td>59</td>
<td>15,476.80</td>
<td>262.32</td>
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<td></td>
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<tr>
<td>Ruler</td>
<td>1</td>
<td>155.87</td>
<td>0.59</td>
<td>0.444</td>
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<tr>
<td>Scale</td>
<td>1</td>
<td>816.71</td>
<td>3.11</td>
<td>0.083</td>
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<td>725.05</td>
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<td>Total (abn-1)</td>
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<td>17,987.82</td>
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### Table 19

**ANOVA SUMMARY TABLE**

Cognitive Subtest of Change Score at "Comprehension/Application" Level

<table>
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<th>P</th>
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<tr>
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<td>0.985</td>
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<tr>
<td>B</td>
<td>1</td>
<td>427.36</td>
<td>281.22</td>
<td>1.54</td>
<td>0.220</td>
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<td>12.38</td>
<td>0.04</td>
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<td>16,404.29</td>
<td>278.04</td>
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<tr>
<td>Ruler Covariate</td>
<td>1</td>
<td>24.26</td>
<td>0.09</td>
<td>0.769</td>
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<tr>
<td>Scale Covariate</td>
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<td>70.17</td>
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<td>0.617</td>
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<td>18,091.59</td>
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Table 20
ANCova Summary Table
Cognitive Change Score Measures

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<td>189.10</td>
<td>229.48</td>
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<td>126.74</td>
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<td>0.485</td>
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<td>680.01</td>
<td>4.09</td>
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<td>11,197.59</td>
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</table>
Nonsignificant ANCOVA Results--Initial and Retention Scores

Summary Tables 21 through 28 detail the remaining ANCOVA results. The nonsignificant results reported in this section are grouped as follows: Tables 21 through 24 report results from initial tests of skill performance and cognitive knowledge, and Tables 25 through 28 report retention results on skill performance and cognitive knowledge.

Table 21 is concerned with initial architect's scale performance results. The $A \times B$ interaction which has the largest $F$ ratio is clearly nonsignificant at $F (1, 59) = 1.10, p = .298$. Similarly, there was no difference in initial cognitive posttest scores as illustrated in Table 22. Independent Variable $A$, type of introduction, held the strongest $F$ ratio here at $F (1, 59) = .29, p = .594$. Tables 23 and 24 depict results of the knowledge level cognitive subtest and comprehension/application level cognitive subtest respectively. Clearly, the evidence suggests that all treatment groups performed equally well on these subtests. The largest $F$ ratio was for the $A \times B$ interaction on the knowledge level subtest: $F (1, 59) = .78, p = .382$.

Nonsignificant retention of scaling performance is reported in Table 25 with an $F$ ratio of $F (1, 59) = .88, p = .352$. Cognitive knowledge retention is shown in
### Table 21

**ANCOVA SUMMARY TABLE**

Initial Architect's Scale Performance

<table>
<thead>
<tr>
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<td>2279.20</td>
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<td>0.998</td>
</tr>
<tr>
<td>AB</td>
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<td>393.04</td>
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Table 22
ANOVA SUMMARY TABLE
Initial Cognitive Posttest

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<td>35.15</td>
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<td>B</td>
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<td>6.28</td>
<td>785.73</td>
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<td><strong>Total (abn-1)</strong></td>
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</table>
**Table 23**

**ANCOVA SUMMARY TABLE**

Initial Cognitive Subtest at "Knowledge Level"

<table>
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<td>118.44</td>
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<tr>
<td>B</td>
<td>1</td>
<td>11.06</td>
<td>657.22</td>
<td>0.06</td>
<td>0.805</td>
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<td>AB</td>
<td>1</td>
<td>139.41</td>
<td>0.78</td>
<td>0.382</td>
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<td>10,611.04</td>
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</table>
Table 24

ANCOVA SUMMARY TABLE
Initial Cognitive Subtest at
"Comprehension/Application" Level

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<td>43.32</td>
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<td>0.639</td>
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<td>63.13</td>
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<td>0.32</td>
<td>0.571</td>
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Table 25
ANCOVA SUMMARY TABLE
Architect's Scale Performance Retention

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### Table 26

**ANCOVA SUMMARY TABLE**

**Cognitive Knowledge Retention Test**

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<td>10,461.72</td>
<td>177.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ruler Covariate</td>
<td>1</td>
<td>642.53</td>
<td>3.52</td>
<td>0.0655</td>
<td></td>
</tr>
<tr>
<td>Scale Covariate</td>
<td>1</td>
<td>2,432.29</td>
<td>13.72</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>IQ Covariate</td>
<td>1</td>
<td>257.15</td>
<td>1.45</td>
<td>0.233</td>
<td></td>
</tr>
<tr>
<td>Total (abn-1)</td>
<td>65</td>
<td>16,097.94</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 27

**ANCOVA SUMMARY TABLE**

Retention Cognitive Subtest at "Knowledge" Level

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sums of Squares</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>22.03</td>
<td>0.10</td>
<td>0.748</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>61.79</td>
<td>969.93</td>
<td>0.29</td>
<td>0.591</td>
</tr>
<tr>
<td>AB</td>
<td>1</td>
<td>339.81</td>
<td>1.61</td>
<td>0.210</td>
<td></td>
</tr>
<tr>
<td>S/AB</td>
<td>59</td>
<td>12,483.69</td>
<td>211.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ruler Covariate</td>
<td>1</td>
<td>289.81</td>
<td>1.37</td>
<td>0.247</td>
<td></td>
</tr>
<tr>
<td>Scale Covariate</td>
<td>1</td>
<td>3,006.27</td>
<td>14.21</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>IQ Covariate</td>
<td>1</td>
<td>24.46</td>
<td>0.12</td>
<td>0.735</td>
<td></td>
</tr>
<tr>
<td><strong>Total (abn-1)</strong></td>
<td><strong>65</strong></td>
<td><strong>18,303.27</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 28

ANCOVA SUMMARY TABLE

Retention Cognitive Subtest at "Comprehension/Application" Level

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sums of Squares</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>5.85</td>
<td>0.02</td>
<td>0.885</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>198.56</td>
<td>996.01</td>
<td>0.72</td>
<td>0.399</td>
</tr>
<tr>
<td>AB</td>
<td>1</td>
<td>19.60</td>
<td>0.07</td>
<td>0.791</td>
<td></td>
</tr>
<tr>
<td>S/AB</td>
<td>59</td>
<td>16,283.24</td>
<td>275.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ruler</td>
<td>1</td>
<td>955.51</td>
<td>3.46</td>
<td>0.068</td>
<td></td>
</tr>
<tr>
<td>Scale</td>
<td>1</td>
<td>2,072.41</td>
<td>7.51</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td>1</td>
<td>649.27</td>
<td>2.35</td>
<td>0.130</td>
<td></td>
</tr>
<tr>
<td>Total (abn-1)</td>
<td>65</td>
<td>22,259.27</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 26. Here, the largest \( F \) ratio is \( F (1, 59) = 0.71, p = .402 \). The subtests of retained knowledge level and comprehension/application level cognitive knowledge are shown in Tables 27 and 28 respectively. Again, all groups are shown to have performed equally well. The strongest \( F \) ratio from Tables 27 and 28 is from the A, B interaction on Table 27 where \( F (1, 59) = 1.61, p = .210 \).

### Analysis of Practice Worksheets

The four practice worksheets were administered at four separate intervals during each of the treatments and were identical across treatments. Each worksheet consisted of four practice items of scaling skill directly related to the instruction. Each subject's set of 16 practice items was scored as a single composite measure. The composite measures were then analyzed with a two-way ANOVA to test for significant differences between treatment groups. Table 29 reports the results. The \( p \) values were so large that no further analysis was performed and the researcher concluded that all intact classes performed equally well on the practice worksheets.
Table 29  
Practice Worksheets ANOVA Summary Table

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sums of Squares</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>321.79</td>
<td>321.79</td>
<td>0.872</td>
<td>0.354</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>57.57</td>
<td>57.57</td>
<td>0.156</td>
<td>0.694</td>
</tr>
<tr>
<td>AB</td>
<td>1</td>
<td>742.83</td>
<td>742.83</td>
<td>2.013</td>
<td>0.161</td>
</tr>
<tr>
<td>S/AB</td>
<td>61</td>
<td>22,514.00</td>
<td>369.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>(abn-1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary

The experimental results yielded a significant interaction effect between type of introduction and instructional presentation method on retained skill with the architect's scale. The importance of this interaction and its potential worth to instructional design will be discussed in Chapter V. Chapter V will also include a discussion of noteworthy, though nonsignificant, results of: (a) the overall MANOVA A, B interaction on retention of both skill and cognitive knowledge, and (b) the ANCOVA A, B interaction of cognitive knowledge retention at the "knowledge" level.
CHAPTER V

SUMMARY, CONCLUSIONS, DISCUSSION, AND IMPLICATIONS

This chapter includes a summary, conclusions, discussion, and implications. The summary of findings briefly restates the problem and summarizes the findings. Statements of conclusion follow, and the discussion probes explanations for the findings, conclusions, and noteworthy though nonsignificant findings. The discussion also relates the results to educational theory, weaknesses in the study, and recommendations for instructional design. Finally the implications for research identify refinements in design and make recommendations for further research.

Summary

Restatement of the Problem

Presently, there is little verifiable knowledge founded in cognitive learning theory to prescribe the instructional design of industrial arts subject matter. Specifically, instructional design methods are needed which
facilitate cognitive learning and enactive skill performance. This study investigated the effects of a concept organizer and instructional schemata on the cognitive learning and task skill performance of the principles and procedures of measuring scaled distances with an architect's scale.

The concept organizer was designed using the criteria of Ausubel (1980) and Mayer (1979) for the construction of advance organizers and is founded upon Ausubel's assimilation and subsumption theories. The instructional schemata were based on information processing schema theory as proposed by Rumelhart and Ortony (1977), Rumelhart (1980), Calfee (1981), Anderson, et al. (1977, 1978, 1983), Brooks and Dansereau (1983, Rand (1984), and others.

Findings

The only statistically significant finding concerned the improvement of performance on skill oriented scaling tasks as measured by change scores. Specifically, subject's skill retention test scores were subtracted from their initial criterion skill test scores to derive a skill test
"change score" which provided a measure of differential retention based on what each subject had learned rather than on raw retention test scores. The subjects then, retained more of what the initial posttest of scaling skill showed they had learned.

Furthermore, this improvement of retention resulted from an $A \times B$ interaction and was not due to the main effects of type of introduction or type of instructional presentation. Null hypothesis 15 was neither accepted nor rejected, but superceded by the interaction effect $MU_1 + MU_{14} = MU_3 + MU_2$. Stated in terms of independent variables, the concept organizer in combination with the traditional instruction and the traditional introduction combined with the schema ordered instruction effected significantly higher values of skill retention than other combinations. Statistically the strength of this interaction was $F (1, 59) = 5.33, p = .024$. Finally, the study provides empirical evidence that all treatments and interactions of treatments performed equally well in their effect on other initial and retention criterion measures.

Conclusions

Based on the findings of the current study, two conclusions were drawn. First, that students who receive
traditionally organized instructional presentations may retain more of the scaling task skills they learn initially if presentations are preceded by concept organizers. And that students may retain more of the scaling task skills they learn initially if schema organized instructional presentations are preceded by traditional introductions.

Discussion

The discussion deals with (a) additional (though not statistically significant) findings, (b) educational theories, (c) weaknesses of the study, and (d) recommendations for instructional design.

Additional Findings

In addition to the ANCOVA effects reported, the MANCOVA analysis provided notable, though not statistically significant results. The A x B interaction effects of treatments on scaling skill change scores and cognitive knowledge change scores, taken together, produced the following Telling-Lawley Trace Test Ratio: \( F(2, 58) = 2.74, p = .073 \). The Telling-Lawley Test suggests a 92.7% probability that differences in skill and cognitive learning retention (as measured by their respective change scores) were not due to chance. A closer look at the
ANCOVA results of the cognitive subtest at the "knowledge" level (Bloom, et al., 1956) yields an $F$ ratio of: $F (1, 59) = 3.49, p = .067$, whereas the cognitive subtest at the "comprehension and application" levels (Bloom, et al., 1956) revealed a very small $F$ ratio: $F (1, 59) = .04, p = .834$.

The relationship of $F$ ratios between skill performance and knowledge level cognitive learning may reflect a relationship between a subject's retention of the procedural steps needed to perform scaling operations and the performance of those operations. The lack of a relationship of $F$ ratios between skill performance and comprehension and application levels of cognitive learning may indicate an absence of a correlation between higher level cognitive learning and the direct performance of scaling skill operations. This latter notion is argued by Calfee (1981, p. 11).

At the alpha $= .10$ level, Tukey's HSD post hoc analysis of all multiple comparisons produced results which were identical to the ANCOVA results with one exception. The exception being that the statistically superior treatments (traditional introduction combined with schema instruction, and concept organizer combined with traditional instruction) were found to be superior only to the traditional introduction combined with traditional
instruction and not to the concept organizer combined with
the schema instruction. More precisely, on measures of
skill change scores, the concept organizer combined with
the schema instruction showed an increase in skill
retention of +3.23% compared with a loss in skill retention
of -6.07% for the traditional introduction combined with
the traditional instruction. Students who received the
concept organizer and schema presentation then, averaged
9.30% better on skill change score measures than students
who received the traditional introduction and traditional
instruction. This may be noteworthy considering that the
students who received the concept organizer and the
traditional instruction scored 12.74% higher than the
students who received the traditional introduction and
traditional instruction, or only 3.44% higher than the
students who received the concept organizer coupled with
the schema presentation.

Finally, it is noteworthy that students who received
the combined traditional introduction and schema
presentation treatment achieved the highest overall
cognitive retention scores (including both the knowledge
level and the comprehension/application level subtests).
This same experimental group also achieved the highest retention change scores for knowledge level learning and were a close second on the comprehension/application level change score measure.

Discussion of Theory

Ausubel's subsumption theory is only partially supported by the results of the present study. In general, Ausubel (1980) and Mayer (1979) would have predicted the significant positive effects of an advance organizer preceding traditionally organized unfamiliar subject matter for which students might not possess subsumers or readily associate existent subsumers with the new material. However, Ausubel would have predicted its effect to be stronger in the comprehension and application levels of cognitive learning rather than in retention of acquired skill or knowledge level cognitive learning.

The concept organizer did not produce similar results when coupled with the schema presentation. This may indicate that since the schemata organized the instructional material in a conceptual hierarchy and provided its own conceptual relations, anchorage in memory may have been generalized through bottom-up or data driven schema processing as described by Rumelhart (1980). In this case, Ausubel would not have predicted an AO to have
an additional positive effect. Mayer (1979), who notes that organizers may only be effective when the subject matter is difficult to organize or is not preorganized for the level of learning, would also have predicted no positive effect in this instance.

The schema theory was also partially supported inasmuch as the schema organized instruction coupled with the traditional introduction significantly enhanced skill performance over the traditional instruction coupled with the traditional introduction as measured by change scores. As previously noted, the schema ordered presentation did have a positive influence on knowledge level procedural learning ($p = .067$). This gain in the knowledge of scaling sequences may account for a portion of the differential scaling skill retention between treatment groups.

Since there were "no differences" in initial skill levels between groups and all subjects received identical skilled practice items, it appears reasonable to conclude that differences in retained skill were due to the greater knowledge of scaling procedure. Rumelhart (1980) argues that learners may modify schema already in memory to accommodate new knowledge. Some experimental subjects may have processed the scaling procedures as a modification of their measuring with a 12 inch English ruler schema. However, since an appropriate structural schema was
presented with usage instructions prior to the specific content, and the specific content was ordered with separate content schemata for the 1" scale and the 1/2" scale, most learners probably used the given schemata to order the novel sequences. Rumelhart calls this "top-down processing" (1980). In either case, with practice being held constant, the improvement in differential skill retention between groups is best explained in this study by the differential retention of knowledge level cognitive learning which encompasses knowledge of scaling sequences.

Weaknesses

Two salient weaknesses may effect the validity of the study. First, the low percentage of explained variance on criterion tests attributed to treatment effects, and second, the relatively small data producing sample. The percentage of explained variance has a direct impact on the statistical efficiency of the ANCOVA analysis. In short, the greater the percentage of between group test score variance attributable to treatment effects, the smaller the error variance, and therefore statistical significance can be demonstrated with smaller between group variances. The second weaknesses also bears on the statistical power afforded the analyses. Since one of the simplest ways to increase statistical power is to reduce the standard error,
and since the standard error is equal to $s/\sqrt{N}$ (where $s$ is the standard deviation of the sample, and $N$ is sample size), therefore, increasing $N$ from 14 or 18 to 25 or 30 would have had a clear beneficial effect on the statistical results, especially on the results of knowledge level cognitive change scores and the MANCOVA analysis of cognitive and enactive change scores.

**Explained Variance.** The explained variance of each criterion measure is given in Table 30. The explained variance of scores on dependent variables ranges from 12.3% on the measures of cognitive change scores to 39.3% on the initial posttest of scaling skill. Though explained variance percentages of scores on the posttests themselves are not inordinately low, students' scores on both the cognitive and enactive posttests were quite low (Tables 8 through 13). The highest overall mean score on any criterion test being 67.05% on the scaling skill retention test, while the lowest was 38.59% on the initial comprehension/application cognitive subtest. Overall, the cognitive test score means averaged 41.70%, while the skill test score overall mean was 65.6%. Additionally, observation during the experiment revealed that many subjects tired of taking two difficult tests during the same class period. This researcher believes the difficulty level of the cognitive test was too high and that if both
Table 30
Percent of Test Score Variance Due to Treatment

<table>
<thead>
<tr>
<th>TEST NAME</th>
<th>PERCENTAGE OF EXPLAINED VARIANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Posttests</strong></td>
<td></td>
</tr>
<tr>
<td>Scaling Skill</td>
<td>39.3</td>
</tr>
<tr>
<td>Cognitive Knowledge</td>
<td>39.5</td>
</tr>
<tr>
<td>Knowledge Level Cognitive Subtest</td>
<td>27.0</td>
</tr>
<tr>
<td>Comprehension/Application Level</td>
<td>36.0</td>
</tr>
<tr>
<td>Cognitive Subtest</td>
<td></td>
</tr>
<tr>
<td><strong>Retention Posttests</strong></td>
<td></td>
</tr>
<tr>
<td>Scaling Skill</td>
<td>25.3</td>
</tr>
<tr>
<td>Cognitive Knowledge</td>
<td>35.0</td>
</tr>
<tr>
<td>Knowledge Level Cognitive Subtest</td>
<td>31.7</td>
</tr>
<tr>
<td>Comprehension/Application Level</td>
<td>26.8</td>
</tr>
<tr>
<td>Cognitive Subtest</td>
<td></td>
</tr>
<tr>
<td><strong>Change Scores</strong></td>
<td></td>
</tr>
<tr>
<td>Scaling Skill</td>
<td>18.3</td>
</tr>
<tr>
<td>Cognitive Knowledge</td>
<td>12.3</td>
</tr>
<tr>
<td>Knowledge Level Cognitive Subtest</td>
<td>13.9</td>
</tr>
<tr>
<td>Comprehension/Application Level</td>
<td>9.3</td>
</tr>
<tr>
<td>Cognitive Subtest</td>
<td></td>
</tr>
</tbody>
</table>
the cognitive and skill tests were shortened 10% to 20%, more valid results would have been achieved.

Sample Size. The second weakness, a small data producing sample, was due to high differential mortality. Initially, each experimental group contained 22 to 24 subjects. However, through absenteeism, the data producing sample held only 14 to 18 students in each group. This was especially influential on the MANCOVA test of cognitive and skill test of A, B interaction effects; \( F (2, 58) = 2.74, p = .067 \). Had the experimental groups been larger or mortality lessened, either one or both of these treatment effects might have proved statistically significant at \( \alpha = .05 \).

Recommendations for Instructional Design

If, as defined in this study, a primary goal of industrial arts/technology education is to facilitate the "knowledgeable doing" of industrial arts subject matter tasks (Lux, 1981) then, the following recommendations hold promise for the improvement of instructional design. This research, however, is relatively exploratory in its treatment of both concept organizer design (formatting COs as structural schemata) and application of instructional schemata (presenting both structural and content schemata to learners intact). For this reason and because of the
weaknesses discussed in the prior section of this chapter, this researcher considers the specific recommendations for instructional design to be tentative until confirmed by further research.

**Concept organizers.** The study shows that concept maps with brief explanations of conceptual relations can serve as effective introductions to traditionally organized industrial arts subject matter. Therefore, this researcher recommends that concept maps which exhibit the superordinate, coordinate, and subordinate relationships of industrial arts subject matter concepts be written at the appropriate learning level and be presented in place of the traditionally oriented skill utilization, career related introductions in common usage.

**Schema organized instruction.** The study demonstrates that both conceptual and procedural components of industrial arts subject matter can be organized into instructional schemata. Additionally, that when presented to learners (immediately following a traditional introduction) these schemata can positively influence the acquisition and recall of both cognitive knowledge and skilled performance. This researcher recommends that both superordinate concepts and generalized task sequence outlines of industrial arts subject matter be organized into structural schemata; and that the specific subject
matter concepts and sequences to be taught in a particular lesson be organized into content schemata which are compatible instances of (or which instantiate) the higher order structural schemata. The final recommendations are that these schemata be presented intact to learners just prior to the subject matter which instantiates them and that the learners be instructed to use them to help organize and remember the specific lesson content.

Implications for Research

The data patterns, findings, and conclusions of the present study do provide empirical evidence to support the experimental instructional designs, especially in specific combinations. The study does not, however, represent a conclusive work which prescribes instructional design. Several questions are left unanswered:

1. Can an increase in cognitive procedural knowledge of task performance predictably improve initial skill and retained skill performance?

2. Is student learning style a major factor in students' successes with traditional vs. schema organized industrial arts instructional presentations?
3. Is student learning style a major factor in students' successes with traditional instructional introductions vs. concept organizer introductions?

4. Can traditionally organized subject matter presentations preceded by concept organizers or can schema organized instructional presentations preceded by traditional introductions produce significant gains in students' cognitive knowledge of industrial arts/technology education subject matter?

5. Does either type of introduction contribute significantly to students' learning outcomes tested in this study or would control groups have performed equally well?

6. Did subjects' lack of experience with concept organizers and schema organized instruction influence the experimental results?

To attempt to answer the above questions, this researcher proposes a follow-up study of the following design (Table 31). In addition, this researcher recommends subjects be blocked within groups on a measure of learning style, and subjects be accustomed to the use of concept organizers and schema ordered lesson presentations prior to participation in the experimental sequence.

To overcome the problem of differential mortality which plagued the present study, each cell should contain 35-45 subjects (two intact classes if complete
randomization is not possible). The increased cell size would also allow for the application of learning style as a blocking variable.

An additional research question which arises from the present study is:

Can concept organizers coupled with schema ordered instructional presentations facilitate cognitive and enactive learning with lower IQ/Learning Disabled students?

The presentation of subsumer/higher order schemata in the form of a concept organizer coupled with structural schemata for the specific learning material, instructions on using schemata, and organization of the specific subject content into appropriate content schemata may have a facilitative effect with students who possess poor information processing skills.
Table 31
Proposed Research Design

<table>
<thead>
<tr>
<th></th>
<th>A₁</th>
<th>A₂</th>
<th>A₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B₁</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of</td>
<td>Concept</td>
<td>Traditional</td>
<td>No Introduction</td>
</tr>
<tr>
<td>B</td>
<td>Organizer</td>
<td>Instruction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traditional</td>
<td></td>
<td>Traditional Instruction</td>
</tr>
<tr>
<td>Cell 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B₂</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concept</td>
<td>Traditional</td>
<td></td>
<td>Traditional Instruction</td>
</tr>
<tr>
<td>Organizer</td>
<td>Instruction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cell 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Instruction</td>
<td></td>
</tr>
<tr>
<td>Cell 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B₂</td>
<td>Concept</td>
<td>Traditional</td>
<td>No Introduction</td>
</tr>
<tr>
<td></td>
<td>Organizer</td>
<td>Instruction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Schema-Ordered</td>
<td></td>
<td>Schema-Ordered Instruction</td>
</tr>
<tr>
<td>Cell 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Instruction</td>
<td></td>
</tr>
<tr>
<td>Cell 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Introduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Schema-Ordered</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Instruction</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX A

Pretest of Enactive Performance/Skill with Standard Twelve Inch Ruler
TEST OF SKILL WITH STANDARD 12" RULER

Part I.
Note: Please do all work on this test as quickly and accurately as possible— to the nearest 1/16th of an inch.

Directions: Mark off the distances listed on the line below each question.

Example: ____________ 3" ____________

1. ____________ 3½" ____________

2. ____________ 4 3/4" ____________

3. ____________ 2 5/8" ____________

4. ____________ 2 13/16" ____________

5. ____________ 2 5/16" ____________

Part II.
Directions: Measure the lines marked below and write their length in the space to the left of each line.

Example: ____________ 2" ____________

6. ____________ ____________

7. ____________ ____________

8. ____________ ____________

9. ____________ ____________

10. ____________
APPENDIX B

Pretest of Enactive Performance/Skill with the Architect's Scale
Architect's Scale Skill Test

Note: when answering the questions on this test, make your measurements from the middle of the two end dashes.

Line up the mark on the scale with the middle of the dash on the line.

Line is 4 feet 0 inches long

Not with the outside edge of the dash

Not 4 feet 1 inch long
ARCHITECT’S SCALE SKILL TEST I

PART I
Directions: Starting at the left end, scale each distance on the line provided below each question.

1. Using the 1" scale, mark a scaled line 5'6" long.

2. Using the 1" scale, mark a scaled distance of 4'1".

3. Using the 1/2" scale, mark a scaled distance 4'3" long.

4. Using the 1/2" scale, mark a scaled distance 9'5" long.

5. Using the 1/2" scale, mark a scaled distance 3'7" long.

PART II
Directions: Write the answers to each question on the blank to the left. Be accurate to the nearest inch mark on the scale.

6. The line below was drawn with the 1" scale. What length does it represent?

7. The full-sized length of this scaled line is _____ if scaled with the 1/2" scale.
8. The full-scale length of this line, which was scaled with the 1" scale is.


9. Line A below was drawn actual size with a standard 12" ruler. Then it was scaled with two different scales. Which scale was used in figure 1? (9)_

10. And which scale was used in figure 2? (10) ___

<table>
<thead>
<tr>
<th>Line A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig. 1</td>
</tr>
</tbody>
</table>

PART III. Multiple Choice

Directions: Circle the letter which corresponds to the best answer.

11. & 12. Note the reduced scale line below. The line is (11) long when scaled with the (12) scale.

| 11. a. 5'6" 12. a. 4" b. 10'2" b. standard 12" ruler c. 5'0" c. 1" d. 6'6" d. 2" e. 10'11" e. 1" |

13. 14 & 15. What are the lengths of each of the three sides of the figure below if it is scaled with the 5" scale?

| 13. a. 1'9" 14. a. 1'4" 15. a. 2'1" b. 3'6" b. 2'6" b. 4'1" c. 9'6" c. 2'7" c. 4'2" d. 18'3" d. 2'8" d. 4'3" e. 3'7" e. 2'9" e. 4'4" | 13 = ? 14 = ? 15 = ? |
16. The triangle in Figure 1 was scaled with the 4" scale. In Figure 2, it was further reduced. Which scale was used in Figure 2?

- a. 3/8"
- b. 1/4"
- c. 1/8"
- d. 3/16"
- e. 3/32"

17. The triangle in Figure 1 was scaled with the 4" scale. The same triangle was scaled with the 3/8" scale in Figure 2, but an error was made in scaling side_______. in Figure 2.

- a. A
- b. B
- c. C
- d. No error was made.

PART IV.

Directions: Perform the operations in the questions below.

18. Figure 1 below was scaled with the 4" scale of the architect's scale. Scale and draw the same figure (start with the lines provided in Figure 2) using the 1" scale.
19. The line below was scaled with the 3" scale. Draw a line of the same scaled length with the $\frac{1}{2}$" scale on the line provided.

\[ \text{Line 1} \]
\[ \text{Line 2} \]

20. The line below was scaled with the 1" scale. Draw a line of the same scaled length with the $\frac{1}{2}$" scale on the line provided.

\[ \text{Line 3} \]
\[ \text{Line 4} \]
APPENDIX C

Initial Criterion Test of Enactive Performance/Skill with the Architect's Scale
Architect's Scale Skill Test

Note: When answering the questions on this test, make your measurements from the middle of the two end dashes.

Line up the mark on the scale with the middle of the dash on the line.

Line is 4 feet 0 inches long

Not with the outside edge of the dash

Not 4 feet 1 inch long
ARCHITECT'S SCALE SKILL POSTTEST I

PART I
Directions: Starting at the left end, scale each distance on the line provided below each question.

1. Using the 1" scale, mark a scaled line 5'6" long.

2. Using the 1" scale, mark a scaled distance of 4'1".

3. Using the ½" scale, mark a scaled distance 4'3" long.

4. Using the ½" scale, mark a scaled distance 9'5" long.

5. Using the ¼" scale, mark a scaled distance 3'7" long.

PART II
Directions: Write the answers to each question on the blank to the left. Be accurate to the nearest inch mark on the scale.

6. The line below was drawn with the 1" scale. What length does it represent?

7. The full-sized length of this scaled line is (?) if scaled with the ½" scale.
8. The full-scale length of this line, which was scaled with the 1" scale is.

9 & 10.

9. Line A below was drawn actual size with a standard 12" ruler. Then it was scaled with two different scales. Which scale was used in figure 1? (9). And which scale was used in figure 2? (10).

10. Line A

[Diagram of Line A]

Fig. 1

Fig. 2

PART III. Multiple Choice

Directions: Circle the letter which corresponds to the best answer.

11. & 12. Note the reduced scale line below. The line is (11) long, when scaled with the (12) scale.

11. a. 5'6"
   b. 10'2"
   c. 5'0"
   d. 6'6"
   e. 10'11"

12. a. 1"
   b. standard 12" ruler
   c. 1"
   d. 2"
   e. 1/2"

(3, 14 & 15. What are the lengths of each of the three sides of the figure below if it is scaled with the 1/2" scale?

13. a. 1'9"
    b. 3'6"
    c. 9'6"
    d. 18'3"
    e. 3'7"

14. a. 1'4"
    b. 2'6"
    c. 2'7"
    d. 2'8"
    e. 2'9"

15. a. 2'1"
    b. 4'1"
    c. 4'2"
    d. 4'3"
    e. 4'4"
16. The triangle in Figure 1 was scaled with the 3/8" scale. In Figure 2, it was further reduced. Which scale was used in Figure 2?

A - 2' 6"
B - 3/8" 
C - 1/4" 
D - 1/8" 
E - 3/16" 
F - 3/32"

17. The triangle in Figure 1 was scaled with the 3/8" scale. The same triangle was scaled with the 3/8" scale in Figure 2, but an error was made in scaling side _____ in Figure 2.

A - A 
B - B 
C - C 
D - No error was made.

PART IV.
Directions: Perform the operations in the questions below.

18. Figure 1 below was scaled with the 3/8" scale of the architect's scale. Scale and draw the same figure (start with the lines provided in Figure 2) using the 1" scale.

Scaled with 3/8" Scale

C = 1'6"

Scaled with 1" Scale

C = 1'6"
19. The line below was scaled with the 3" scale. Draw a line of the same scaled length with the 1" scale on the line provided.

---

20. The line below was scaled with the 1" scale. Draw a line of the same scaled length with the 1/2" scale on the line provided.

---
APPENDIX D

Initial Criterion Test of Cognitive Learning
TEST OF REDUCED SCALING KNOWLEDGE FOR THE ARCHITECT'S SCALE

Directions: All questions on this test are multiple choice. Select the best choice from the alternative choices to complete the question correctly. Write the letter of the correct answer on the blank line to the left of each question.

Note: All questions which refer to reading a particular scale assume you are holding that scale face-up and parallel to the line or distance being measured—the same as in the slide program.

1. The total number of separate scales on the architect's scale is:
   a. 10
   b. 7
   c. 9
   d. More than 10
   e. Less than 6

2. On the architect's scale, inches are read on the 1" scale at which location marked on the scale below?

3. Inches are read in the ______ section of the 1" scale on the architect's scale.
   a. front
   b. fully-divided
   c. open-divided
   d. label end
   e. undivided
4. While holding the 1" scale on a line parallel to the top of the paper, the 1" scale foot marks are read by reading
   a. right to left.
   b. to the right of the 1" scale label end.
   c. all foot marks renumbered to read left to right from 1 to 20.
   d. to the right of the 1" scale zero mark.
   e. to the left of the 1" scale zero mark.

5. When measuring a line which has a scaled length of exactly 6'
   with the 1" scale
   a. you only need the fully-divided section of the scale.
   b. you only need the label end and fully-divided section of the scale.
   c. you only need the open-divided section of the scale.
   d. you need both the open-divided and fully-divided sections of the scale.
   e. you can use either the fully-divided section or the section to the left of the zero mark.

6. If a small building 18' long and 10' wide is scaled down with the 1" scale, it would measure _____ on the drawing.
   a. 24" X 12"
   b. 18" X 10"
   c. 9" X 5"
   d. 4½" X 2½"
   e. 1.8" X 1.0"

7. If a building is 24' long and 18' wide and was drawn with the 1" scale, the size of the drawing would be:
   a. 24" long and 18" wide
   b. 16" long and 12" wide
   c. 12" long and 9" wide
   d. 18" long and 12" wide
   e. 12" long and 9" wide

8. If a scaled drawing of a building measured 10" X 12" and you knew it was drawn with the ½" scale, the actual full size of the building would be:
   a. 10' X 12'
   b. 20" X 24"
   c. 10" X 12"
   d. 30' X 36'
   e. 20' X 24'
9. The 1" scale is used to scale distances to 1/12 their actual size. Similarly, the 1/12 scale is used to scale distances to their actual size.
   a. 1/8
   b. 1/12
   c. 1/24
   d. 1/48

10. The 3" scale is used to scale distances to _____ of their actual size.
   a. 1/8
   b. 1/12
   c. 1/24
   d. 1/48

11. If you scaled an 18'6" line, its actual full size length would be
   a. 9'3" long if scaled with the 1" scale.
   b. longer than both the fully-divided and open-divided sections combined on the 1" scale.
   c. 9 1/2" when scaled with the 1" scale.
   d. 9 1/2" when scaled with the 1/12 scale.
   e. 9 1/2" when scaled with the 1/24 scale.

12. If a scaled drawing of a building measured 6" X 9" and you knew the building was drawn with the 1" scale, the actual full-size building would be:
   a. 12' X 18'
   b. 24' X 36'
   c. 24" X 36"
   d. 30' X 45'
   e. 30" X 45"

13. To scale an existing line on a sheet of paper with the 1" scale, you first:
   a. place the architect's scale on the line.
   b. line up the closest foot mark on the 1" scale with the right end of the line.
   c. find the 1" scale on the architect's scale.
   d. line up the zero mark with the left end of the line.
   e. draw the line.
14. To measure an existing line which has a scaled length of less than 12" with the 1" scale, you would first line up the right end of the line with the 1" scale zero mark. Then ________.
   a. line up the nearest foot mark with the left end of the line.
   b. read the length of the line in inches.
   c. record the length of the line.
   d. read the answer in the open-divided section of the scale.

15. To measure a scaled line (such as 4'6") with the 1" scale, you would first place the scale on the line. Then ________.
   a. line up the closest 1" scale foot mark with the end of the line.
   b. read the number of inches to the left of the zero mark.
   c. read the number of feet to the right of the zero mark.
   d. line up the zero mark with the left end of the line.
   e. locate the 6" mark and place it on the end of the line.

16. Which of the following steps is used only when drawing a line to scale?
   a. line up the zero mark with one end of the line.
   b. select the right scale.
   c. mark a thin dash.
   d. slide the scale to the closest foot mark.
   e. read the number of inches.

17. When drawing a distance to reduced scale you are drawing it to a fraction of its original size. To draw a distance larger than actual size with the 1" scale:
   a. it cannot be done.
   b. 1" on the enlarged scale drawing could equal \( \frac{1}{2} \)" of actual size.
   c. 1" of scale size could equal 2" of actual size.
   d. 1" of scale size could equal \( \frac{1}{2} \)" on the enlarged scale drawing.
   e. it can be done, but neither B, C, nor D are correct answers.
18. & 19. Two points in the process of drawing a line to scale are shown in Figure 1 and Figure 2. From the lists below, identify the two steps which were performed to progress from Fig. 1 to Fig. 2.

Figure 1

Figure 2

18. First you would:
   a. place a dash above the correct inch mark.
   b. read the required number of feet.
   c. read the required number of inches.
   d. line up the selected inch mark with the dash.

19. Then you would:
   a. place a dash above the correct inch mark.
   b. read the required number of feet.
   c. read the required number of inches.
   d. line up the selected inch mark with the dash.

20. The scale in the figure below has been lined up with the closest foot mark. What is the next step in measuring the length of this line?

   a. slide the scale to the closest inch mark.
   b. read the inch mark which lines up with the left end of the line.
   c. line up the zero mark with the left end of the line.
   d. record the answer in feet and inches.
   e. not enough information is given to read the 1/8" scale.
21. Which of the following steps is out of order for drawing a line to scale with the \( \frac{1}{4} \)" scale?

a. place the scale parallel to the thin line.
b. mark a dash at one end of the thin line.
c. line up the closest foot mark with the dash.
d. read the number of feet on the scale.
e. read the number of inches on the scale.

22. Lined-up

The line above is being scaled with the 1" scale, but even if it were being scaled with the \( \frac{1}{4} \)" scale, the step after lining-up the closest footmark is:

a. read the number of inches
b. record the answer.
c. line up the zero mark with the end of the line.
d. line up the right end dash of the line with the \( \frac{1}{4} \)" scale zero mark.

23. & 24.

After you line up the zero mark (as shown in the figure above) the next step is to slide the scale to the (23) to line up the (24) with the right end dash of the line.

23. a. right 24. a. 4' mark.
   b. left  b. foot mark.
   c. left end dash to the  c. inch mark
   d. label end  d. 3' mark

When scaling with the 1" scale, mark a dash at one end of the line.
Next, (25) Line up the selected foot mark with the dash and then (26). 

25. a. slide the scale to the zero mark
   b. line up the dash with the closest foot mark
   c. read the number of feet on the scale
   d. mark the number of inches with a dash
   e. select the right scale to use

26. a. mark a dash at the line's other end
   b. mark a dash above the selected inch mark
   c. record the distance
   d. read the number of inches
   e. select the right scale to use

27. Two steps in drawing a line to scale with the ½" scale are:
    Line up the thin dash with the selected foot mark, and then ________.
    a. slide the scale to the right to line up the closest inch mark.
    b. slide the scale to the left to line up the closest inch mark.
    c. mark a dash above the selected inch mark.
    d. darken the line between the dashes.

28. In measuring a scaled distance, the third main step is to ________.
    a. record the distance.
    b. identify the distance.
    c. select the scale.
    d. read the scale.
APPENDIX E

Initial Criterion Measure of Cognitive Learning at the "Knowledge" Level
(Bloom, 1956)
TEST OF REDUCED SCALING KNOWLEDGE FOR THE ARCHITECT’S SCALE

Directions: All questions on this test are multiple choice. Select the best choice from the alternative choices to complete the question correctly. Write the letter of the correct answer on the blank line to the left of each question.

Note: All questions which refer to reading a particular scale assume you are holding that scale face-up and parallel to the line or distance being measured—the same as in the slide program.

Label end is face up and parallel to the top of the paper.

1. The total number of separate scales on the architect’s scale is:
   a. 10
   b. 7
   c. 9
   d. More than 10
   e. Less than 6

2. On the architect’s scale, inches are read on the 1” scale at which location marked on the scale below?

3. Inches are read in the _____ section of the ½” scale on the architect’s scale.
   a. front
   b. fully-divided
   c. open-divided
   d. label end
   e. undivided
4. While holding the 1" scale on a line parallel to the top of the paper, the 1" scale foot marks are read by reading
   a. right to left
   b. to the right of the 1" scale label end.
   c. all foot marks renumbered to read left to right from 1 to 20.
   d. to the right of the 1" scale zero mark.
   e. to the left of the 1" scale zero mark.

5. When measuring a line which has a scaled length of exactly 6' with the 1" scale
   a. you only need the fully-divided section of the scale.
   b. you only need the label end and fully-divided section of the scale.
   c. you only need the open-divided section of the scale.
   d. you need both the open-divided and fully-divided sections of the scale.
   e. you can use either the fully-divided section or the section to the left of the zero mark.

6. To scale an existing line on a sheet of paper with the 1" scale, you first:
   a. place the architect's scale on the line.
   b. line up the closest foot mark on the 1" scale with the right end of the line.
   c. find the 1" scale on the architect's scale.
   d. line up the zero mark with the left end of the line.
   e. draw the line.

   Zero mark lined up

7. To measure an existing line which has a scaled length of less than 12" with the 1" scale, you would first line up the right end of the line with the 1" scale zero mark. Then
   a. line up the nearest foot mark with the left end of the line.
   b. read the length of the line in inches.
   c. record the length of the line.
   d. read the answer in the open-divided section of the scale.
8. To measure a scaled line (such as 4'6") with the 1" scale, you would first place the scale on the line. Then ________.
   a. line up the closest 1" scale foot mark with the end of the line.
   b. read the number of inches to the left of the zero mark.
   c. read the number of feet to the right of the zero mark.
   d. line up the zero mark with the left end of the line.
   e. locate the 6" mark and place it on the end of the line.

9. Which of the following steps is used only when drawing a line to scale?
   a. line up the zero mark with one end of the line.
   b. select the right scale.
   c. mark a thin dash.
   d. slide the scale to the closest foot mark.
   e. read the number of inches.

10. & 11. Two points in the process of drawing a line to scale are shown in Figure 1 and Figure 2. From the lists below, identify the two steps which were performed to progress from Fig. 1 to Fig. 2.

10. First you would:
    a. place a dash above the correct inch mark.
    b. read the required number of feet.
    c. read the required number of inches.
    d. line up the selected inch mark with the dash.

11. Then you would:
    a. place a dash above the correct inch mark.
    b. read the required number of feet.
    c. read the required number of inches.
    d. line up the selected inch mark with the dash.

---

Figure 1

```
8 4 9 2 10 11
```

Figure 2

```
6 4 9 2 10 11
```
12. Which of the following steps is out of order for drawing a line to scale with the $\frac{1}{2}$" scale?
   a. place the scale parallel to the thin line.
   b. mark a dash at one end of the thin line.
   c. line up the closest foot mark with the dash.
   d. read the number of feet on the scale.
   e. read the number of inches on the scale.

13. Two steps in drawing a line to scale with the $\frac{1}{2}$" scale are:
   Line up the thin dash with the selected foot mark, and then ___.
   a. slide the scale to the right to line up the closest inch mark.
   b. slide the scale to the left to line up the closest inch mark.
   c. mark a dash above the selected inch mark.
   d. darken the line between the dashes.

14. In measuring a scaled distance, the third main step is to ____.
   a. record the distance.
   b. identify the distance.
   c. select the scale.
   d. read the scale.
APPENDIX F

Initial Criterion Measure of Cognitive Learning at the "Comprehension" and "Application" Levels (Bloom, 1956)
TEST OF REDUCED SCALING KNOWLEDGE FOR THE ARCHITECT’S SCALE

Directions: All questions on this test are multiple choice. Select the best choice from the alternative choices to complete the question correctly. Write the letter of the correct answer on the blank line to the left of each question.

Note: All questions which refer to reading a particular scale assume you are holding that scale face-up and parallel to the line or distance being measured—the same as in the slide program.

Label end is face up and parallel to the top of the paper.

1. If a small building 18' long and 10' wide is scaled down with the 4" scale, it would measure _______ on the drawing.
   a. 24" X 12"
   b. 18" X 10"
   c. 9" X 5"
   d. 4½" X 2½"
   e. 1.8" X 1.0"

2. If a building is 24' long and 18' wide and was drawn with the 1" scale, the size of the drawing would be:
   a. 24" long and 18" wide
   b. 16" long and 12" wide
   c. 12" long and 9" wide
   d. 18" long and 12" wide
   e. 12' long and 9' wide
3. If a scaled drawing of a building measured 10" X 12" and you knew it was drawn with the 1/8" scale, the actual full size of the building would be:
   a. 10' X 12'
   b. 20' X 24'
   c. 10" X 12"
   d. 30' X 36'
   e. 20' X 24'

4. The 1" scale is used to scale distances to 1/12 their actual size. Similarly, the 1/4" scale is used to scale distances to
   ________ of their actual size.
   a. 1/4
   b. 1/8
   c. 1/12
   d. 1/24
   e. 1/48

5. The 3" scale is used to scale distances to ________ of their actual size.
   a. 1/4
   b. 1/8
   c. 1/12
   d. 1/24
   e. 1/48

6. If you scaled an 18'6" line, its actual full-size length would be
   a. 9'3" long if scaled with the 1/8" scale.
   b. longer than both the fully-divided and open-divided sections combined on the 1" scale.
   c. 9 ¾" when scaled with the 1" scale.
   d. 9 ½" when scaled with the ½" scale.
   e. 9 ¾" when scaled with the ½" scale.

7. If a scaled drawing of a building measured 6" X 9" and you knew the building was drawn with the 1/4" scale, the actual full-size building would be:
   a. 12' X 18'
   b. 24' X 36'
   c. 24" X 36"
   d. 30' X 45'
   e. 30" X 45"
8. When drawing a distance to reduced scale you are drawing it to a fraction of its original size. To draw a distance larger than actual size with the 1" scale:
   a. it cannot be done.
   b. 1" on the enlarged scale drawing could equal \( \frac{1}{2} " \) of actual size.
   c. 1" of scale size could equal 2" of actual size.
   d. 1" of scale size could equal \( \frac{1}{2} " \) on the enlarged scale drawing.
   e. it can be done, but neither B, C, nor D are correct answers.

9. The scale in the figure below has been lined up with the closest foot mark. What is the next step in measuring the length of this line?

   a. slide the scale to the closest inch mark.
   b. read the inch mark which lines up with the left end of the line.
   c. line up the zero mark with the left end of the line.
   d. record the answer in feet and inches.
   e. not enough information is given to read the 1/8" scale.

10. The line above is being scaled with the 1" scale, but even if it were being scaled with the ½" scale, the step after lining up the closest foot mark is:

   a. read the number of inches.
   b. record the answer.
   c. line up the zero mark with the end of the line.
   d. line up the right end dash of the line with the ½" scale zero mark.
11. & 12.

After you line up the zero mark (as shown in the figure above) the next step is to slide the scale to the (11) to line up the (12) with the right end dash of the line.

11. a. right  
    b. left  
    c. left end dash to the  
    d. label end

12. a. 4' mark  
    b. foot mark  
    c. inch mark  
    d. 3' mark


When scaling with the 1' scale, mark a dash at one end of the line. Next, (13). Line up the selected foot mark with the dash and then (14).

13. a. slide the scale to the zero mark  
    b. line up the dash with the closest foot mark  
    c. read the number of feet on the scale  
    d. mark the number of inches with a dash  
    e. select the right scale to use

14. a. mark a dash at the line's other end  
    b. mark a dash above the selected inch mark  
    c. record the distance  
    d. read the number of inches  
    e. select the right scale to use
APPENDIX G

Retention Test of Enactive Performance/
Skill with the Architect's Scale
Architect's Scale Skill Test

Note: when answering the questions on this test, make your measurements from the middle of the two end dashes.

Line up the mark on the scale with the middle of the dash on the line.

Line is 4 feet 0 inches long

Not with the outside edge of the dash

Not 4 feet 1 inch long
ARCHITECT'S SCALE SKILL POSTTEST II

PART I
Directions: Starting at the left end, scale each distance on the line provided below each question.

1. Using the 1" scale, mark a scaled line 5'6" long.

2. Using the 1" scale, mark a scaled distance of 4'1".

3. Using the 1/4" scale, mark a scaled distance 4'3" long.

4. Using the 1/4" scale, mark a scaled distance 9'5" long.

5. Using the 1/8" scale, mark a scaled distance 3'7" long.

PART II
Directions: Write the answers to each question on the blank to the left. Be accurate to the nearest inch mark on the scale.

6. The line below was drawn with the 1" scale. What length does it represent?

7. The full-sized length of this scaled line is (?) if scaled with the 1/8" scale.

Name ____________________________
8. The full-scale length of this line, which was scaled with the 1" scale is, 


9. Line A below was drawn actual size with a standard 12" ruler. Then it was scaled with two different scales. Which scale was used in figure 1? (9) 

10. And which scale was used in figure 2? (10) 

Line A 

Fig. 1 

Fig. 2 

PART III. Multiple Choice 
Directions: Circle the letter which corresponds to the best answer. 

11. & 12. Note the reduced scale line below. The line is (11) long, when scaled with the (12) scale. 

11. a. 5'6" b. 10'2" c. 5'0" d. 6'6" e. 10'11" 

12. a. ½" b. standard 12" ruler c. 1" d. 2" e. ½" 

13. & 14 & 15. What are the lengths of each of the three sides of the figure below if it is scaled with the ½" scale? 

13. a. 1'9" b. 9'6" c. 18'3" d. 3'7" 

14. a. 1'4" b. 2'6" c. 2'7" d. 2'9" 

15. a. 2'1" b. 4'1" c. 4'2" d. 4'3" e. 4'4" 

14 = ? 

15 = ?
16. The triangle in Figure 1 was scaled with the \( \frac{3}{8} \)" scale. In Figure 2, it was further reduced. Which scale was used in Figure 2?

\[ A = 2' 6'' \]

- a. \( \frac{3}{8} \)"
- b. \( \frac{1}{4} \)"
- c. \( \frac{1}{8} \)"
- d. \( \frac{3}{16} \)"
- e. \( \frac{3}{32} \)"

17. The triangle in Figure 1 was scaled with the \( \frac{1}{4} \)" scale. The same triangle was scaled with the \( \frac{3}{8} \)" scale in Figure 2, but an error was made in scaling side ______ in Figure 2.

- a. A
- b. B
- c. C
- d. No error was made.

PART IV.

Directions: Perform the operations in the questions below.

18. Figure 1 below was scaled with the \( \frac{1}{4} \)" scale of the architect's scale. Scale and draw the same figure (start with the lines provided in Figure 2) using the 1" scale.

Scaled with \( \frac{1}{4} \)" Scale

\[ C = 1' 6'' \]

Scaled with 1" Scale

\[ C = 1' 6'' \]
19. The line below was scaled with the 3" scale. Draw a line of the same scaled length with the 4" scale on the line provided.

20. The line below was scaled with the 1" scale. Draw a line of the same scaled length with the 2" scale on the line provided.
APPENDIX H

Retention Test of Cognitive Learning
TEST OF REDUCED SCALING KNOWLEDGE FOR THE ARCHITECT'S SCALE.

Directions: All questions on this test are multiple choice. Select the best choice from the alternative choices to complete the question correctly. Write the letter of the correct answer on the blank line to the left of each question.

Note: All questions which refer to reading a particular scale assume you are holding that scale face-up and parallel to the line or distance being measured—the same as in the slide program.

1. On the architect's scale, inches are read on the 1" scale at which location marked on the scale below?

2. The total number of separate scales on the architect's scale is:
   a. 10
   b. 7
   c. 9
   d. More than 10
   e. Less than 6

3. The 1" scale is used to scale distances to 1/12 their actual size. Similarly, the ½" scale is used to scale distances to their actual size.
   a. 1/2
   b. 1/8
   c. 1/12
   d. 1/24
   e. 1/48
4. While holding the 1" scale on a line parallel to the top of the paper, the 1" scale foot marks are read by reading
   a. right to left.
   b. to the right of the 1" scale label end.
   c. all foot marks renumbered to read left to right from 1 to 20.
   d. to the right of the 1" scale zero mark.
   e. to the left of the 1" scale zero mark.

5. If a scaled drawing of a building measured 6" X 9" and you knew the building was drawn with the 1" scale, the actual full-size building would be:
   a. 12' X 18'
   b. 24' X 36'
   c. 24" X 36"
   d. 30' X 45'
   e. 30" X 45"

6 & 7. Two points in the process of drawing a line to scale are shown in Figure 1 and Figure 2. From the lists below, identify the two steps which were performed to progress from Fig. 1 to Fig. 2.

   First you would:
   a. place a dash above the correct inch mark.
   b. read the required number of feet.
   c. read the required number of inches.
   d. line up the selected inch mark with the dash.

   Then you would:
   a. place a dash above the correct inch mark.
   b. read the required number of feet.
   c. read the required number of inches.
   d. line up the selected inch mark with the dash.
13.

The line above is being scaled with the 1" scale, but even if it were being scaled with the \( \frac{1}{2} \)" scale, the step after lining up the closest foot mark is:

1. read the number of inches.
2. record the answer.
3. line up the zero mark with the end of the line.
4. line up the right end dash of the line with the \( \frac{1}{2} \)" scale zero mark.

14. & 15.

When scaling with the 1" scale, mark a dash at one end of the line. Next, (14). Line up the selected foot mark with the dash and then (15).

14.
1. slide the scale to the zero mark
2. line up the dash with the closest foot mark
3. read the number of feet on the scale
4. mark the number of inches with a dash
5. select the right scale to use

15.
1. mark a dash at the line's other end
2. mark a dash above the selected inch mark
3. record the distance
4. read the number of inches
5. select the right scale to use

16. If a building is 24' long and 18' wide and was drawn with the 1" scale, the size of the drawing would be:

1. 24" long and 18" wide
2. 16" long and 12" wide
3. 12" long and 9" wide
4. 18" long and 12" wide
5. 12' long and 9' wide
17. To scale an existing line on a sheet of paper with the 1" scale, you first:
   a. place the architect's scale on the line.
   b. line up the closest foot mark on the 1" scale with the right end of the line.
   c. find the 1" scale on the architect's scale.
   d. line up the zero mark with the left end of the line.
   e. draw the line.

18. The 3" scale is used to scale distances to ______ of their actual size.
   a. 1
   b. 1/8
   c. 1/12
   d. 1/24
   e. 1/48

19. To measure a scaled line (such as 4'6") with the 1" scale, you would first place the scale on the line. Then ______.
   a. line up the closest 1" scale foot mark with the end of the line.
   b. read the number of inches to the left of the zero mark.
   c. read the number of feet to the right of the zero mark.
   d. line up the zero mark with the left end of the line.
   e. locate the 6" mark and place it on the end of the line.

20 & 21.

After you line up the zero mark (as shown in the figure above) the next step is to slide the scale to the (20) ______ with the right end dash of the line.

20. a. right  
   b. left  
   c. left end dash to the 10" mark.
   d. label end

21. a. 4' mark  
   b. foot mark  
   c. inch mark
   d. 3' mark
22. In measuring a scaled distance, the third main step is to ______
   a. record the distance
   b. identify the distance
   c. select the scale
   d. read the scale

23. Which of the following steps is used only when drawing a line to scale?
   a. line up the zero mark with one end of the line.
   b. select the right scale.
   c. mark a thin dash.
   d. slide the scale to the closest foot mark.
   e. read the number of inches.

24. To measure an existing line which has a scaled length of less than 12" with the 1" scale, you would first line up the right end of the line with the 1" scale zero mark. Then ______
   a. line up the nearest foot mark with the left end of the line.
   b. read the length of the line in inches.
   c. record the length of the line.
   d. read the answer in the open-divided section of the scale.

25. If you scaled an 18' 6" line, its actual full size length would be ______
   a. 9'3" long if scaled with the ½" scale.
   b. longer than both the fully-divided and open-divided sections combined on the 1" scale.
   c. 9½" when scaled with the 1" scale.
   d. 9 ⅛" when scaled with the ½" scale.
   e. 9 ⅛" when scaled with the ⅛" scale.
26. The scale in the figure below has been lined up with the closest foot mark. What is the next step in measuring the length of this line?

a. slide the scale to the closest inch mark.
b. read the inch mark which lines up with the left end of the line.
c. line up the zero mark with the left end of the line.
d. record the answer in feet and inches.
e. not enough information is given to read the 1/8" scale.

27. If a small building 18' long and 10' wide is scaled down with the 1" scale, it would measure _______ on the drawing.
   a. 24" X 12" 
   b. 18" X 10" 
   c. 9" X 5" 
   d. 4½" X 2½" 
   e. 1.8" X 1.0" 

28. When drawing a distance to reduced scale you are drawing it to a fraction of its original size. To draw a distance larger than actual size with the 1" scale:
   a. it cannot be done.
   b. 1" on the enlarged scale drawing could equal ½" of actual size.
   c. 1" of scale size could equal 2" of actual size.
   d. 1" of scale size could equal ½" on the enlarged scale drawing.
   e. it can be done, but neither B, C, nor D are correct answers.
APPENDIX I

Retention Test of Cognitive Learning at the "Knowledge" Level (Bloom, 1956)
TEST OF REDUCED SCALING KNOWLEDGE FOR THE ARCHITECT'S SCALE II

Directions: All questions on this test are multiple choice. Select the best choice from the alternative choices to complete the question correctly. Write the letter of the correct answer on the blank line to the left of each question.

Note: All questions which refer to reading a particular scale assume you are holding that scale face-up and parallel to the line or distance being measured—the same as in the slide program.

Label end is face up and parallel to the top of the paper.

1. On the architect's scale, inches are read on the 1" scale at which location marked on the scale below?

2. The total number of separate scales on the architect's scale is:
   a. 10
   b. 7
   c. 9
   d. More than 10
   e. Less than 6

3. While holding the 1" scale on a line parallel to the top of the paper, the 1" scale foot marks are read by reading
   a. right to left.
   b. to the right of the ½" scale label end.
   c. all foot marks renumbered to read left to right from 1 to 20.
   d. to the right of the 1" scale zero mark.
   e. to the left of the 1" scale zero mark.
4. & 5. Two points in the process of drawing a line to scale are shown in Figure 1 and Figure 2. From the lists below, identify the two steps which were performed to progress from Fig. 1 to Fig. 2.

**Figure 1**

![Figure 1]

**Figure 2**

![Figure 2]

4. First you would:
   a. place a dash above the correct inch mark.
   b. read the required number of feet.
   c. read the required number of inches.
   d. line up the selected inch mark with the dash.

5. Then you would:
   a. place a dash above the correct inch mark.
   b. read the required number of feet.
   c. read the required number of inches.
   d. line up the selected inch mark with the dash.

6. Inches are read in the _______ section of the ½" scale on the architect's scale.
   a. front
   b. fully-divided
   c. open-divided
   d. label end
   e. undivided

7. Which of the following steps is out of order for drawing a line to scale with the ½" scale?
   a. place the scale parallel to the thin line
   b. mark a dash at one end of the thin line
   c. line up the closest foot mark with the dash
   d. read the number of feet on the scale
   e. read the number of inches on the scale
8. Two steps in drawing a line to scale with the \( \frac{1}{2} \)" scale are:
   Line up the thin dash with the selected foot mark, and then ___.
   a. slide the scale to the right to line up the closest inch mark
   b. slide the scale to the left to line up the closest inch mark
   c. mark a dash above the selected inch mark
   d. darken the line between the dashes

9. When measuring a line which has a scaled length of exactly 6' with the 1" scale
   a. you only need the fully-divided section of the scale.
   b. you only need the label end and fully-divided section of the scale.
   c. you need both the open-divided and fully-divided sections of the scale.
   d. you need both the open-divided and fully-divided sections of the scale.
   e. you can use either the fully-divided section or the section to the left of the zero mark.

10. If a building is 24' long and 18' wide and was drawn with the 1" scale, the size of the drawing would be:
    a. 24" long and 18" wide
    b. 16" long and 12" wide
    c. 12" long and 9" wide
    d. 18" long and 12" wide
    e. 12' long and 9' wide

11. To scale an existing line on a sheet of paper with the 1" scale, you first:
    a. place the architect's scale on the line.
    b. line up the closest foot mark on the 1" scale with the right end of the line.
    c. find the 1" scale on the architect's scale.
    d. line up the zero mark with the left end of the line.
    e. draw the line.

12. To measure a scaled line (such as 4'6") with the 1" scale, you would first place the scale on the line. Then ________.
    a. line up the closest 1" scale foot mark with the end of the line.
    b. read the number of inches to the left of the zero mark.
    c. read the number of feet to the right of the zero mark.
    d. line up the zero mark with the left end of the line.
    e. locate the 6" mark and place it on the end of the line.
13. In measuring a scaled distance, the third main step is to ____.
   a. record the distance.
   b. identify the distance.
   c. select the scale.
   d. read the scale.

14. 

To measure an existing line which has a scaled length of less than 12" with the 1" scale, you would first line up the right end of the line with the 1" scale zero mark. Then ____.
   a. line up the nearest foot mark with the left end of the line.
   b. read the length of the line in inches.
   c. record the length of the line.
   d. read the answer in the open-divided section of the scale.
APPENDIX J

Retention Measure of Cognitive Learning at the "Comprehension" and "Application" Levels (Bloom, 1956)
TEST OF REDUCED SCALING KNOWLEDGE FOR THE ARCHITECT'S SCALE II

Directions: All questions on this test are multiple choice. Select the best choice from the alternative choices to complete the question correctly. Write the letter of the correct answer on the blank line to the left of each question.

Note: All questions which refer to reading a particular scale assume you are holding that scale face-up and parallel to the line or distance being measured—the same as in the slide program.

Label end is face up and parallel to the top of the paper.

1. The 1" scale is used to scale distances to 1/12 their actual size. Similarly, the 1/2" scale is used to scale distances to their actual size.
   a. 1
   b. 1/8
   c. 1/12
   d. 1/24
   e. 1/48

2. If a scaled drawing of a building measured 6" X 9" and you knew the building was drawn with the 1/2" scale, the actual full-size building would be:
   a. 12' X 18'
   b. 24' X 36'
   c. 24" X 36"
   d. 30' X 45'
   e. 30" X 45"
3. If a scaled drawing of a building measured 10" X 12" and you knew it was drawn with the \( \frac{1}{8} \)" scale, the actual full size of the building would be:
   a. 10' X 12'
   b. 20' X 24'
   c. 10" X 12"
   d. 30' X 36'
   e. 20' X 24'

4. The line above is being scaled with the \( \frac{1}{8} \)" scale, but even if it were being scaled with the \( \frac{1}{2} \)" scale, the step after lining up the closest foot mark is:
   a. read the number of inches.
   b. record the answer.
   c. line up the zero mark with the end of the line.
   d. line up the right end dash of the line with the \( \frac{1}{2} \)" scale zero mark.

5. & 6. When scaling with the \( 1 \)" scale, mark a dash at one end of the line.
   Next, [5]. Line up the selected foot mark with the dash and the [6].
   a. slide the scale to the zero mark
   b. line up the dash with the closest foot mark
   c. read the number of feet on the scale
   d. mark the number of inches with a dash
   e. select the right scale to use

6. a. mark a dash at the line's other end
   b. mark a dash above the selected inch mark
   c. record the distance
   d. read the number of inches
   e. select the right scale to use
7. If a building is 24' long and 18' wide and was drawn with the 1" scale, the size of the drawing would be:
   a. 24" long and 18" wide
   b. 16" long and 12" wide
   c. 12" long and 9" wide
   d. 18" long and 12" wide
   e. 12" long and 9" wide

8. The 3" scale is used to scale distances to _______ of their actual size.
   a. 1/3
   b. 1/8
   c. 1/12
   d. 1/24
   e. 1/48


After you line up the zero mark (as shown in the figure above) the next step is to slide the scale to the ______ of the line.
   9. a. right
   b. left
   c. left end dash to the 10" mark
   d. label end
   10. a. 4' mark
       b. foot mark
       c. inch mark
       d. 3' mark

11. If you scaled an 18'6" line, its actual full size length would be
   a. 9'3" long if scaled with the 1" scale.
   b. longer than both the fully-divided and open-divided sections combined on the 1" scale.
   c. 9 1/2" when scaled with the 1" scale.
   d. 9 1/2" when scaled with the 1" scale.
   e. 9 1/2" when scaled with the 1" scale.
12. The scale in the figure below has been lined up with the closest foot mark. What is the next step in measuring the length of this line?

![Scale Diagram]

- a. slide the scale to the closest inch mark
- b. read the inch mark which lines up with the left end of the line
- c. line up the zero mark with the left end of the line
- d. record the answer in feet and inches
- e. not enough information is given to read the 1/8" scale

13. If a small building 18' long and 10' wide is scaled down with the 1/8" scale, it would measure ________ on the drawing.

- a. 24" X 12"
- b. 18" X 10"
- c. 9" X 5"
- d. 4½" X 2½"
- e. 1.8" X 1.0"

14. When drawing a distance to reduced scale you are drawing it to a fraction of its original size. To draw a distance larger than actual size with the 1" scale:

- a. it cannot be done
- b. 1" on the enlarged scale drawing could equal ½" of actual size
- c. 1" of scale size could equal 2" of actual size
- d. 1" of scale size could equal ½" on the enlarged scale drawing
- e. it can be done, but neither B, C, nor D are correct answers
APPENDIX K

Practice Worksheet--Schema Instruction
Practice Worksheet Number 1
Measuring a Scaled Distance with the 1" Scale

Directions: With the 1" scale, measure the lines marked below. Write your answers in feet and inches on the lines provided at the right. Note: Be accurate to the closest inch mark on the scale.

1. Answer 1.

2. Answer 2.

3. Answer 3.

Practice Worksheet Number 2

Measuring a Scaled Distance with the $\frac{1}{4}$" Scale

Directions: With the $\frac{1}{4}$" scale, measure the lines marked below. Write your answers in feet and inches on the lines provided at the right. Note: Be accurate to the closest inch mark on the scale.

1. Answer

2. Answer

3. Answer

4. Answer
Practice Worksheet Number 3

Drawing a Line to Scale with the 1" Scale

**Directions:** With the 1" Scale, mark off the following scaled distances on the lines provided and draw a dark heavy line between the marks.

1. Three Feet, Zero Inches (3'0")

2. Three Feet, Six Inches (3'6")

3. Two Feet, Eight Inches (2'8")

4. Four Feet, One Inch (4'1")
Practice Worksheet Number 4

Drawing a Line to Scale with the 4" Scale

Directions: With the 4" Scale, mark off the following scaled distances on the lines provided and draw a dark heavy line between the marks.

1. Two Feet, Zero Inches (2'0")

2. Eight Inches (8"")

3. Twelve Feet, Three Inches (12'3")

4. Eleven Feet, Ten Inches (11'10")
APPENDIX L

Practice Worksheets--Traditional Instruction
Practice Worksheet Number 1
Measuring a Scaled Distance with the 1" Scale

Directions: With the 1" scale, measure the lines marked below. Write your answers in feet and inches on the lines provided at the right. Note: Be accurate to the closest inch mark on the scale.

1. 

2. 

3. 

4. 

Answers 1. 

Answers 2. 

Answers 3. 

Answers 4.
Practice Worksheet Number: 2
Drawing a Line to Scale with the 1" Scale

Directions: With the 1" Scale, mark off the following scaled distances on the lines provided and draw a dark heavy line between the marks.

1. Three Feet, Zero Inches (3'0")

2. Three Feet, Six Inches (3'6")

3. Two Feet, Eight Inches (2'8")

4. Four Feet, One Inch (4'1")
Practice Worksheet Number 3

Measuring a Scaled Distance with the \( \frac{1}{4} \)" Scale

Directions: With the \( \frac{1}{4} \)" scale, measure the lines marked below. Write your answers in feet and inches on the lines provided at the right. Note: Be accurate to the closest inch mark on the scale.

1. Answer

2. Answer

3. Answer

4. Answer
Practice Worksheet Number 4
Drawing a Line to Scale with the $\frac{1}{4}$" Scale

Directions: With the $\frac{1}{4}$" Scale, mark off the following scaled distances on the lines provided and draw a dark heavy line between the marks.

1. Two Feet, Zero Inches (2'0")

2. Eight Inches (8")

3. Twelve Feet, Three Inches (12'3")

4. Eleven Feet, Ten Inches (11'10")
APPENDIX M

Classroom Procedures for Administration of Pretests, Treatments and Practice Worksheets, Posttests, and Retention Tests
Directions to Administer Pretests

Mr. Siebold: "Mr. Nix has invited me to present to you a unit of instruction on how to read an architect's scale, but first we want to know how much you already know about it.

So, today I've got two tests for you, a short test of skill for reading a regular 12" ruler, and then a 20 question test to see if you already know how to read an architect's scale. You may not be able to answer all of the questions. If you come to a question you don't understand or cannot answer, just leave it out and go on to the next. Tomorrow you will receive instruction on using the architect's scale.

As soon as you receive your test paper and ruler, you may begin. When you're finished, put your ruler and pencil on top of your paper and wait quietly for others to finish. Be sure to put your name on the top of the paper. You will have about eight minutes.

1. Pass out rulers and pencils
2. Pass out 12" Ruler Skill Test
3. Collect rulers and tests in eight minutes

This next test is on the architect's scale. You will probably find it harder than the ruler test. Please do your best. You may start as soon as you receive your scale and test paper. Be sure to put your name on the top of the paper. You will have about 20 minutes to
complete it. Skip over any items you don't know how to do.

1. Pass out scales
2. Pass out Architect's Scale Skill Test
3. Collect scales and tests in 20 minutes
Directions To Administer Instructional Units

Mr. Nix: "I have asked Mr. Vick and Mr. Siebold from Murray State to present this instruction on the architect's scale. For those of you who don't know how to use the scale, you may be surprised how useful it can be and how widely it is used to design buildings and manufactured products. If you can already use the scale, this will be an opportunity to get better at it."

Mr. Siebold: "Hi, I'm Mr. Siebold, and this is Mr. Vick from Murray State. Today we will show you a couple of slide shows on how to read an architect's scale. The first will be an introduction and will be quite short. The second part will take about 25 minutes. Together they are designed to help you learn to use the scale."

Start Introduction (Slides and Auto-Advance Tape)
Stop slide tape unit and change trays and tapes

Mr. Vick: While changing the slide trays and tapes say, "This next part is the main body of instruction on the architect's scale and is divided into several short units. We will stop four times during the instruction and complete a short worksheet. These worksheets are meant to give you a chance to practice using the scale and ask questions about it. Immediately following each worksheet, the answers to the practice problems will be given so you can check yourself."
At completion of fourth-practice worksheet, collect:

Worksheets
Pencils
Scales

Mr. Vick: "Pay special attention to the review section you are about to see, because tomorrow you will have a two-part test on this material. Part One will be like the skill test you took on the architect's scale yesterday, and Part Two will test your knowledge of the parts of the scale and other things in the slide show."
Directions to Administer Posttests

Mr. Siebold: "Today, I have two follow-up tests for you to take. The first is a skill test to see how well you can use the architect's scale. The second is a knowledge test to see how much you know about the names of the parts and other things about the scale."

Mr. Nix: "Class, since I have asked Mr. Siebold to present this lesson, the grades on these two tests will count in your grade average."

Pass out: Pencils
Scales
Tests

Mr. Siebold: "This is the skill test. Do your best on each item, but do not get stuck on any one item. Skip over anything you cannot do and come back to it later. You will have about 20 minutes. As soon as you have your pencil, scale and test, you may begin. Be sure to put your name on the test as soon as you get it. When you finish, just turn the test upside down and wait quietly for everyone else to finish."

Time Test: 20 minutes
Announce time when only 4 minutes remain
Collect tests ONLY

Mr. Siebold: "Keep the scales and pencils for use on this next test. You don't actually need the scale to answer any of the questions, but you may want to look at it to help you remember things about it."
Pass out Knowledge Posttest

Mr. Siebold: "You will have about 25 minutes to complete this test. When you finish, turn your paper over and wait quietly for everyone else to finish."

Announce time when only 10 minutes remain
Announce time when only 4 minutes remain
Collect: Tests
Scales
Pencils
Directions to Administer Retention Posttests

Mr. Siebold: "Mr. Nix and I have decided you need another try at the skill and knowledge tests you took last Wednesday, a chance to improve your scores. This is the deal. If you do better on them this time than last time, we will drop the first grade and count only this one. But your scores today will count regardless of whether you beat last Wednesday's scores or not. In other words, if you do better today than last Wednesday, only today's scores will count toward your grade. But today's scores will count even if you do worse than last Wednesday.

Pass out: Pencils
Scales
Tests

Mr. Siebold: "This is the skill test. Do your best on each item, but do not get stuck on any one item. Skip over anything you cannot do and come back to it later. You will have about 20 minutes. As soon as you have your pencil, scale and test, you may begin. Be sure to put your name on the test as soon as you get it. When you finish, just turn the test upside down and wait quietly for everyone else to finish."

Time Test: 20 minutes
Announce time when only 4 minutes remain
Collect tests ONLY
Mr. Siebold: "Keep the scales and pencils for use on this next test. You don't actually need the scale to answer any of the questions, but you may want to look at it to help you remember things about it."

Pass out Knowledge Posttest

Mr. Siebold: "You will have about 25 minutes to complete this test. When you finish, turn your paper over and wait quietly for everyone else to finish."

Announce time when only 10 minutes remain
Announce time when only 4 minutes remain
Collect: Tests
Scales
Pencils


