R E P O R T R E S U M E S

ED 016 148 24 AC 001 649

DIFFERENTIALLY STRUCTURED INTRODUCTORY LEARNING MATERIALS AND LEARNING TASKS.

BY- GROTELUESCHEN, ARDEN
COLUMBIA UNIV., NEW YORK, TEACHERS COLLEGE

REPORT NUMBER BR-6-2447 PUB DATE OCT 67
GRANT OEG-1-7-002447-2042
EDRS PRICE MF-$1.00 HC-$10.24 254P.

DESCRIPTORS- *ADULT LEARNING, *NUMBER CONCEPTS, *INTELLIGENCE LEVEL, *PAIRED ASSOCIATE LEARNING, *SEQUENTIAL APPROACH, LEARNING THEORIES, NUMBER SYSTEMS, TEACHING MACHINES, INTELLIGENCE, PROGRAMED INSTRUCTION, PROGRAMED TEXTS, TASK PERFORMANCE, SEX DIFFERENCES, EFFECTIVE TEACHING, TEXTBOOK CONTENT, MATHEMATICS, SEQUENTIAL LEARNING, COGNITIVE PROCESSES, TIME FACTORS (LEARNING)

AN ATTEMPT WAS MADE TO ASSESS THE EFFECTS ON ADULT LEARNING OF DIFFERENTIALLY STRUCTURED INTRODUCTORY COGNITIVE LEARNING TASKS AND MATERIALS, AND THE INTERACTION OF INTELLIGENCE WITH THE EXPERIMENTALLY MANIPULATED MATERIAL AND TASK CATEGORIES. ABOUT 96 ADULTS WHO WERE UNFAMILIAR WITH THE CONCEPT OF NUMBER BASES WERE CLASSIFIED ACCORDING TO A 4X3X4 FACTORIAL DESIGN. DURING INDIVIDUAL SESSIONS, THE LEARNER, CLASSIFIED BY INTELLIGENCE LEVEL, WAS GIVEN A PROGRAMED BOOKLET ON ONE OF FOUR STRUCTURAL LEARNING MATERIALS RANDOMLY ASSIGNED. UPON COMPLETION, THE LEARNER WAS GIVEN A LEARNING TASK, BY TEACHING MACHINE, UNDER AN EXPERIMENTAL CONDITION CONSISTING OF THREE DIFFERENTIALLY SEQUENCED SETS OF PAIRED ASSOCIATES, CORRESPONDING TO NUMBERS IN THE BASE FOUR NUMBER SYSTEM. THE NUMBER OF TRAILS REQUIRED, TOTAL ERRORS, AND POSTTEST SCORES SERVED AS MEASURES OF THE EFFECTIVENESS OF THE EXPERIMENTAL CONDITIONS. INTELLIGENCE WAS POSITIVELY RELATED TO TASK PERFORMANCE, COMPLETE TASK SEQUENCING LED TO MORE RAPID LEARNING THAN DID PARTIAL SEQUENCING, INTRODUCTORY MATERIALS WERE ESPECIALLY USEFUL WITH THE MORE INTELLIGENT ADULTS, COMPLETELY SEQUENCED LEARNING TASKS WERE EVIDENTLY MOST BENEFICIAL WITH THE LESS INTELLIGENT ADULTS, AND MEN CONSISTENTLY OUTPERFORMED WOMEN, PARTICULARLY IN APPLYING NUMBER BASE PRINCIPLES. (LY)

FINAL REPORT

Project No. 6-2447
Grant No. OEG-1-7-002447-2042

DIFFERENTIALLY STRUCTURED INTRODUCTORY LEARNING MATERIALS AND LEARNING TASKS

October 1967

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

DIFFERENTIALLY STRUCTURED INTRODUCTORY LEARNING MATERIALS AND LEARNING TASKS

Project No. 6-2447
Grant No. OEG-1-7-002447-2042

Arden Grotelueschen

October 1967

The research reported herein was performed pursuant to a grant with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

Teachers College, Columbia University
New York, New York 10027

TABLE OF CONTENTS

PROBLEM 1

The Problem 2

Theoretical Background 5

Related Literature 15

Hypotheses 28

METHOD 31

Sample Selection and Classification 31

Experimental Conditions 34

Introductory Programed Materials 34

Learning Tasks 37

Experimental Design 38

Criterion Measures 41

General Procedures 41

Introductory Programed Material 41

Prelearning Task 42

Learning Task 43

Statistical Procedures 46

RESULTS 48

Analysis One 49

Analysis Two 56

Analysis Three 62

Other Analyses 68

DISCUSSION 73

Findings in Relation to Hypotheses 73

Validity of the Study 91

Further Research 100

SUMMARY 104

REFERENCES 112

APPENDIXES 115

Appendix A. Project Questionnaire

Appendix B. Number Base Systems Pretest

Appendix C. Means and Standard Deviations of Selected Variables by Intelligence Classification and Sex

Appendix D. History of Measurement Program
Base Ten Number System Program
Base Seven Number System Program
Principles of Number Bases Program

Appendix E. History of Measurement Program Supplementary Sheet 1

Appendix F. Differentially Sequenced Learning Tasks

Appendix G. Posttest

Appendix H. Instructions for Administration of Materials

Appendix I. Intercorrelation Matrix of Selected Variables

LIST OF TABLES

Table		Page
1	Sample Means and Standard Deviations of Pretest, WAIS Full Scaled Score, and Age Variables by Sex and Intelligence Level	33
2	Number of Frames, Responses, Mean Errors, and Mean Time by Introductory Programed Material	37
3	Definition of Factors	39
4	Schematic of the Factorial Design	40
5	ANOVA of Posttest Total Scores for 4 x 3 x 4 x 2 Analysis	50
6	Significant Posttest Total Score Main Effect and Interaction Means for 4 x 3 x 4 x 2 Analysis	50
7	ANOVA of Trials to Criterion for 4 x 3 x 4 x 2 Analysis	51
8	Significant Trials Main Effect Means for 4 x 3 x 4 x 2 Analysis	52
9	ANOVA of Errors to Criterion for 4 x 3 x 4 x 2 Analysis	55
10	Significant Errors Main Effect Means for 4 x 3 x 4 x 2 Analysis	56
11	ANOVA of Posttest Total Scores for 4 x 3 x 2 x 2 Analysis	57
12	ANOVA of Trials to Criterion for 4 x 3 x 2 x 2 Analysis	59
13	ANOVA of Errors to Criterion for 4 x 3 x 2 x 2 Analysis	61
14	*L* Test of Total Posttest Cell Means of Upper Intelligence Subgroup by Introductory Material and Learning Task Conditions	64

Table		Page

15 *L* Test of Transfer Cell Means of Upper Intelligence Subgroup by Introductory Material and Learning Task Conditions 66

16 *L* Test of Errors Cell Means of Upper Intelligence Subgroup by Introductory Material and Learning Task Conditions 66

17 *L* Test of Trials Cell Means of Upper Intelligence Subgroup by Introductory Material and Learning Task Conditions 67

18 Programed Introductory Material Errors and Completion Time by Intelligence 70

LIST OF FIGURES

Figure		Page
1	Top view of adapted teaching machine	45
2	Side view of timer	45
3	Adapted teaching machine with subject and session administrator	45
4	Trials means of introductory materials for 4 x 3 x 4 x 2 analysis	53
5	Trials means for levels of intelligence at each introductory material level for 4 x 3 x 4 x 2 analysis	54
6	Posttest means for levels of intelligence at each introductory material level for 4 x 3 x 2 x 2 analysis	58
7	Posttest means of introductory materials for 4 x 3 x 2 x 2 analysis	59
8	Trials means for levels of intelligence at each learning task level for 4 x 3 x 2 x 2 analysis	60

ACKNOWLEDGMENTS

In conducting a project such as the present one, the assistance of many people is required. Among the many whose assistance was enlisted, the writer is particularly indebted to Dr. Douglas Sjogren of Colorado State University; Dr. Alan Knox of Teachers College, Columbia University; and Dr. Royce Ronning of the University of Nebraska.

Dr. Sjogren and Dr. Knox did much to assist in the development of the design and procedures whereby this study was conducted. They also provided the sample of adults on whom the project was conducted, and their continued support and assistance throughout the study was of an indeterminate value. Special appreciation is also given to Dr. Ronning who provided much guidance and assistance, especially in preparing the final manuscript.

Thanks is given to Mr. Gordon Bruning, Mr. Jerome Donahue, Mr. Donald Frerichs, Mrs. Jowann Grotelueschen, Miss Judy Hill, Miss Irene Lachmann, Mrs. Susan Lewis, Mr. Larry Looby, and Mrs. Janice Vasey, who served as session administrators.

For secretarial and clerical assistance on various aspects of the project the writer wishes to thank Mrs. Janice Vasey, Mrs. MarVelle McCarron, and Miss Louise Spears.

Special thanks is also given to the 179 adults who participated in some form or another in this study.

For assistance in programing the introductory materials, the writer wishes to acknowledge his wife, Jowann, who provided various

technical skills as well as the much appreciated constant support and encouragement.

Finally, the financial support of the Office of Adult Education Research, University of Nebraska; the Center for Adult Education, Teachers College, Columbia University; and the Bureau of Research, U. S. Office of Education was greatly appreciated.

A. G.

PROBLEM

The effects of prior learning on subsequent learning have been demonstrated by a large number of research studies dealing with infrahuman as well as human subjects. In the field of adult learning as well, the fact that previous educational experience affects the learning of adults is acknowledged by researchers of the adult learning process, teachers of adults, and adult learners themselves who are engaged in formal educational activities. The influence of the educational background of the adult education participant on learning outcomes has been investigated by various researchers (e.g., Sorenson, 1930; Sjogren and Knox, 1965, 1967). Findings from these studies suggest that adults who have not recently participated in an educational activity or who do not have a high level of formal educational background are not able to perform as well in a learning situation as those who have recently been involved in some educational activity or who have a high level of formal education. As a result, the adult with an inadequate educational background frequently becomes dissatisfied and drops out of the activity. Furthermore, the varied educational backgrounds of students in many adult education classes make it difficult for the instructor to arrange the external conditions of learning.

An approach by which the instructor may influence variables relevant to learning outcomes, places emphasis on the structure and

sequencing of a body of knowledge.[1] To facilitate learning, background information is given to the learner through a process that includes the appropriate selection of subject matter which is effectively sequenced.

It is recognized that some learner characteristics will ordinarily influence the achievement of desired learning outcomes. However, it is also important to consider the characteristics of the instructional activity which affect learning. Knowledge about the effectiveness of instructional activity, combined with information about learner characteristics, should result in a more effective educational experience for adults.

The Problem

An important task of the educator is to present the optimal structure and sequence of educative activities. For example, the classroom teacher is concerned with the selection, organization, and presentation of a subject matter in the form of lessons, units, and courses. The curriculum specialist, too, is concerned with the design of an educative experience which is deliberately structured and sequenced in a manner that facilitates the achievement of intended objectives. Other educators, such as the programed

---

[1]The term *structure* refers to the content and organization of a selected subject matter, and *sequence* refers to the sequential arrangement in which the content is presented. (This distinction is somethat similar to the familiar curriculum concepts of scope and sequence.)

learning specialist, the author of educational texts and materials, and the educational psychologist have recently placed increased emphasis on the efficient programming of educational materials.

Learning theorists have also emphasized that the structure and sequence of the educative activity have an effect on the outcomes of learning. The appropriate sequential arrangement of the learning material, within a topic to be learned and among the topics that make up a subject matter, is viewed as a requirement for effective learning. For example, both behavioristic and cognitive learning theorists assert that the sequential arrangement of the subject matter is an important variable in the study of learning.

The behavioristic viewpoint, as exemplified by Skinner and linear programed instruction, emphasizes the logical step by step sequencing of the subject matter. Through appropriate sequential arrangement of the subject matter the learner is guided progressively to a desired outcome.

Cognitive theorists, such as Ausubel, Gagné, and Bruner, also emphasize the necessity of sequential arrangements of the subject matter and, in effect, advocate programming the learning material. Furthermore, they emphasize the importance of the structure of a subject matter (cf., Ausubel, 1963b; Bruner, 1960, 1964; Gagné, 1965). Also, cognitive theorists stress the assumption that subject matter which is appropriately structured and sequenced not only is more readily learned, but also becomes an important independent

variable which influences the subsequent learning of related material (Ausubel, 1965). Hence, in the latter instance, one may theorize that meaningful learning can be brought about most effectively and efficiently by the manipulation of the structure and sequence of selected subject matter.

Two general procedures have been identified by Ausubel (1963b, 1965) whereby *cognitive structure* (i.e., the learner's existing organized body of knowledge regarding a learning topic) can be influenced so as to facilitate the learning of new material. One such variable is the structure of the subject matter itself. This refers to those *substantive* aspects of the subject matter that have the greatest generalizability, inclusiveness, and relatability within that subject matter area. The second variable is concerned with the manner in which the subject matter is presented, arranged, and ordered. This proper sequence of activities in which a learner is involved is referred to as the *programmatic* aspect of presenting material.

The general purpose of the present study, then, was to experimentally manipulate two aspects of the instructional process, both of which serve to influence adult learning. More specifically, the purpose was to ascertain the effects of introductory materials, which were differentially structured with regard to content, on conceptually related learning tasks which were differentially sequenced.

The first variable manipulated was the structure of the introductory learning material presented to the subject prior to the actual learning task. This variable was manipulated for the purpose of ascertaining the effects on learning which accompany the variation of the substantive aspect of the subject matter. The second variable was manipulated to examine the influence of the sequential arrangement of the learning material on learning outcomes (i.e., the manipulation of a programmatic variable).

Theoretical Background

One of the primary proponents of the recent emphasis on the structure and sequencing of learning materials and of knowledge has been David P. Ausubel. Because the impetus and the conceptual framework for the present study were basically derived from the theoretical concepts of meaningful verbal learning, as presented in various publications by Ausubel (e.g., 1961, 1962, 1963a, 1963b, 1965, 1966), a summary of this theory is necessary. Following this section on theoretical background, a sampling of the empirical literature on this topic is included as a background for the more specific problems of the present research investigation.

Although the major aspects of Ausubel's cognitive theory will be summarized, there are three areas which are particularly relevant to the purpose of this study. These areas include (a) the systematic change in extent and type of knowledge brought about by the integration and incorporation of new information into the learner's

existing cognitive structure; (b) the identification of those factors that have an effect on the acquisition of new information; and (c) the manipulation of the learner's cognitive structure so that the acquisition of newly presented information is enhanced.

In general, this theory is limited to various principles regarding the integration and organization of the learner's knowledge, and to various procedures whereby knowledge is acquired, retained, and forgotten. Within this frame of reference, Ausubel further limits his theory to meaningful verbal reception learning, which he believes is the most characteristic type of school learning. Reception or expository learning, as contrasted to discovery learning, refers to learning material presented in its entirety to the learner. Thus, the entire content to be learned is given to the learner, who only needs to internalize the material presented to him for future reproduction.

For reception learning to take effect, it is assumed that the learner possesses a mature cognitive structure. That is, the learner understands the concepts and principles of the meaningfully presented material without any necessary prior concrete experience with the material. This is in direct contrast to learning characteristics of young learners who need relevant concrete experiences directly prior to their understanding any abstract learning material (Inhelder and Piaget, 1958). Furthermore, because the reception type of learning is presented verbally, it may be presented in

either a rote or a meaningful manner without prior nonverbal and problem solving experiences. It is important, therefore, to note that Ausubel's emphasis is on meaningful reception learning and not on rote learning.

Meaningful learning refers primarily to a learning process rather than a learning outcome, and is distinguished from the process of rote learning. It assumes that the learner possesses an expectation that the learning material will be meaningful to him and that the learning material actually is potentially meaningful to him. The meaningful expectation or set that is a requisite for the occurrence of meaningful learning serves to relate the substantive aspects of the learning material to relevant elements of the learner's existing cognitive structure. Obviously, the meaningful set to learn results in meaningful learning only when the material to be learned is potentially meaningful.

For learning material to be potentially meaningful two important criteria must be satisfied. The first criterion is the nonarbitrary relatability of the learning material to relevant concepts in the potential learner's cognitive structure. This criterion applies only to the total learning material itself and not to the component parts. The second criterion involves the relatability of the learning material to the cognitive structure of a specific learner. This second criterion refers to a characteristic of the learner, whereas, the first criterion has reference to a characteristic of the learning material.

Learning materials which satisfy the criteria of potential meaningfulness are learned according to principles of learning and retention that are quite different from materials learned by rote. Meaningfully learned materials are related and anchored to an existing ideational system within the cognitive structure of the learner. In contrast, materials learned by rote are discrete entities relatable to cognitive structure in an arbitrary manner, and as a consequence are not anchored to any existing ideational system. Therefore, the meaningfully learned material is more effectively learned and has greater stability, retention, and transferability.

For potentially meaningful material to become actually meaningful, it must interact with, and be subsumed or incorporated into, the learner's existing ideational system. For this to occur, it is assumed that the content of the field of knowledge which is being learned is organized and that the relevant content within the learner's cognitive structure is also organized. First, it is assumed that the subject matter of which the potentially meaningful material is a part, is organized in some hierarchical fashion. Second, it is assumed that the organization of the learner's cognitive structure is also hierarchically organized. Within the learner's cognitive structure the most general or inclusive concepts are located at the apex of the structure under which are subsumed the less inclusive concepts and specific information.

The fact that the potentially meaningful material has interacted with and is relatable to organized conceptual and ideational

elements in the learner's cognitive structure is the basis for its meaningfulness. As the new material is introduced into the learner's cognitive structure, the initial efforts of the subsumption process involve various orienting, relational, and cataloging operations. These operations are necessary for learning and retention because they provide the mechanisms whereby new material is subsumed and incorporated within the existing cognitive structure of the learner. Furthermore, anchorage within the ideational system is provided for the newly learned material. That is, newly learned material is attached to or subsumed by related concepts in cognitive structure. As a result, the newly learned material, for some variable time period, remains a separate and distinct entity within the learner's subsuming ideational system. Thus the material can be separated from its subsumer and recalled by the learner.

Although anchorage of the newly learned material within the learner's ideational system enhances its stability and retention, the material in time loses its individual identity. According to Ausubel, this is brought about by a conceptualizing trend in cognitive structure whereby less inclusive concepts and information are subsumed into more highly inclusive concepts. When this second or obliterative stage of the subsumption process begins, the specific identifiable elements of the learned material gradually become less separable from the learner's existing ideational system until they no longer have any distinct identity of their own. At this point the material is said to be forgotten.

Within meaningful reception learning the process of subsumption, therefore, is theorized to be responsible for (a) the acquisition of knowledge, (b) the stability and retention of newly-acquired material, (c) the hierarchical organization of the body of knowledge within the learner's cognitive structure, and (d) the occurrence of forgetting.

Two different types of subsumption theoretically occur in the learning and retention of meaningful material. The meaningful material which is subsumed and related to existing conceptual elements may be either derived from or correlated to established concepts in the learner's cognitive structure. If new learning material is an example or illustration of some established concept or idea in the learner's cognitive structure, it is derivable from or implicit in a more inclusive concept of the established subsumer. The outcome of this type of subsumption is manifest in the easy and quick acquisition of meaning, and in rapid forgetting. The reason for rapid acquisition and forgetting is that the meaning of the new material is highly relatable to a more inclusive concept in the learner's existing cognitive structure. This inclusive concept readily subsumes the meaning of the material so that the identifiable elements of the learned material are lost. Although the learned material loses its specific identity, the material is not entirely forgotten because substantive ideas of the learned material are maintained within relevant subsumers in the learner's cognitive structure.

On the other hand, if new material is an extension, qualification, or elaboration of an established concept in the learner's cognitive structure, then it is defined as correlated to a more inclusive established subsumer. The incorporation and interaction of the meaning of this new material, which is only tangentially related to the more inclusive subsumer, is not implicit in and cannot be adequately represented by the existing subsumption system. As a consequence, newly learned material which is correlated to existing more highly inclusive concepts undergoes obliterative subsumption similar to derivatively subsumed material. The effects of obliterative subsumption are, however, more serious in the case of correlated materials. The reason for this is that when correlated materials lose their identity and can no longer be separated from their subsumers, the substance of the correlated material is not adequately represented within the subsumer and, therefore, cannot be reproduced in the future. Therefore, in this instance, the entire substance of what was learned is lost. Needless to say, obliterative subsumption occurs most rapidly when the existing conceptual subsumers are not stable and clear and when the learning material has not been overlearned.

In summary, the subsumption of potentially meaningful derivative and correlated material is dependent upon an existing hierarchical organization of meaningfully learned materials in the learner's cognitive structure. This subsumption process efficiently

reduces the new material to a least common denominator of relevant established meanings.

Ausubel theorized that learning and retention of derivative and correlated materials is influenced, in the narrow sense, by relevant subsuming concepts in the learner's cognitive structure; and, in the general sense, by the learner's subject matter knowledge. In either instance, a clear, stable, and organized existing cognitive structure will enhance the learning and retention of new relevant material. Ausubel also theorized that the extent to which transfer occurs is dependent upon the influence of these *cognitive variables* (i.e., the clarity, stability, and organization of a learner's knowledge in a subject matter). Hence the strengthening of these relevant aspects of cognitive structure will facilitate new learning, retention, and transfer.

The acquisition of an adequate cognitive structure which facilitates new learning is dependent upon two factors. One factor is the structure of the subject matter itself. This refers to those *substantive* aspects of the subject matter that have the greatest generalizability, inclusiveness, and relatability within that subject matter area. The second factor is the manner in which subject matter is presented, arranged, and ordered. This proper sequence of activities in which a learner is involved is referred to as the *programmatic* aspect of presenting material.

Thus, Ausubel theorizes that cognitive structure is influenced by substantive and programmatic factors of the subject matter.

These factors facilitate the acquisition, retention, and subsequent transfer of ideas and concepts in newly learned material.

Two principles are hypothesized to have a significant role in the sequential arrangement of learning materials. These principles, which have a marked influence on cognitive structure, are the principles of progressive differentiation and integrative reconciliation. According to the principle of progressive differentiation the most general and inclusive concepts in an area of subject matter are presented first to the learner. This is followed by content which is increasingly differentiated with regard to detail and specificity.

This order of presentation corresponds to the assumptions presented earlier regarding the organization of a subject matter area and the organization of that subject within the learner's cognitive structure. Thus if the organization of a body of knowledge and the organization of knowledge in cognitive structure conform to the principle of progressive differentiation, it is assumed that effective learning occurs. The acquisition of new material is dependent upon the availability of generalized relevant concepts in the learner's cognitive structure whose function it is to incorporate and subsume the new material.

The principle of integrative reconciliation refers to the process of relating newly acquired information to previously acquired material. By applying this principle in the programming of new

learning material, ideas and concepts are integrated and reconciled with previously learned content in cognitive structure. As a consequence, relationships between ideas are more easily discovered, ideational similarities and differences are made evident, and the resolution of real or apparent inconsistencies is achieved. This procedure is in striking contrast to the common practice of presenting the ideas and content in learning material in segregated and compartmental segments.

In summary, Ausubel's theory of meaningful reception learning is based on the premise that if an individual's existing cognitive structure in a particular subject matter area is clear, stable, and organized, then the learning and retention of new meaningful material is enhanced. On the other hand, if the existing cognitive structure is ambiguous, unstable, and disorganized, then the learning and retention of new meaningful material is inhibited. As a result, attention should be directed to the strengthening of relevant aspects of the learner's cognitive structure in a subject matter area so that new learning and retention can be facilitated.

The following section presents findings from a number of experimental research investigations conducted by Ausubel and his associates, in which deliberate attempts were made to influence the learner's cognitive structure so that meaningful learning and retention would be maximized.

Related Literature

In recent years a number of articles (e.g., Ausubel and Fitzgerald, 1961a; McDonald, 1964) and books (e.g., Anderson and Ausubel, 1965; Ausubel, 1963b) have contained reviews of relevant literature on meaningful verbal learning. Although some of the reviewed or cited studies are of direct relevance, a great number of the studies reported are only tangentially related to the specific problems of the present research investigation. A detailed review is presented of only those studies that are directly relevant to the specific problem of the present investigation, and whose origin is implicit in the theoretical propositions of meaningful verbal learning as stated by Ausubel.

The following studies by Ausubel and his associates were designed to test the basic theoretical proposition that cognitive structure variables are significant factors which influence the learning and retention of relevant and related new material. Prior to attempting a specific learning task, the learner studied material that was relevant to, and inclusive of, existing concepts in the learner's cognitive structure and in the actual learning task material. These *advance organizers* or introductory materials were presumably structured, however, at a higher level of abstractness, generality, and inclusiveness than the existing relevant knowledge in the learner's cognitive structure and the actual learning material. Furthermore, the introductory material included substantive

content that for organizational and integrative purposes had the greatest generalizability, inclusiveness, and relatability within the subject matter content. This introductory material was also sequentially arranged so that the organizational strength of cognitive structure would be enhanced.

The use of introductory materials, then, purportedly draws together the available relevant ideas and concepts in the learner's cognitive structure and provides an overview for new related learning material at the appropriate level of conceptualization. These introductory materials presumably provide a subsuming role or a conceptual and ideational framework for the reception of new learning material. Also, relevant and inclusive introductory materials presumably increase the discriminability of new materials by indicating similarities and differences between existing concepts in cognitive structure and the information in the new learning material.

To test this complex theory, an experimental study by Ausubel (1960) hypothesized that the learning and retention of unfamiliar but meaningful verbal material could be facilitated by the introduction of advance organizers prior to the actual presentation of the learning task. This hypothesis was based on the theory that if the introductory material made relevant and inclusive subsumers available to the learner, then these subsumers would provide an ideational framework for the incorporation and retention of more specific material inherent in the subsequent learning task.

Control and experimental groups of college undergraduates were matched according to sex, ability to learn unfamiliar scientific material, and academic field of specialization. Forty-eight hours prior to and immediately prior to studying a 2,500 word learning passage dealing with the metallurgical properties of plain carbon steel, the control and experimental groups studied a 500 word introductory passage. The experimental introductory passage contained highly abstract and inclusive background information about the learning material. It was designed as an organizer for the steel learning passage, and it served to relate the learning material to the learner's existing cognitive structure. The control introductory passage presented historical information about the methods used in processing iron and steel. A multiple choice test was administered to both groups three days after the learning passage was studied.

Significant differences between the means of the control and experimental groups supported the hypothesis that the use of highly abstract and inclusive introductory material in the teaching of meaningful verbal material would facilitate retention.

To further test the effects of stable and clear subsuming concepts in cognitive structure and the discriminability of the new learning material from its subsumers, Ausubel and Fitzgerald (1961b) hypothesized that advance organizers used to discriminate between new material and related material already established in the

learner's cognitive structure would facilitate the learning and retention of the new material. Three groups of university undergraduate subjects studied one of three 500 word organizers two days before studying a 2,500 word passage on Buddhism. One experimental group studied a passage that compared the major ideas of Buddhism and Christianity; a second group studied an exposition on the principal Buddhist doctrines, without any reference to Christianity; and the third group, a control group, studied historical material about Buddha and Buddhism. In the analysis, subjects in each of the three treatment groups were divided into above- and below-median subgroups according to their knowledge of Christianity.

The results indicated that subjects with greater background knowledge scored significantly higher on the Buddhism retention scores than subjects with less knowledge of Christianity. Also, after three days, the retention of the Buddhism material was significantly better for the group that received the comparative introductory treatment. After 10 days, the subjects exposed to the comparative and expository organizers did significantly better than the group that had studied the historical introduction. The difference obtained by the facilitating effects of the organizers, however, only applied to the subgroups of learners who had achieved below-median scores on the Christianity pretest.

Ausubel and Fitzgerald concluded that advance organizers appeared to increase discrimination of unfamiliar material for

learners when existing relevant concepts in cognitive structure were not clear and stable.

In a subsequent study, Ausubel and Fitzgerald (1962) studied the effects of an expository advance organizer, antecedent learning, and general background knowledge on the learning and retention of two unfamiliar sequential passages dealing with the endocrinology of pubescence.

Subjects were predominantly university seniors. At the first experimental session, the experimental group studied a 500 word expository passage that was structured to provide an organizational framework for the first learning passage, and the control group studied a 500 word introductory passage which had no organizational properties in relation to the first learning passage. Two days after the first experimental session, both experimental and control groups restudied their respective introductory passages and then studied a 1,400 word passage on the specific hormonal factors initiating and regulating pubescence. A test on the 1,400 word passage was administered two days later. Three days later the second learning passage, a 1,600 word description of pathological variations in pubescence and their treatment, was administered, and after four days the subjects were tested on the second passage.

Results indicated that the organizer facilitated the learning and retention of the first pubescence passage for those subjects with low verbal ability or those subjects with a higher endocrinology

background. Knowledge of the first passage had a significant facilitating effect on learning the second passage when general background knowledge of the subject matter and verbal ability were statistically controlled. Finally, with verbal ability statistically controlled general background knowledge in endocrinology facilitated the learning of the unfamiliar material in a similar subject matter area, presumably by increasing its general familiarity.

Furthermore, Ausubel and Youssef (1963) hypothesized that (a) the discriminability of new material from previously learned material is a function of the clarity and stability of the previously learned material, and (b) an advance organizer increases the discriminability of new material from previously learned related material. It was predicted that the facilitative effects of the advance organizer would be observed with subjects who either have low verbal ability or whose relevant cognitive structure is unstable and unclear.

Undergraduate university students who were classified within two experimental treatments studied two 500 word comparative organizers before studying 2,500 word passages dealing with the principal concepts of Buddhism and Zen Buddhism, respectively. The first comparative organizer pointed out similarities and differences between Christian and Buddhist doctrines, and the second organizer performed the same function for Buddhist and Zen Buddhist doctrines. The control group studied two introductory passages dealing with the historical and biographical nature of Buddhism and Zen Buddhism.

Two days after studying their respective introductory passages, both control and experimental groups restudied their introductory passages and then studied the Buddhism passage. Two days later the experimental and control groups were tested on the Buddhism passage and then studied the comparative Buddhism-Zen Buddhism organizer and the control introduction, respectively. Again, after two days the groups restudied their respective introductory passages and then studied the Zen Buddhism passage. Both groups were tested on the Zen Buddhism passage after one week.

Results indicated that the previously learned background knowledge had a significant facilitating effect on the learning and retention of the Buddhism material when verbal ability was statistically controlled. Similarly, knowledge of the Buddhism passage significantly facilitated the learning and retention of the Zen Buddhism passage. The organizer treatment facilitated the learning and retention of the Buddhism passage; however, the organizer treatment for the Zen Buddhism passage did not significantly facilitate learning and retention. Finally, although there was a significant difference among the verbal ability categories, a noticeable but not statistically significant interaction between the organizer and verbal ability was observed for the Buddhism criterion scores.

Finally, Fitzgerald and Ausubel (1963) hypothesized that learners who had a negative attitudinal bias toward a controversial topic lacked clear and stable subsumers in cognitive structure

regarding the topic. More specifically, it was hypothesized that (a) there is a positive relationship between the clarity and stability of cognitive structure and the learning and retention of controversial material, and (b) the introduction of a relevant comparative organizer would facilitate the learning and retention of controversial material.

Two hundred sixty-four high school juniors enrolled in 16 sections of an American history course were stratified according to attitude, prior knowledge of the subject matter, sex, and class section and randomly assigned to one of four treatment groups. The treatment groups consisted of two experimental groups and two control groups. Each experimental group studied a 450 word comparative introductory passage one day before studying a 2,900 word Southern interpretation of the causes of the Civil War. The comparative introductory material pointed out the principal similarities and differences between the Northern and Southern viewpoints regarding the causes of the Civil War. A multiple choice knowledge test was administered to one experimental group directly after it studied the longer learning passage, and the other group took the test one week later.

The procedure for the two control groups was the same as that of the experimental groups, with the exception that the introductory material discussed the possibility of different historical interpretations of the Civil War.

Results indicated that the comparative introductory treatment had a statistically significant effect in facilitating learning and retention of controversial material. These effects were also noted when verbal reasoning ability was statistically controlled. The benefits derived from the comparative introductory treatment were especially associated with the retention scores rather than on the immediate test of knowledge. Finally, it was suggested that prior relevant knowledge, as measured by a pretest, facilitated learning and retention. The data also indicated that those persons who were in the upper subgroup with regard to prior knowledge regarding the topic appeared to benefit most from the comparative treatment.

In summary, the preceding studies give strong support to the facilitative effect on cognitive structure of introductory material structured at a high level of abstraction, generality, and inclusiveness. The evidence provides support for the suggestion that cognitive structure facilitates the subsequent learning and retention of related meaningful material. In particular, when new material was completely unfamiliar to the learner, expository introductory material appeared to provide a conceptual framework for the incorporation of the new material (Ausubel, 1960; Ausubel and Fitzgerald, 1962). On the other hand, when new material was substantially unfamiliar but relatable to concepts in the learner's cognitive structure, comparative introductory material appeared to increase discrimination of the unfamiliar material (Ausubel and

Fitzgerald, 1961b; Ausubel and Youssef, 1963; Fitzgerald and Ausubel, 1963).

Introductory material also appeared to increase the discriminability of relatable but relatively unfamiliar material for subjects whose existing cognitive structure was inadequate (Ausubel and Fitzgerald, 1961b). However, when the unfamiliar learning material was unrelatable or conflicted with general background knowledge regarding the topic, the introductory material appeared to benefit only those subjects with more background knowledge or whose cognitive structure was more clear and stable (Ausubel and Fitzgerald, 1962; Fitzgerald and Ausubel, 1963).

In learning completely unfamiliar material, the evidence indicated that introductory material was more beneficial for learners of low verbal ability (Ausubel and Fitzgerald, 1962). A similar but not statistically significant finding was obtained when the unfamiliar learning material was substantially related to existing knowledge (Ausubel and Youssef, 1963).

Accompanying the findings above, which provided support for the facilitative effects of introductory materials, were statistically significant differences in learning and retention among the verbal ability classifications in those studies (Ausubel and Fitzgerald, 1962; Ausubel and Youssef, 1963) where verbal ability was a control variable. These differences, as might be anticipated, favored the upper verbal ability subgroup.

Furthermore, evidence regarding the facilitating effect of previously learned relevant background knowledge on the subsequent learning and retention of unfamiliar material indicated that persons with more background knowledge in a general subject matter field obtained significantly higher scores on tests covering the related learning material (Ausubel and Fitzgerald, 1961b; Ausubel and Fitzgerald, 1962; Ausubel and Youssef, 1963; Fitzgerald and Ausubel, 1963). This dependence of learning and retention on related subject matter knowledge was also supported by data regarding the facilitating effects of initial learning on sequentially presented material (Ausubel and Fitzgerald, 1962) and on parallel learning material (Ausubel and Youssef, 1963).

Although little direct evidence regarding the effects of sex on learning and retention has been presented in the previously reviewed research investigations, Ausubel (1960) found in a preliminary analysis of retention scores on a passage dealing with the metallurgical properties of plain carbon steel that men performed better than women. To control for this effect, experimental and control groups had to be rematched.

The studies by Ausubel and Fitzgerald (1961b, 1962), Ausubel and Youssef (1963), and Fitzgerald and Ausubel (1963) controlled the sex variable by placing equal proportions of men and women in each treatment group. This was done primarily because higher ability scores were associated with the women subjects in each of the sample populations.

Even though the results of Ausubel's work appear to be highly relevant to teaching, and attempts might well be made to implement the findings in educational situations, there are a number of questions that are raised by the findings that require further study in order to more fully understand the function of introductory material. Following are several of the many questions that might be raised:

1. Will introductory materials that are differentially structured with regard to the content and organization of a subject matter have the same effect as introductory materials in the previously cited studies which were substantively and programmatically structured to influence the learner's cognitive structure?

2. Does the sequencing of a potentially meaningful learning material have a substantial effect on the clarity and stability of cognitive structure, and on subsequent learning? That is, would highly sequenced material be learned more readily than material that is less well sequenced?

3. When differentially sequenced materials are combined in various ways with differentially structured introductory learning materials, which combination most facilitates learning? It would seem that if the learning material itself is highly sequenced, then the structure of the introductory material will not have as great an effect as when the learning material is not highly sequenced. In other words, an interaction between these two conditions would be anticipated.

4. Will similar facilitative effects of introductory materials be obtained with samples other than college undergraduates, and will there be a similar interaction between intelligence and introductory material which is differentially structured? The low verbal ability group in a college population would be relatively high in a general adult population. Also, much evidence and information has been accumulated which supports the viewpoint that adults approach learning tasks somewhat differently from college students (Birren, 1963; Sjogren and Knox, 1965). Consequently, it seems desirable to conduct a related study with a sample different from the samples that have been used.

5. Is there an interaction between differentially sequenced learning materials and learners who are classified according to different levels of intelligence? If the effect of a differentially sequenced material is parallel to the effect noted by the differentially structured introductory material in Ausubel's studies, it would be anticipated that there would also be an interaction between the sequentially arranged learning material and the ability of the learner.

6. Does the sex of the adult subject have a differential effect in learning when intelligence, age, and background knowledge are controlled? In previously cited studies, the primary intent in placing equal proportions of men and women in each treatment group was not to control sex differences per se, but to control for the

effects of verbal ability which was sex related. Although this procedure is valid, considerable evidence (e.g., Billings, 1934; Guetzkow, 1951; Maier, 1945) suggests that men perform better than women in solving certain kinds of problems. In fact, sex differences in problem solving have been demonstrated when certain intellectual variables are controlled (Sweeney, 1953). Furthermore, certain evidence suggests that sex differences in problem solving could be accounted for by differences in nonintellectual variables (Carey, 1958; Nakamura, 1958; Milton, 1957). Therefore, in the present study where subjects are to be presented with mathematical subject matter, it is expected that men will achieve better than women, even if the effects of intelligence, age, and prior knowledge are controlled.

For the present study a sample of adults who ranged in age from 23 through 53 and who had negligible background knowledge regarding the learning topic were selected so as to allow an exploration of the various questions. Following are the specific hypotheses of this study. An experiment that is designed to test each of these hypotheses and to seek answers to the previously asked questions is described in the following Method section.

Hypotheses

The following hypotheses form the basis for the design of this experiment. They apply to each of the three criterion measures used in ascertaining the effects of differentially structured materials on differentially sequenced learning tasks.

1. There is a significant difference among the differentially structured introductory learning materials. It is expected that the more generalizable and inclusive the introductory material, the greater effect there will be on learning.

2. There is a significant difference among the differentially sequenced learning tasks. It is expected that the greater the extent to which the learning task is sequentially arranged, the greater will be the effect on learning.

3. There is a significant difference among the intelligence categories. It is expected that those persons in the higher intelligence categories will perform better than those in the lower categories.

4. There is a significant difference between the sex categories. It is expected that the men will perform better on the criterion measures than the women.

5. There is a significant interaction among the differentially structured introductory materials and the differentially sequenced learning tasks. It is expected that the highly structured introductory material will not have as great an effect when the learning task is highly sequenced.

6. There is a significant interaction among the intelligence categories and the differentially structured introductory materials. It is expected that those persons in the lower intelligence categories will profit more from the introductory materials than will those in the higher intelligence categories.

7. There is a significant interaction among the intelligence categories and the differentially sequenced learning tasks. It is expected that those persons in the lower intelligence categories will benefit most from the completely sequenced learning tasks.

METHOD

In this chapter, the techniques and procedures by which this experimental study was conducted are described in the following order: sample selection and classification, experimental conditions, experimental design, criterion measures, general procedures, and statistical procedures.

Sample Selection and Classification

The first phase of this study was the selection of the sample. The subjects for this study were selected from a stratified sample of adults who participated in a Cooperative Research Project (Sjogren and Knox, 1965) that was conducted in the Office of Adult Education Research at the University of Nebraska.

All available subjects who had participated in the Sjogren and Knox study were contacted and asked if they would be willing to participate in another, but shorter, experiment. Of the 208 subjects who completed the Sjogren and Knox study, 179 were contacted and all indicated a willingness to participate in the second experiment. Subsequently, these subjects attended an initial session at which they were given more detailed information about the project.

Following the initial session, the subjects who expressed continued interest in participating in the project were asked to complete a questionnaire (Appendix A), which served to update existing biographic information, and a pretest (Appendix B) on the concept of number bases. The procedure of pretesting the subjects on number

bases allowed the experimenter to satisfy the requirement of unfamiliarity regarding the general subject matter that was to be used in the study. Subjects with a pretest score of six or less on the 15 item pretest were selected for possible participation in the experiment.

Although a score of three on a 15 item multiple choice test with five alternative choices is a chance score, it was felt that a score of six would represent the upper limit for acceptance regarding the unfamiliarity of the subject matter. This was empirically verified by the fact that the distribution of scores for persons with scores of six or less appeared to be normally distributed around the chance score of three. The specific pretest mean and standard deviation of the subjects finally selected for the study were 2.97 and 1.40, respectively.

In order that the age range of the subjects in the sample would be representative of adults who had participated in continuing educational programs (Johnstone and Rivera, 1965), those persons who were 54 years of age or older were not included for possible selection in this experiment. The ages of the subjects ranged from 23 through 53.

Furthermore, qualified subjects were classified by sex and intelligence. The intelligence classification consisted of four subgroups that were categorized according to the subject's performance on the Wechsler Adult Intelligence Scale (WAIS) full scaled score (Wechsler, 1955). The WAIS scores on the subjects were available from the Sjogren and Knox study.

The use of the scaled score instead of the IQ of the individual in classifying intelligence was used because the scaled score provides a direct comparison between the test performance of subjects at any age. In contrast the IQ score is based on a comparison between the learner's IQ and that of others in his own age group. The WAIS total scaled scores for the selected sample ranged from 102 through 161.

In summary, the subjects who were selected for participation in this experiment had a score of six or less on the number base pretest, ranged in age from 23 through 53, and were classified according to sex and four levels of intelligence. Table 1 shows the means and standard deviations of the number base pretest score, WAIS full scaled score, and age, by sex and intelligence level of the study

Table 1

Sample Means and Standard Deviations of Pretest, WAIS Full Scaled Score, and Age Variables by Sex and Intelligence Level

Intelligence Quarter		Number Base Pretest Score		WAIS Full Scaled Score		Age to Nearest Birthday	
		Men	Women	Men	Women	Men	Women
First	*M*	2.67	2.00	110.92	110.33	41.08	39.83
	SD	1.31	1.22	4.41	5.48	8.66	10.38
Second	*M*	3.08	3.00	126.67	126.67	37.00	37.92
	SD	1.32	1.15	4.13	3.90	8.58	9.38
Third	*M*	3.25	3.33	140.83	140.33	38.75	36.75
	SD	1.23	1.55	3.02	3.25	9.35	8.82
Fourth	*M*	3.00	3.42	152.08	152.42	37.67	41.42
	SD	1.53	1.32	3.59	5.12	7.26	8.79
Total	*M*	3.00	2.94	132.63	132.44	38.63	38.98
	SD	1.37	1.43	15.90	16.32	8.64	9.53

sample. A more complete presentation of the means and standard deviations of selected variables of the project participants is presented in Appendix C.

Experimental Conditions

Introductory Programed Materials. Educational researchers generally agree that programed instruction is an exceedingly useful learning activity in research on instructional and learning variables. Because the introductory learning material constitutes a treatment condition in this study, it was felt that the programing of the different introductory instructional materials would facilitate the manipulation of the independent variable. The programed materials utilized in this study were of the linear type (Skinner, 1958). This type of program presents the subject matter in a series of small steps arranged in logical sequence. The learner actively participates in the learning process by constructing appropriate responses or by choosing from several alternatives to each frame. After responding, the learner is immediately provided with a knowledge of results. Finally, through frequent repetition of the material the learner is led, step by step, to a desired behavior.

The use of programed instruction in this experiment, therefore, assisted in controlling the sequential arrangement of the different introductory treatment conditions so that observed differences in treatment would be attributed to the content or substantive aspects of the material, and not to the method in which the material was presented.

Four differentially structured introductory learning materials were used in this experiment. Each was presented to the learner in programed instructional format prior to the study of a learning task. The introductory material used in the experimental treatments was structured to provide varying degrees of relevant information that was conceptually related to the subsequent learning task. To meet the requirement that the introductory materials be conceptually related to the learning task, it was necessary to select a subject matter with principles which were applicable to a variety of learning tasks containing common elements of application. It was also important to select material that would be interesting and stimulating for adults, and similar to current educational subject matter. The topic of base number systems, which is currently being taught in beginning modern mathematics courses, appeared to staisfy these requirements.

The different types of the introductory material included (a) history of measurement, (b) base ten number system, (c) base seven number system, and (d) principles of number bases. The introductory material on the history of measurement was intended primarily as a control treatment. It contained historical and descriptive information on different units of measurement such as cubit, span, digit, hand, and so on. The introductory material on the base ten number system was written to present concepts of grouping, numbers, numerals, face value, and place value as applied to the base ten

number system. Likewise, the introductory materials on both the base seven number system and the principles of number bases covered concepts that were similar to those presented in the base ten introductory material, but for base seven and the principles of number bases, respectively.

The introductory material on base ten was structured so that it was less generalizable but more familiar to the learner's existing cognitive structure than the base seven and principles of number bases introductory materials. That is, the base ten material was highly specific in content and familiar to the subject's existing knowledge, thus having a limited transfer effect. It was hoped that the base seven introductory material would be more generalizable and less familiar than the base ten material, but less generalizable and more familiar than the principles of number bases introductory material. Therefore, the content of the introductory materials provided differentially structured substantive information which was generalizable and relatable in varying degrees to the base number systems learning topic.

The history of measurement program was adapted from a published program[2] (TMI-Grolier, 1962) and served as a control condition in this study. The remaining programs on base ten, seven, and

---

[2]Permission to adapt this program for this study was given by Teaching Machines, Inc.

principles of number bases were written by the experimenter. The three treatment programs were written so that the sequential steps within each of the programs were parallel with the other treatment programs. Thus, the content of the material would be the differentiating factor to which obtained differences could be attributed. A copy of each of the introductory programed materials is attached as Appendix D. Also attached (Appendix E) is a supplementary sheet to the history of measurement program. Table 2 provides summary and subject response information for each of the introductory programs.

Table 2

Number of Frames, Responses, Mean Errors, and Mean Time by Introductory Programed Material

Program	No. of Frames	No. of Responses	Mean No. of Errors	Mean Time in Minutes
History of Measurement	94	126	6.42	33.62
Base Ten Number System	94	116	5.21	37.33
Base Seven Number System	95	111	9.38	43.42
Principles of Number Bases	96	121	13.00	56.83

Learning Tasks. This experimental condition consisted of three differentially sequenced sets of 13 symbols corresponding with the first 13 numbers in the base four number system. One of the learning tasks was completely sequenced (e.g., the first stimulus word presented to the subject was "ZERO," the second was "ONE," the third

"TWO," and so on through "TWELVE"). The second learning task was partially sequenced (e.g., the first stimulus word was "ZERO," the second was "ONE," the third "TWO," the fourth "THREE," the fifth "FOUR," with the remaining stimulus words presented in random order). The third learning task was not sequentially arranged. The stimulus words were presented randomly. The paired items for each trial of the three different conditions were always presented in the same prescribed order. Thus it was anticipated that the differential sequencing of the learning task would have a differential effect on the learning of the new material. Appendix F shows the three differentially sequenced learning tasks.

Experimental Design

The basic experimental design of this study was a 4 x 3 x 4 x 2 factorial design. Table 3 shows the levels and definitions of the different factors. All the variables were considered to be fixed effects and not random samples of larger population categories.

Of those subjects whose pretest score was six or less, who ranged in age from 23 to 53, who were classified according to four levels of intelligence and two levels of sex, 96 persons were selected for participation in this experiment. Those persons who qualified but were not selected were retained for possible use as replacements for any of the original 96.

Table 3

Definition of Factors

Introductory Learning Material (A)	A_1	History of measurement
	A_2	Base ten number system
	A_3	Base seven number system
	A_4	Principles of number bases
Learning Task (B)	B_1	Random sequence
	B_2	Partial sequence
	B_3	Complete sequence
WAIS Total Scaled Score (C)	C_1	First quarter
	C_2	Second quarter
	C_3	Third quarter
	C_4	Fourth quarter
Sex (D)	D_1	Male
	D_2	Female

Table 4 shows the classification scheme of the 4 x 3 x 4 x 2 factorial design for the experiment. One-eighth of the sample who had a WAIS full scaled score in the upper quarter range of the sample and were male, were assigned at random to one of the 12 treatment conditions. Likewise, the 12 female subjects in the upper quarter range on the WAIS full scaled score were randomly assigned to one of the 12 cells of the treatment classifications, and so on for men and women in the third, second, and first intelligence

Table 4

Schematic of the Factorial Design

		B_1				B_2				B_3			
		C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4
A_1	D_1												
	D_2												
A_2	D_1												
	D_2												
A_3	D_1												
	D_2												
A_4	D_1												
	D_2												

quarter. Therefore, one person was randomly assigned to each classification cell. To illustrate, the person assigned to the $A_1B_1C_1D_1$ cell received the history of measurement introductory material prior to studying a randomly sequenced learning task, was in the first intelligence quarter, and was a male. The person assigned to the $A_1B_1C_1D_2$ cell received the history of measurement material before studying a randomly sequenced learning task, was in the lowest intelligence range, but was a female, and so on. Summarizing the basic design of the study, unfamiliarity of the subject matter and age of the subject were controlled prior to the classification of 96 adults according to two experimental and two organismic variables.

Criterion Measures

Several criterion measures were used in ascertaining the effectiveness of the experimental conditions on learning and retention. The three criterion measures were (a) number of correct responses on a posttest administered immediately after the presentation of the learning task, (b) number of trials to criterion, with criterion meaning two perfect repetitions, and (c) number of total errors made to criterion. The posttest (Appendix G) had two parts, one consisting of five items learned in the learning task, and the other consisting of nine items not specifically studied in the learning task, but related to the same number base.

General Procedures

After the sample of project participants had been selected and assigned to treatment conditions, arrangements were made for the subject to attend an individual session. The subject was informed that the session would last approximately two hours and that he could choose a time that was convenient for him to attend.

Introductory Programed Material. During this part of the session, the subject was administered a programed booklet on one of the four differentially structured introductory learning materials which had been randomly assigned to him. Verbatim directions were given to the subject prior to his studying the programed material and for subsequent parts of the session. A copy of the instructions is attached as Appendix H. A record was kept of the time it took the

subject to complete the program and the number of response errors that were made while working the program.

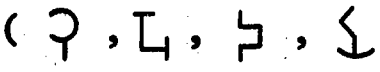
Although no evidence has been presented to verify that the subjects learned from the programed material other than the number of error responses, previous administrations of earlier versions of the programed material on adults with similar characteristics as those included in this study indicated a significant gain in knowledge from a pretest to a test administered immediately after the administration of the programs. Furthermore, a study by Sjogren (Grotelueschen and Sjogren, 1967) which used an earlier version of the programed materials with beginning graduate students provided evidence that individuals learned by studying the materials.

Prelearning Task. Upon completion of the introductory material the subject was individually administered a prelearning task by a randomly assigned session administrator. Ten young adults, five men and five women, served as session administrators for presenting the prelearning task and subsequent parts of the experimental session. Although the sessions were individually administered it was possible to have as many as 10 individuals concurrently administered to in a testing laboratory.

Session administrators presented the symbols to be learned by a flash-card method. A written number on the front side of a three by five card was shown to the subject. The subject was instructed to write the appropriate symbol for this number on a response pad.

After the subject responded, he was given feedback regarding the correctness of his response by being shown the correct symbol for the written number which was printed on the back side of the card. When the subject had responded correctly to two trials of the four symbols the subject proceeded to the learning task.

The main purpose of the prelearning task was to have the subject learn the four basic symbols used in the subsequent learning task so that the effects of the sequential arrangement of the learning task could be ascertained.

The response symbols that the subject was asked to learn were constructed so that they would be unfamiliar to the subject, and, therefore, he could not immediately attach a label to them. The rationale for using unfamiliar symbols rather than the familiar Arabic numerals is based on evidence from a pilot study which indicated that the use of familiar symbols might have an interfering effect on learning a new number base. Furthermore, the interfering effect of familiar symbols might have had a differential effect for different age groups of adult learners. The constructed symbols () representing the number values of zero through three were empirically tested, and, therefore, were believed to be highly satisfactory for the purposes of this study.

<u>Learning Task</u>. A modified TMI-Grolier Min-Max Teaching Machine with the attached answer-mate was used to present, in paired associates form, the three differentially sequenced learning tasks. The

stimulus material was placed in the machine on a long sheet of paper which was taped together at the ends to make a continuous loop. The response paper consisted of a spool of adding machine tape.

A timing mechanism with a soft bell and two colored lights was used to cue the session administrator to the presentation rate of the stimulus material. The bell sounded every six and nine seconds with one light flashing at the beginning of one time interval and the second light flashing at the beginning of the other time interval. The use of lights as signals was helpful to the administrator in that it provided a check regarding the presentation of the correct stimulus material. This was necessary because the stimulus material was manually fed through the machine. Pictures of the teaching machine and timer are presented in Figures 1, 2, and 3.

The subject was seated across from the administrator before a small table on which the machine was placed. The timer was in back of the subject, but in full view of the administrator.

A stimulus word (e.g., ZERO) was manually presented in the aperture of the apparatus by turning a knob. The subject was expected to write the appropriate symbol (e.g.,) on the response tape in the attached answer-mate. After a nine second interval the administrator manually moved the stimulus material so that the stimulus word appeared together with the correct response symbol in the aperture. This procedure enabled the subject to receive immediate feedback regarding the correctness of his response to the stimulus

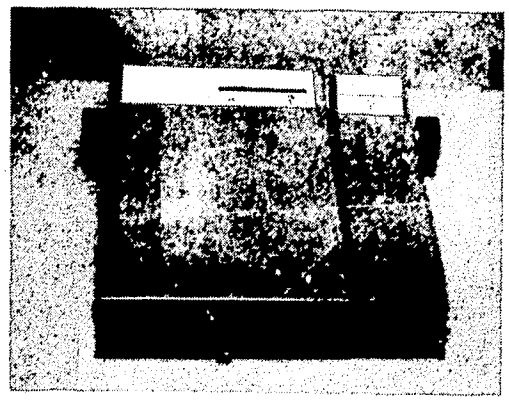


Fig. 1. Top view of adapted teaching machine.

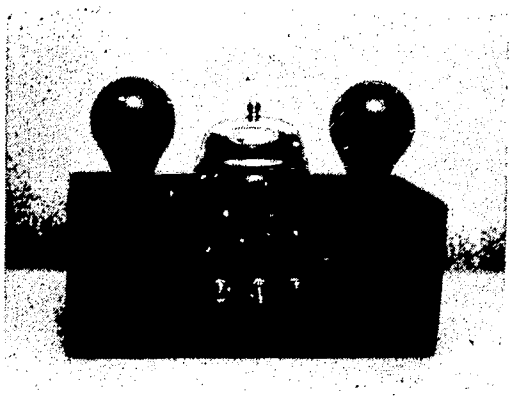


Fig. 2. Side view of timer.

Fig. 3. Adapted teaching machine with subject and session administrator.

word. After six seconds the stimulus word and the correct symbol along with the subject's response disappeared from sight as the next stimulus word was presented. The time intervals of six and nine seconds which were empirically arrived upon in a pilot study indicated that this rate of presentation would be optimal for the different treatment classifications of the study. The presentation of the stimulus word of nine seconds and the six second feedback interval was repeated for each of the 13 symbols of each trial. Upon responding correctly to two perfect trials the subject was administered the posttest. The subject's response tape was retained as a record of his performance.

After each subject had completed the learning session he was given an honorarium of five dollars for participating in the project.

Statistical Procedures

The primary statistical technique used in the analyses of the data was the analysis of variance (ANOVA). Other analyses of the data included the use of the *L* test (Page, 1963) and the Pearson product moment correlation.

The ANOVA provided a test of significance of the differences among the different levels of the main effect variables and all possible two-way interactions of these variables. The ANOVA contrasts the variance of individual values around the group means within equal-sized groups with the variance of the group means around the grand mean of the ungrouped data.

For each statistically significant ANOVA main effect, where the performance of more than two groups was being compared on a criterion measure, a *post hoc* comparison to examine differences between pairs of means was conducted using the Tukey method (Glass, 1967). This procedure has been suggested by Scheffé (1959, p. 76) as a powerful technique to use when comparisons are only being made between pairs of means.

The L statistic provided a test of the null hypothesis against the ordered alternative among the treatment effects. Thus it was ascertained whether a significant amount of agreement existed between the predicted rankings of the introductory material and learning task treatments and the observed rankings of these treatments for the data from the different criterion measures.

The probability level used to indicate significant differences was the five per cent level. This level of confidence determines whether a null hypothesis should be rejected or accepted. It also seemed appropriate for several reasons to discuss findings that were significant at the .10 level of confidence. Because the main effect hypotheses were ordered predictions of group means, it was felt that there would be some theoretical significance if obtained means were generally in the predicted direction, even if differences among these means were not significant at the .05 level. Furthermore, if the observed mean ordering was similar to that which was predicted, one would expect that the probability of committing a type-II error would be increased.

RESULTS

The data were analyzed in accordance with the stated hypotheses in the framework of the design of the study. The chapter following this one presents a discussion of the findings and their interpretation.

The data were collected from three criterion measures. The criterion measures consisted of a total posttest score, trials to criterion, and errors to criterion. It had been anticipated that subtest scores consisting of learning task and transfer items of the total posttest score could be analyzed separately. Because these subtest scores generally lacked sufficient variance on which statistical tests could be conducted, the basic criterion measure for knowledge gain was the total posttest score.

For each of the three criterion measures, two separate ANOVA analyses were made with respect to the data. The first was an analysis of the three criterion measures according to the 4 x 3 x 4 x 2 factorial design of the study. This analysis was made of four categories of introductory learning materials, three categories of learning tasks, four categories of intelligence, and two categories of sex. (See Table 3 for the levels and definitions of the four main effect factors.)

The second analysis was similar to the first, with the exception that this analysis included only the first and the fourth intelligence levels in the intelligence classification.

In both of these ANOVA analyses only the main effect and the two-way interaction sum of squares were obtained. The basic error term estimate was obtained by aggregating the four-way interaction with the available three-way interactions. This procedure was consistent with the hypotheses of the study and the suggestion by Green and Tukey (1960) regarding the appropriate choice of error term.

A third analysis of scores obtained from each of the three criterion measures and an additional posttest transfer subscore was performed by use of the *L* test. This separate analysis of the introductory material and learning task treatment effects was based on data from subjects who were categorized in the upper intelligence subgroup.

Analysis One

In this section the findings of a multivariate analysis are presented in tabular form for each of the three criterion measures according to the 4 x 3 x 4 x 2 factorial design of the study. The analysis presented in Table 5 for the total posttest criterion measure indicated that the intelligence and the sex classifications accounted for a significant portion of the variance while the introductory material and learning task classifications did not. It was also noted that there was a significant disordinal interaction between the intelligence and sex classifications.

Tukey's test revealed that the difference between the first and fourth intelligence subgroups (q (4,57) = 6.24, p < .01) was

Table 5

ANOVA of Posttest Total Scores for 4 x 3 x 4 x 2 Analysis

Source	*df*	*SS*	*MS*	*F*
Introductory Material (A)	3	13.08	4.36	<1.00
Learning Task (B)	2	.44	.22	<1.00
Intelligence (C)	3	106.25	35.42	6.56**
Sex (D)	1	54.00	54.00	10.00**
AB	6	26.48	4.41	<1.00
AC	9	67.33	7.48	1.38
AD	3	6.08	2.03	<1.00
BC	6	25.81	4.30	<1.00
BD	2	5.69	2.84	<1.00
CD	3	80.75	26.92	4.98**
Error	57	308.08	5.40	-
Total	95	694.00	-	-

Note.--In all ANOVA tables one asterisk indicates $p < .05$ and two asterisks for $p < .01$.

significant, and that differences between the first subgroup with both the second (q (4,57) = 3.69, $p < .10$) and the third (q (4,57) = 3.43, $p < .10$) intelligence subgroups approached significance.

Table 6 presents the significant main effect and interaction means of this analysis. As anticipated, the upper intelligence

Table 6

Significant Posttest Total Score Main Effect and Interaction Means for 4 x 3 x 4 x 2 Analysis

Intelligence				Sex		Intelligence by Sex				
1st	2nd	3rd	4th	M	F		1st	2nd	3rd	4th
4.42	6.17	6.04	7.38	6.75	5.25	M	4.00	7.42	6.25	9.33
						F	4.83	4.92	5.83	5.42

group had the highest mean score of the four intelligence categories. It was interesting to note the negligible difference between the second and third groups. Men performed better than women. However, the significant intelligence by sex interaction indicates that the effect of the sex variable was not independent of the intelligence categories. Men scored relatively higher than women at all levels of intelligence with the exception of the lowest category.

The second part of Analysis One was to examine the hypothesized main and two-way interaction effects by an analysis of the trials to criterion data. The ANOVA for trials to criterion is presented in Table 7 and the means of the significant main effects are presented

Table 7

ANOVA of Trials to Criterion for 4 x 3 x 4 x 2 Analysis

Source	*df*	*SS*	*MS*	*F*
Introductory Material (A)	3	346.12	115.37	2.08
Learning Task (B)	2	2479.56	1239.78	22.31**
Intelligence (C)	3	2205.87	735.29	13.23**
Sex (D)	1	126.04	126.04	2.27
AB	6	435.69	72.62	1.31
AC	9	847.96	94.22	1.70
AD	3	72.46	24.15	<1.00
BC	6	333.69	55.62	<1.00
BD	2	26.52	13.26	<1.00
CD	3	282.21	94.07	1.69
Error	57	3167.50	55.57	-
Total	95	10323.62	-	-

in Table 8. The learning task and intelligence classifications accounted for a significant amount of the total variance. The completely sequenced learning task differed significantly from the randomly (q (3,57) = 7.71, p < .01) and partially (q (3,57) = 8.58,

Table 8

Significant Trials Main Effect Means for 4 x 3 x 4 x 2 Analysis

Learning Task			Intelligence			
Random	Partial	Complete	1st	2nd	3rd	4th
19.94	21.09	9.78	23.62	17.33	16.71	10.08

$p < .01$) sequenced tasks. The trials means of the intelligence categories were ordered from high to low with the first intelligence subgroup differing significantly from the second (q (4,57) = 4.13, $p < .05$), the third (q (4,57) = 4.55, $p < .05$), and the fourth (q (4,57) = 8.90, $p < .01$) subgroups. The trials mean of the fourth subgroup differed significantly from that of the second (q (4,57) = 4.76, $p < .01$) and the third (q (4,57) = 4.35, $p < .05$) subgroups.

Although the introductory material classification with an F ratio of 2.08 did not account for a significant portion of the total variance, it did approach the .10 level of confidence. Figure 4 shows a graphic presentation of the cell means of this variable which differed markedly from the expected ordering. Persons who studied the base ten material had the lowest mean trials. This was followed in order by the base seven, history of measurement, and principles subgroups.

Likewise, a noticeable but not statistically significant interaction between intelligence and introductory material was observed.

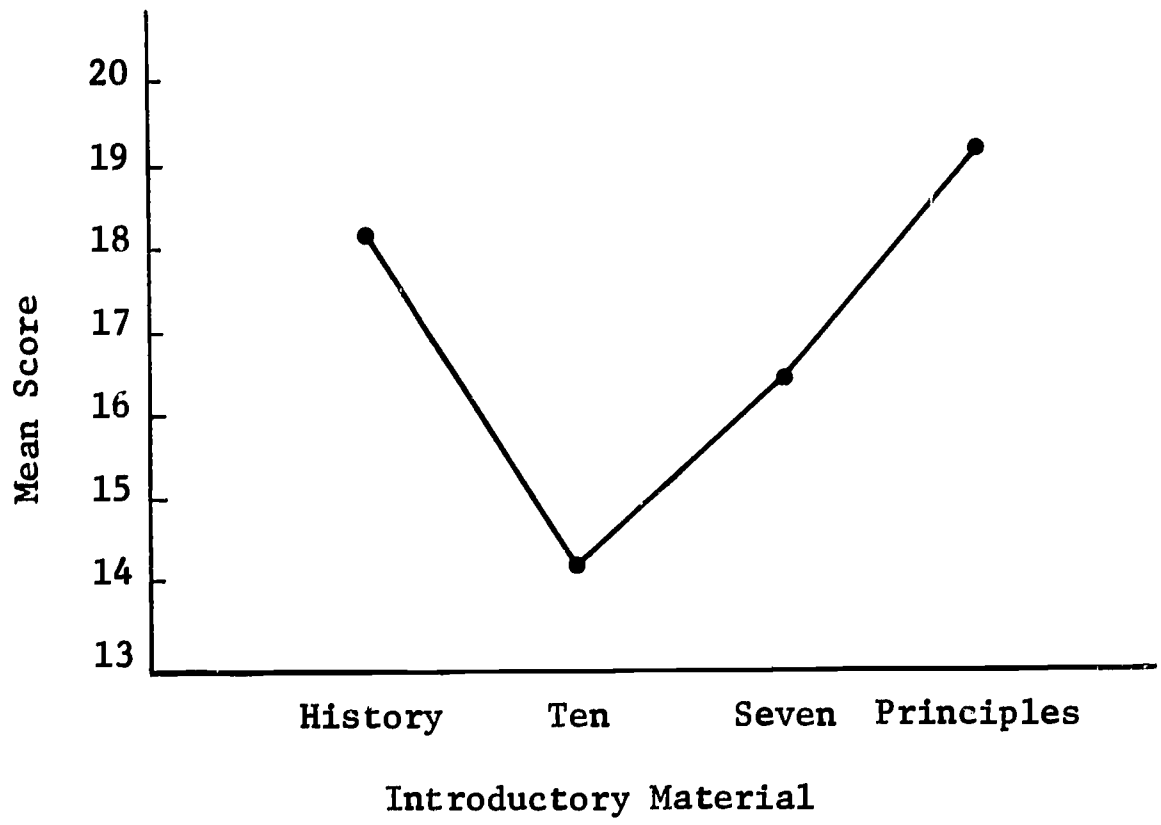


Fig. 4. Trials means of introductory materials for 4 x 3 x 4 x 2 analysis.

This interaction is shown graphically in Figure 5. The direction of the means of the intelligence subgroups was similar for the history and base ten conditions; however, the first three intelligence subgroups differed generally from the fourth intelligence subgroup for the base seven and principles conditions.

Persons in the highest intelligence subgroup who studied the principles introductory material had fewer trials than those who studied the base seven introductory material. Similary, persons who studied base seven performed better than those who studied base ten, and those who studied base ten required fewer trials than did the history subgroup. In contrast, the number of trials of the first three intelligence subgroups generally increased on the base seven

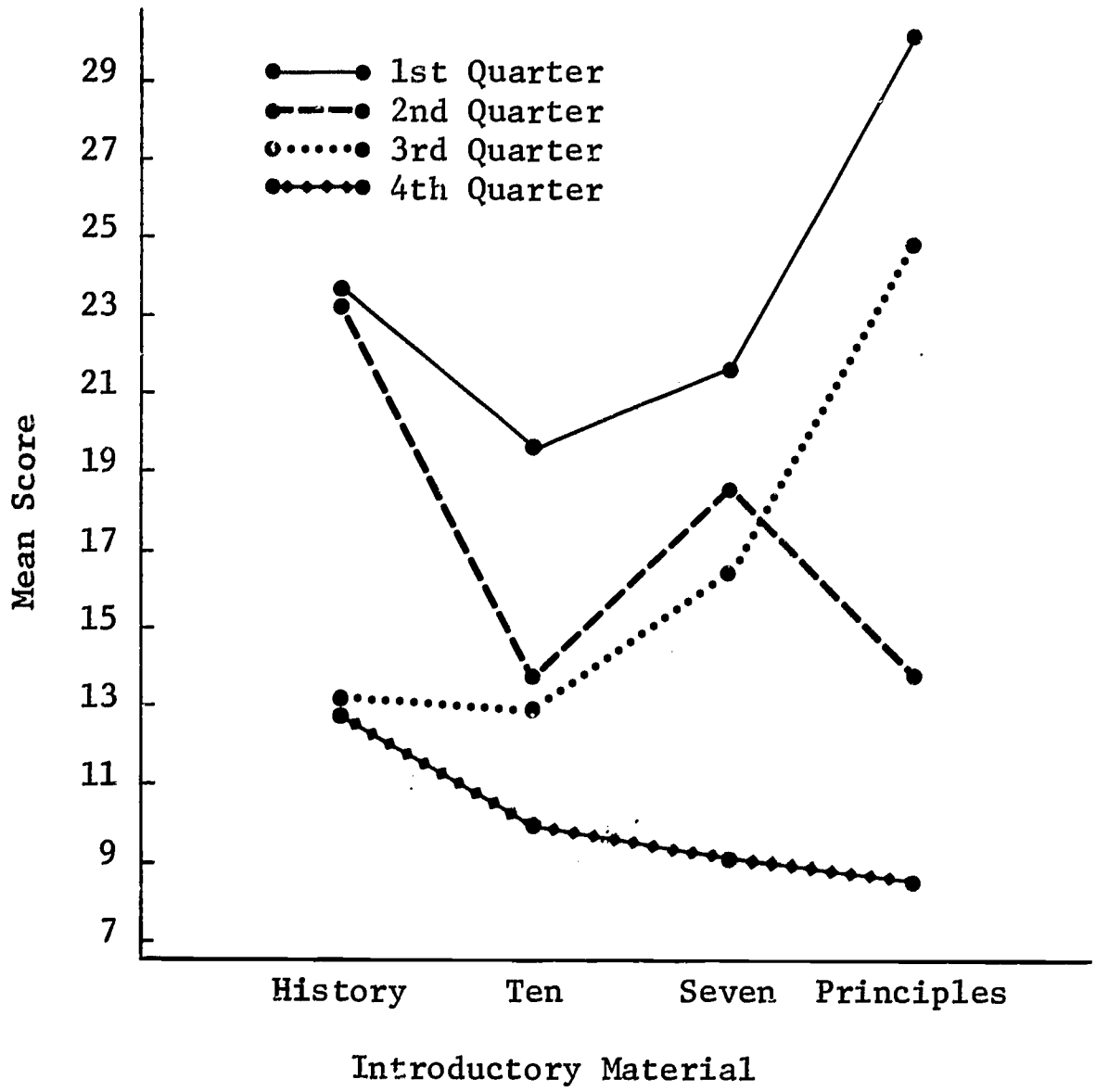


Fig. 5. Trials means for levels of intelligence at each introductory material level for 4 x 3 x 4 x 2 analysis.

and principles conditions. Thus, these findings appeared to suggest that the effects of the introductory materials were not independent of the level of intelligence.

The third part of this section was concerned with the anaylsis of the errors to criterion data. The results of the ANOVA on the errors to criterion are shown in Table 9. The significant learning task and intelligence classification findings were similar to those findings noted in the analysis of the trials to criterion data.

Table 9

ANOVA of Errors to Criterion for 4 x 3 x 4 x 2 Analysis

Source	*df*	*SS*	*MS*	*F*
Introductory Material (A)	3	9917.08	3305.69	1.86
Learning Task (B)	2	58406.01	29203.00	16.40**
Intelligence (C)	3	59325.74	19775.25	11.10**
Sex (D)	1	3775.04	3775.04	2.12
AB	6	12315.73	2052.62	1.15
AC	9	21677.00	2408.56	1.35
AD	3	2427.04	809.01	<1.00
BC	6	6129.57	1021.60	<1.00
BD	2	1510.02	755.01	<1.00
CD	3	10794.20	3598.07	2.02
Error	57	101516.28	1780.99	-
Total	95	287793.75	-	-

This similarity was expected because the Pearson correlation coefficient between the trials and errors to criterion measures was .97.

Tukey's test showed that the errors mean of the fourth intelligence subgroup differed significantly from that of the first (q (4,57) = 8.11, p < .01), the second (q (4,57) = 4.79, p < .01), and the third (q (4,57) = 4.57, p < .05) subgroups. The differences between the first subgroup with both the second (q (4,57) = 3.32, p < .10) and the third (q (4,57) = 3.54, p < .10) intelligence subgroups approached significance. The completely sequenced learning task differed significantly from the errors means of both the partially (q (4,57) = 6.76, p < .01) and randomly (q (4,57) = 7.24, p < .01) sequenced tasks.

Table 10 presents the means for the different categories of the learning task and intelligence classifications. A slight difference in the order of the means was observed in those of the learning task

Table 10

Significant Errors Main Effect Means for 4 x 3 x 4 x 2 Analysis

Learning Task			Intelligence			
Random	Partial	Complete	1st	2nd	3rd	4th
100.47	96.94	46.47	113.54	84.92	83.04	43.67

between the trials and errors to criterion data. For the trials data the highest number of trials was associated with the partial condition, whereas with the errors data the highest number of errors was associated with the random condition.

In summary, the results of Analysis One indicated a significant difference among the intelligence categories for the three criterion measures; a significant difference among the learning task categories for the trials and errors to criterion measures; a significant sex main effect and sex by intelligence interaction for the posttest analysis; a noticeable difference among the introductory materials categories; and a noticeable introductory material by intelligence interaction for the trials to criterion analysis.

Analysis Two

The results of the analysis of the data from the three criterion measures presented in this section were based on a 4 x 3 x 2 x 2 analysis. The second analysis was similar to the first analysis with the exception that the data for this analysis were based on only those persons who were in the first and fourth intelligence quarters. This procedure provided a more intense

analysis of the interaction of intelligence with the manipulated introductory material and learning task variables which appeared to be relevant from the findings presented in Analysis One.

As anticipated, all analyses of the three criterion measures indicated a highly significant difference between the two intelligence categories. Table 11 presents the results of the analysis of the total posttest scores. In addition to the highly significant intelligence classification difference, a significant sex main effect and intelligence by sex disordinal interaction was observed. These findings were the same as the results of the posttest analysis presented in Analysis One. In addition, an observed but not statistically significant interaction of introductory material by intelligence was noted. The *F* value of 2.08 with 3 and 23 degrees of freedom approached the .10 level of significance. The graph of this

Table 11

ANOVA of Posttest Total Scores for 4 x 3 x 2 x 2 Analysis

Source	*df*	*SS*	*MS*	*F*
Introductory Material (A)	3	17.90	5.97	1.11
Learning Task (B)	2	6.79	3.40	<1.00
Intelligence (C)	1	105.02	105.02	19.48**
Sex (D)	1	28.52	28.52	5.29*
AB	6	32.04	5.34	<1.00
AC	3	33.73	11.24	2.08
AD	3	6.23	2.08	<1.00
BC	2	5.29	2.64	<1.00
BD	2	3.29	1.64	<1.00
CD	1	67.69	67.69	12.56**
Error	23	123.98	5.39	-
Total	47	430.48	-	-

interaction is presented in Figure 6. A marked difference between intelligence subgroups appeared on the base seven and principles introductory conditions.

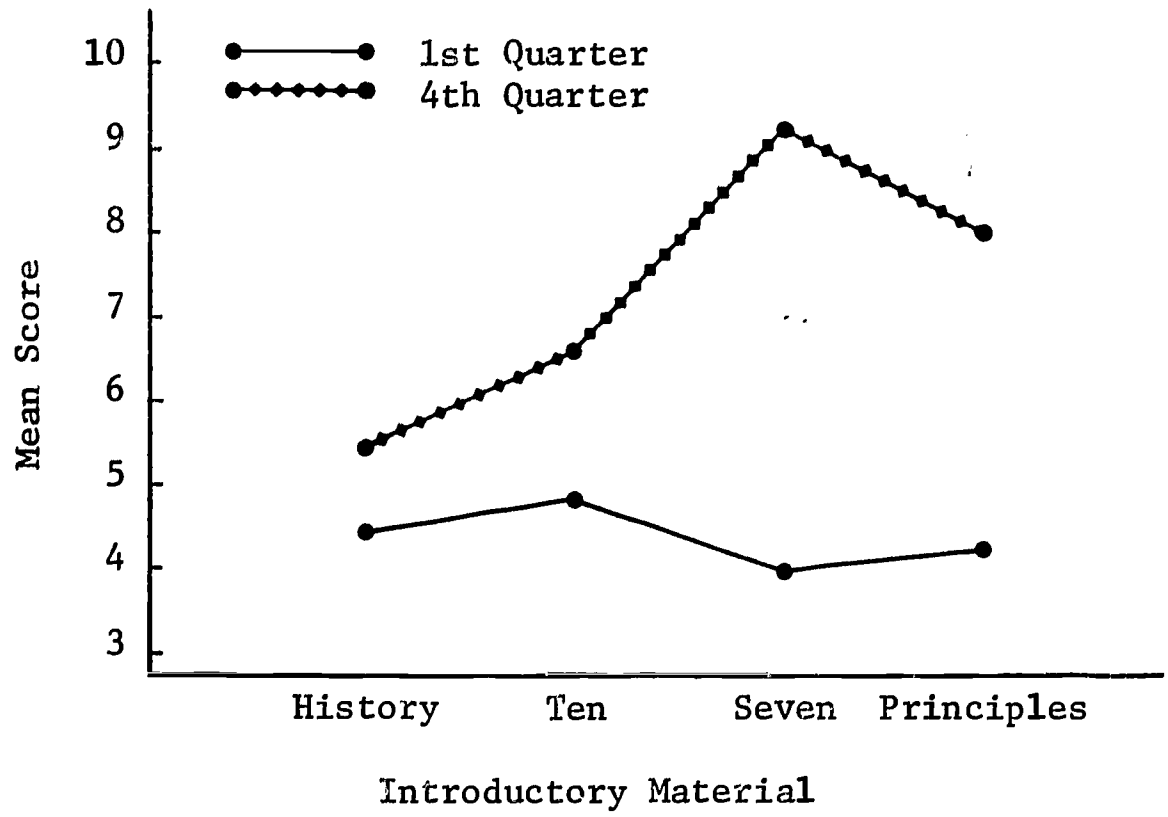


Fig. 6. Posttest means for levels of intelligence at each introductory material level for 4 x 3 x 2 x 2 analysis.

Another observation of theoretical interest which was not statistically significant, was the ordering of the posttest means for the different introductory material categories. Persons studying the history condition performed the lowest on the posttest. This was followed in order by the base ten, principles, and base seven groups. Figure 7 is a presentation of this data. The order of the posttest means for the introductory material in Figure 7 was the same as that found in the respective posttest analysis of Analysis One, but different than the trials to criterion means presented in Figure 4.

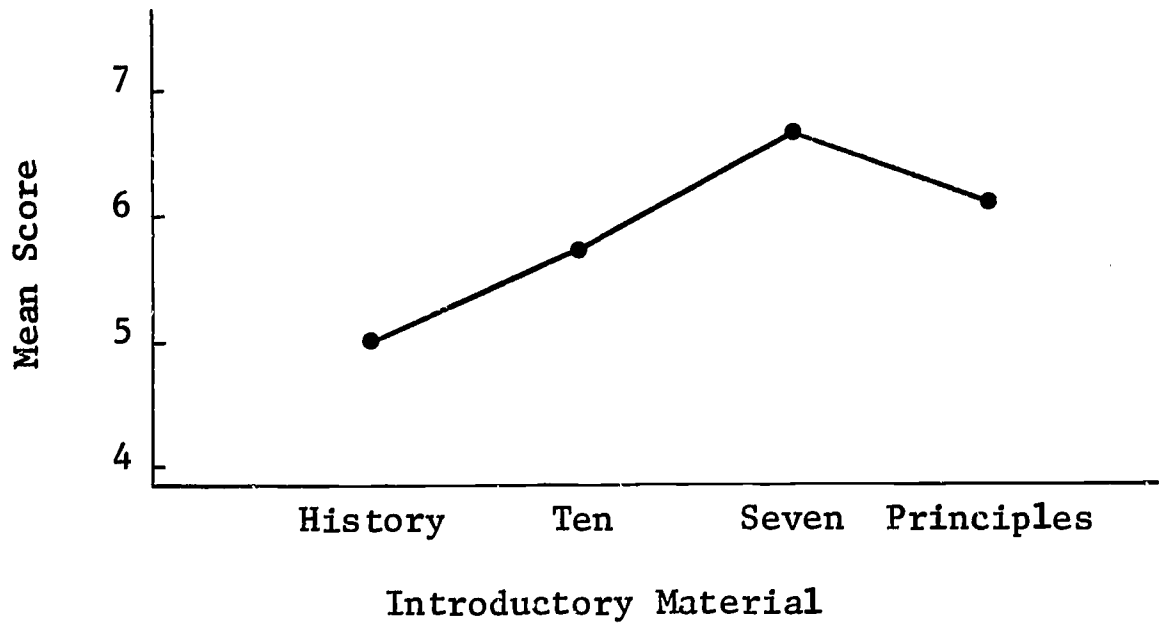


Fig. 7. Posttest means of introductory materials for 4 x 3 x 2 x 2 analysis.

The trials to criterion ANOVA results for this section are shown in Table 12. There was a significant difference among the learning task treatments and the intelligence categories. These findings were similar to those presented in Analysis One. The completely sequenced learning task mean differed significantly from

Table 12

ANOVA of Trials to Criterion for 4 x 3 x 2 x 2 Analysis

Source	*df*	*SS*	*MS*	*F*
Introductory Material (A)	3	161.40	53.80	1.63
Learning Task (B)	2	1279.17	639.58	19.42**
Intelligence (C)	1	2200.52	2200.52	66.82**
Sex (D)	1	20.02	20.02	<1.00
AB	6	227.67	37.94	1.15
AC	3	234.56	78.19	2.37
AD	3	49.73	16.58	<1.00
BC	2	191.17	95.58	2.90
BD	2	32.67	16.34	<1.00
CD	1	229.69	229.69	6.98*
Error	23	757.39	32.93	-
Total	47	5383.98	-	-

the partially (q (3,23) = 10.47, p < .01) and the randomly (q (3,23) = 11.09, p < .01) sequenced task means. The introductory material by intelligence interaction with an F value of 2.37 with 3 and 23 degrees of freedom was significant at the .10 level of confidence. The graphic presentation of this ordinal interaction was previously presented as the first and fourth quarter plottings of Figure 5. The sex by intelligence interaction was significant at the .05 level of confidence.

In addition, a noticeable learning task by intelligence interaction was observed. This ordinal interaction was observed to be statistically significant at the .10 level of confidence, and is shown in Figure 8. The completely sequenced learning task condition

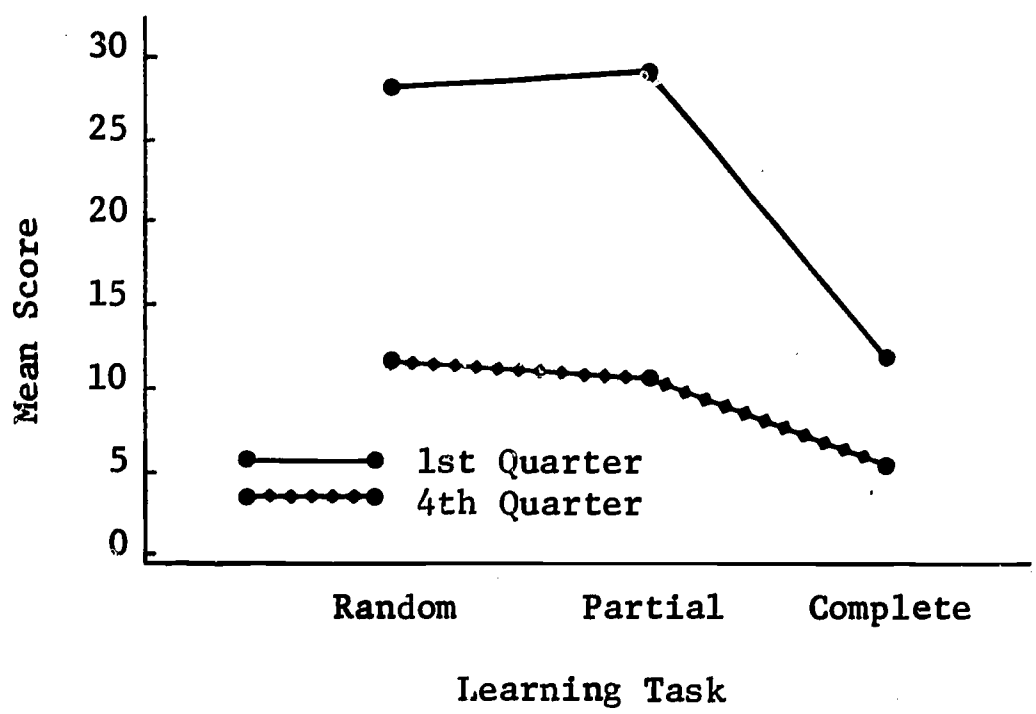


Fig. 8. Trials means for levels of intelligence at each learning task level for 4 x 3 x 2 x 2 analysis.

appeared to have a relatively greater effect on the performance of persons in the lower intelligence subgroup than on those in the upper intelligence subgroup.

Table 13 presents the ANOVA information for the errors to criterion measure of this analysis. These results are similar to the trials analysis in that the learning task and intelligence main effects were significant at the .01 level. The completely sequenced learning task mean differed significantly from the partially (q (3,23) = 8.65, p < .01) and the randomly (q (3,23) = 9.75, p < .01) sequenced task means. The sex by intelligence interaction was significant at the .05 level of confidence. The noticeable interaction effects observed in the introductory material and learning task classifications with intelligence in the preceding trials to criterion analysis were, however, not as pronounced, but similar effects were noted.

Table 13

ANOVA of Errors to Criterion for 4 x 3 x 2 x 2 Analysis

Source	*df*	*SS*	*MS*	*F*
Introductory Material (A)	3	3446.06	1148.69	1.10
Learning Task (B)	2	29894.04	14947.02	14.27**
Intelligence (C)	1	58590.18	58590.18	55.92**
Sex (D)	1	58.52	58.52	<1.00
AB	6	7057.62	1176.27	1.12
AC	3	5157.07	1719.02	1.64
AD	3	1597.06	532.38	<1.00
BC	2	3462.88	1731.44	1.65
BD	2	947.79	473.90	<1.00
CD	1	7081.02	7081.02	6.76*
Error	23	24097.21	1047.70	-
Total	47	141389.46	-	-

In summary, the significant differences in Analysis Two were similar to those found in Analysis One. In addition, however, there were some observed noticeable differences which are of theoretical significance to the present study. There was a noticeable but not statistically significant ordinal interaction between introductory material and intelligence, with the high intelligence subgroup appearing to benefit relatively more from the introductory material than did the lower intelligence subgroup.

Secondly, the ordering of the means of the nonsignificant introductory material main effect for the posttest analysis was quite different from that observed for the trials to criterion results in Analysis One. In fact, in both Analyses One and Two, the order of the posttest means for the introductory material conditions differed from the order of the trials and errors means.

Finally, there was a noticeable learning task by intelligence interaction for the trials to criterion data. The lower intelligence subgroup appeared to profit relatively more from the completely sequenced task than did the higher intelligence subgroup.

Analysis Three

The findings of Analyses One and Two suggested that the facilitative effects of differentially structured introductory materials on an unfamiliar number base learning task appeared to be most beneficial for subjects in the upper intelligence subgroup. To further test the specific treatment hypotheses of this study, *L* tests were

conducted on the data of this subgroup to ascertain the extent to which the predicted rankings of the introductory material and learning task treatments were related to the observed rankings of these treatments.

It will be recalled that for the introductory material treatment the hypothesized ordering of the introductory treatments was principles > base 7 > base 10 > history. This effect was predicted for the total posttest, trials, and errors criterion measures. Since there was sufficient variability among the transfer subtest scores of the total posttest for the upper intelligence subgroup, the same prediction regarding the ordering of the introductory material treatments was made for the transfer measure as with the other criterion measures.

The predictions regarding the ordering of the learning task conditions for each of the criterion measures for the upper intelligence subgroup differed somewhat, however, from the original predictions made in the statement of hypotheses because of the inclusion of the transfer measure. The predicted effect for the learning task treatment was dependent upon the criterion measure used. On the total and transfer posttest criterion measures the predicted order for the learning tasks was partial > complete > random. It was reasoned that the sequential arrangement of the learning task might result in the use of different strategies of learning, which in turn would have a facilitating effect on transfer. That is, the

partially sequenced treatment was expected to influence the subject to employ a strategy of learning in which the subject would attempt to apply some principle in learning the paired associates, whereas the complete and random presentations were expected to encourage the use of a rote memory strategy.

On the other hand, one would expect that the acquisition of the learning task was directly related to the degree of sequential arrangement inherent in the learning task. As a result, the completely sequenced learning task would result in quicker acquisition of the learning task to criterion. Accordingly, on the trials and errors criterion measures, the predicted order for the learning task treatments was complete > partial > random.

The testing of the ordered hypotheses for the posttest criterion measure is presented in Table 14. The data in Table 14 are the

Table 14

L Test of Total Posttest Cell Means of Upper Intelligence Subgroup by Introductory Material and Learning Task Conditions

		Learning Task									
		Random (3)			Partial (1)			Complete (2)			Σ Intro. Ranks
Introductory Material	History (4)	5.50	4	2	5.50	3.5	2	5.50	3	2	10.5
	Base 10 (3)	6.00	3	2	9.50	2	1	4.50	4	3	9
	Base 7 (2)	6.50	2	3	12.00	1	1	9.50	1	2	4
	Principles (1)	9.50	1	1	5.50	3.5	3	9.00	2	2	6.5
	Σ Task Ranks		8			7			9		

L value for introductory material condition = 83.5
L value for learning task condition = 49

cell means by introductory material and learning task treatments. The predicted rankings for the levels within treatments are the numbers enclosed in parentheses; the first number directly to the right of the mean data in each cell is the observed introductory material ranking; and the second number is the learning task ranking. There were two subjects in each cell.

The required L values for significance when four treatments are ranked with three replications are 87 at the .01 level of confidence and 84 at the .05 level. With three treatments and four replications the values are 55 and 54 at the .01 and .05 levels of confidence, respectively.

The agreement between the predicted and the observed rankings of the introductory material conditions approached significance at the .05 level on the total posttest means. The predicted effect for the learning task conditions on the total posttest means was not statistically significant, but the order of the sums of ranks favored the partially sequenced condition as was predicted.

Table 15 presents similar results only for the posttest transfer means. As with the total posttest analysis, the introductory material conditions approached significance and the learning task condition was generally in the predicted direction.

Since the total posttest measure had the transfer and learning task items as part scores, a high similarity between the results of the total and transfer measures would be expected. This is

Table 15

L Test of Transfer Cell Means of Upper Intelligence Subgroup

by Introductory Material and Learning Task Conditions

Introductory Material	Learning Task: Random (3)			Partial (1)			Complete (2)			Σ Intro. Ranks
History (4)	.5	4	3	1.5	3	1.5	1.5	3	1.5	10
Base 10 (3)	1.0	3	2	4.5	2	1	.5	4	3	9
Base 7 (2)	1.5	2	3	7.5	1	1	5.0	1	2	4
Principles (1)	4.5	1	1	.5	4	3	4.0	2	2	7
Σ Task Ranks	9			6.5			8.5			

L value for introductory material condition = 82
L value for learning task condition = 50.5

especially true since there was little variability in the learning task scores, because subjects had learned the learning task items to criterion directly prior to being tested on them.

Table 16 presents a test of the ordered hypotheses for the cell

Table 16

L Test of Errors Cell Means of Upper Intelligence Subgroup

by Introductory Material and Learning Task Conditions

Introductory Material	Learning Task: Random (3)			Partial (2)			Complete (1)			Σ Intro. Ranks
History (4)	79.5	4	3	64.0	4	2	14.5	2	1	10
Base 10 (3)	66.0	2	3	45.5	3	2	26.0	4	1	9
Base 7 (2)	71.0	3	3	38.5	1	2	11.5	1	1	5
Principles (1)	44.5	1	3	41.0	2	2	22.0	2	1	6
Σ Task Ranks	12			8			4			

L value for introductory material condition = 83
L value for learning task condition = 56 $p \leq .001$

means of the errors criterion measure. The hypothesis for the effect of the introductory materials approached significance at the .05 level, and the task order effect was highly significant ($p \leq .001$).

Finally, L tests for the two ordered hypotheses using the trials cell means are presented in Table 17. The L values for the introductory material and learning task conditions were significant at the .05 and .01 levels, respectively. As was expected, these findings were similar to those presented in Table 16. This is explained by the fact that the trials and errors criterion measures for the upper intelligence subgroup correlated .96 with each other.

Table 17

L Test of Trials Cell Means of Upper Intelligence Subgroup by Introductory Material and Learning Task Conditions

		Learning Task									
		Random (3)			Partial (2)			Complete (1)			Σ Intro. Ranks
Introductory Material	History (4)	17.5	4	3	15.5	4	2	5.5	2.5	1	10.5
	Base 10 (3)	12.0	2	3	11.5	3	2	6.5	4	1	9
	Base 7 (2)	15.0	3	3	7.5	1	2	4.5	1	1	5
	Principles (1)	9.0	1	2	11.0	2	3	5.5	2.5	1	5.5
	Σ Task Ranks	11			9			4			

L value for introductory material condition = 84.5 $p < .05$
L value for learning task condition = 55 $p \leq .01$

These results of the L tests on the upper intelligence subgroup criterion measures gave some support to the hypothesis that

introductory materials can be used effectively as facilitators of transfer as well as learning. This was indicated by evidence obtained on the acquisition of learning as measured by errors and trials to criterion, and transfer of learning as measured by the total and transfer posttests.

There was also some support for the hypothesis that partially sequenced learning tasks have a facilitating effect on transfer. On the other hand, it was found that highly sequenced learning material resulted in more rapid acquisition of the material when compared with material that was not sequentially arranged. But, there was little effect on transfer.

Finally, a separate ANOVA between sexes for the upper intelligence subgroup indicated highly reliable differences for each of the criterion measures. The statistically reliable F values with 1 and 22 degrees of freedom for the transfer, total posttest, trials, and errors measures were $F = 9.53$, $p < .01$; $F = 10.25$, $p < .005$; $F = 6.78$, $p < .025$; and $F = 5.47$, $p < .05$, respectively. These differences in favor of the men are in general agreement with findings presented in the previous analyses.

Other Analyses

A third ANOVA was conducted on the study data. For this analysis, the intelligence categories were combined into above- and below-median groups with the other main effect classifications remaining the same. It was anticipated that by combining the

intelligence categories in this manner, more stability might be added to the findings. Because the findings from this analysis did not add anything to the information obtained from Analyses One and Two, the results are only briefly presented. The results for the respective criterion measures were highly similar to the main effect classifications presented previously. As was expected, however, some of the interactions that involved the intelligence classification were less marked.

Finally, Pearson product moment correlations were computed for selected relevant study variables of the total sample. An intercorrelation matrix of these variables for the total sample is presented as Appendix I. Many of the significant correlations are not of particular interest because they were correlations of parts with wholes, for example, the WAIS subtest scores with WAIS total scores. However, several correlations of general interest were noted.

Trials and errors to criterion were negatively related to intelligence scores. The correlation between total posttest scores and trials and errors to criterion were -.54 and -.53, respectively. There was a significant positive correlation between posttest total scores and WAIS arithmetic subtest scores (r = .47), WAIS total scaled scores (r = .40), and WAIS verbal scaled scores (r = .41).

A Pearson r of .52 was observed between the time to complete the introductory material program and the number of errors made on the program; a significant negative relationship of -.40 was

observed between the time taken to complete the introductory material and the WAIS total scaled score; and a -.41 correlation coefficient was observed between the introductory material error rate and the WAIS total scaled score. In other words, length of time to complete the introductory material was positively related to the number of errors made and error rate was negatively related to level of intelligence. Table 18 provides a tabular presentation of the mean introductory material errors and mean completion times in minutes, by the intelligence categories.

Table 18

Programed Introductory Material Errors and

Completion Time by Intelligence

	Mean Errors				Mean Time			
Program	Intelligence Quarter				Intelligence Quarter			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th
History of Measurement	13.50	6.17	2.83	3.17	40.00	34.33	32.17	28.00
Base Ten Number System	10.50	4.17	3.83	2.33	44.00	36.67	33.00	35.67
Base Seven Number System	16.17	7.00	8.33	6.00	61.00	39.83	37.67	35.17
Principles of Number Bases	14.17	15.00	15.33	7.50	65.67	68.83	51.83	41.00

To summarize the results of this study in relation to the originally stated hypotheses, consideration must be given to the type of criterion measure used in the analysis of the data as well as the

analysis itself. A brief summary with regard to each of the stated hypotheses, therefore, will be provided for each criterion measure. A more detailed discussion is presented in the next chapter.

On the ANOVA analyses of the posttest criterion measure, the main effects of intelligence and sex accounted for a significant portion of the variance while the main effects of introductory material and learning task did not. A significant interaction of intelligence by sex and a noticeable interaction of intelligence by introductory material were observed, with the upper intelligence subgroup appearing to benefit most from the introductory materials. No significant or noticeable interactions between intelligence by learning task and introductory material by learning task were found.

Thus, the hypotheses regarding the main effect classifications of introductory material and learning task were not supported by the posttest data for the total sample, but support was obtained for the hypotheses regarding intelligence and sex. The means of the introductory material categories were generally, however, in the predicted direction. The interactions of the learning task with intelligence and with introductory material, and the interaction of intelligence with introductory material did not lend support to the hypotheses.

With regard to the analysis of the trials to criterion data, statistically significant main effects were observed for the learning task and intelligence classifications, and no statistical significance was found for the sex effect. A statistically significant

interaction of sex by intelligence was also observed. The respective hypotheses for these variables exclusive of the sex main effect were, therefore, confirmed.

There were noticeable introductory material main effect differences, and intelligence with introductory material and with learning task interactions. The noticeable introductory material main effect differences and the intelligence with introductory material interaction findings were not in the predicted direction. The observed learning task by intelligence interaction did, however, lend some support to the stated hypotheses. The hypothesized learning task by introductory material interaction was not supported by the data.

Finally, because the errors to criterion data were highly correlated with the trials to criterion data, the ANOVA analyses of the errors to criterion scores were highly similar to the findings obtained in the trials analyses.

The results of the L test on the data of the upper intelligence subgroup yielded support for the ordered prediction that the greater effect on learning and transfer would occur with introductory material that was more generalizable and inclusive regarding the content of the learning topic. There was a significant agreement between the predicted and observed rankings of the learning task condition in the acquisition of a learning task, and a noticeable relationship between partially sequenced learning tasks and transfer.

DISCUSSION

There are three major sections in this chapter. The first section presents a discussion of the findings of this study in relation to the stated hypotheses. The second section is a discussion of the validity of the study. The final section suggests areas for further research.

Findings in Relation to Hypotheses

In this section the results of the analyses of the independent and dependent variables are discussed. Because this study incorporated more than one independent and dependent variable, a careful analysis and discussion of the findings will be presented before arriving at any final interpretations or conclusions regarding the hypotheses of the study.

It was hypothesized that performance on a learning task is positively related to the degree to which material studied prior to the learning task is generalizable, inclusive, and relatable to the content presented in the subsequent learning task.

The results of Analysis One (ANOVA of 4 x 3 x 4 x 2 factorial design) and Analysis Two (ANOVA of 4 x 3 x 2 x 2 factorial design) of the three criterion measures suggested that the hypothesis was not supported by the data. The evidence from the total posttest, trials, and errors criterion measures indicated no statistically significant differences among the introductory material conditions.

In Analysis One and Analysis Two the same ordering of the means of the total posttest criterion measure was observed for the

different introductory treatments. Subjects who studied the history condition performed the lowest on the posttest measure. This was followed in order by the base ten, principles, and base seven treatment groups. This ordering was similar to that which was predicted regarding the effects of the introductory material on learning, with the exception that the base seven and principles treatment effects were reversed. A similar ranking of the introductory material conditions was observed on the total posttest data in Analysis Three (L test of criterion cell means of upper intelligence subgroup by introductory material and learning task conditions).

The difference between the predicted and observed orderings of the base seven and principles conditions is probably a specific function of the structure of the programs. A comparison of the error rates of the two programs suggests that the principles program was perhaps too difficult or abstract, and probably not enough practice in application of the principles of number bases was allowed for persons without any prior knowledge about the learning topic. In fact, the mean errors of each of the first three intelligence subgroups on the principles program were approximately twice as great as that observed for the fourth subgroup. On the other hand, the mean error rates for the first intelligence subgroup on the history, base ten, and base seven programs were generally twice as great as the other intelligence subgroups.

It was interesting to note the marked difference in the total posttest means of the base ten and base seven conditions in each of

the three analyses. These conditions were very similar in format and differed only with respect to the number base content. Therefore, the difference in content between the two programs was presumably the differentiating factor for the noticeable differences in results between these treatment groups.

Although not statistically significant, a noticeable difference among the introductory material conditions was observed on the trials and errors criterion measures. The ordering of the means on these measures was, however, neither consistent with that which was obtained with the total posttest data and the hypothesized effects, nor was it consistent among the analyses. In Analyses One and Two, the fewest trials and errors were associated with the base ten condition. This was followed by the base seven, history, and the principles subgroups.

In contrast, an L test designed to test the significant agreement between the predicted and observed rankings of the introductory material treatments in Analysis Three generally supported the predicted ordering of the introductory material conditions. The ordering of the total posttest means was similar to that obtained in the previous ANOVA analyses of the total posttest data. The order of the means of the trials and errors to criterion in Analysis Three was not consistent, however, with the previous ANOVA analyses of the trials and errors data. The observed ordering of the trials and errors means of the data for the upper intelligence subgroup was the

same as the predicted ordering. That is, the fewest number of trials and errors were obtained by the subjects who studied the principles program. This was followed by the base seven, base ten, and history conditions. Thus, the obtained rankings of the introductory treatments agreed significantly with the predicted rankings for the upper intelligence subgroup on the trials and errors measures. In addition to the evidence obtained on the learning measures, the evidence obtained from the *L* test of the transfer subscores of the total posttest for the upper intelligence subgroup suggested that the introductory materials had a facilitating effect on transfer as well as on learning.

A possible explanation for the different trials and errors mean orderings, especially noted with the base seven and principles conditions in the ANOVA analyses, is that these materials influenced subjects to use different strategies in solving the learning task. As a consequence the number of trials and errors increased as the material became more abstract. If this explanation is accepted then it is difficult to reconcile the Analysis Three findings of the upper intelligence subgroup. The findings of this subgroup were generally in the predicted direction, not only on the total posttest measure, but also on the trials and errors measures as well.

Perhaps a more plausible interpretation of the findings would be that the different intelligence subgroups profited to a different extent from the introductory material. Evidence from tryouts of

earlier versions of the introductory materials with adults who were similar in characteristics to the study subjects indicated significant gains in knowledge after studying the programs. This apparently did not provide complete assurance that the introductory materials would have a facilitating effect on a subsequently administered learning task, which was relatable in different degrees to the introductory material conditions.

It was indicated that persons in the total sample who had a high error rate in completing the introductory material not only took more time to complete the material but also were of lower intelligence. This finding seems to suggest that persons in the lower intelligence categories had more difficulty in studying the introductory material because it was either too difficult or the learning topic was too abstract. The relatively low error ratio obtained for the programs (cf., the mean number of errors to the number of responses required for each program in Table 2) seems to support the explanation that the topic was too abstract. These subjects who were not able to relate the information obtained in the introductory material to the learning task, evidently had to rely upon rote memorization to learn the learning task to criterion.

The inverse relationship between time to complete the introductory material and performance on the learning task also provides evidence to discount the alternative hypothesis that the effectiveness of the introductory materials was related to the time that it took to study the materials.

Furthermore, the increase in trials and errors associated with the base seven and principles conditions in Analyses One and Two and the inability of subjects in the three lower intelligence categories to profit from these programs are reflected in the means of the trials and errors criterion measures. Because the upper intelligence subgroup appeared to benefit relatively more from the base seven and principles materials than the other intelligence subgroups, the increase in trials and errors in the base seven and principles conditions in Analyses One and Two would be expected. Conversely, a posttest which was designed to measure application of the number base concept would reflect the increased performance of the upper intelligence subgroup on the base seven and principles conditions.

Findings to support the interpretation that the introductory materials appeared to benefit most those in the higher intelligence category, were provided by analyses of the interaction between the introductory material and intelligence classifications. Although the obtained evidence was in direct contrast to that which was hypothesized, the results are of significant theoretical and practical interest. On the basis of previous research findings, it was hypothesized that the effects of the introductory materials would especially benefit persons in the lower intelligence categories.

The results of Analysis One of the total sample indicated a noticeable, but not statistically significant, ordinal interaction.

Persons in the upper intelligence subgroup appeared to do relatively better as the introductory material provided more substantive information regarding the learning topic. This finding was especially observed on the trials to criterion data. The direction of the means of all four intelligence subgroups was the same for the history and base ten conditions. On the other hand, the mean trials of the base seven and principles treatments for the first three intelligence subgroups generally increased, whereas the mean scores for the persons in the highest intelligence subgroup continued to decrease for the base seven and principles conditions, respectively.

A similar, but more noticeable, introductory material by intelligence ordinal interaction was noted from the results of Analysis Two on the first and fourth quarter intelligence groups. These findings were consistent for each criterion measure.

Previously cited research findings found an interaction between the introductory condition and verbal ability, with persons of low verbal ability being more favorably affected by the introductory material. Whether the differences between the findings of the previous investigations and the present study are due to intelligence differences of the study samples cannot be directly ascertained. But it does seem reasonable to assume that the college undergraduate samples and the third and fourth intelligence subgroups of the present study would be somewhat comparable with regard to intelligence. If that were the case, then one might expect that the effects of

introductory material in the present study would have been more facilitating for the third (or even the second) intelligence subgroup. Because the introductory materials had a relatively better facilitative effect for the fourth intelligence subgroup, it appears that a previously unconsidered variable is accounting for the observed differences between previous research findings and the present study findings. The findings of the present study suggest that the complexity of the learning topic is a significant variable to consider in ascertaining the extent to which introductory materials facilitate subsequent learning. Moreover, given a very complex learning task, those of high ability appear to benefit as much from introductory materials as those of low ability did in a less complex learning task.

The introductory material by intelligence interaction of the present study is perhaps somewhat related to previous research findings. These findings suggest that if unfamiliar learning material was unrelatable or conflicted with general background knowledge regarding the topic, then the introductory material appeared to benefit those subjects who had more background knowledge or whose connitive structure was assumed to be more clear and stable. There also might be some relationship between the findings of the present study and the research evidence which suggests the dependence of learning and retention on existing related knowledge within the learner's cognitive structure.

The findings also lend support to the theory that the learning of meaningful material is facilitated through the use of introductory materials, which at the appropriate difficulty level are assumed to influence and enhance the clarity, stability, and organization of the learner's cognitive structure.

Theoretically it was assumed that the reception of information in the form of introductory learning material which is presented at a high level of abstraction, generality, and inclusiveness, is limited for young learners who characteristically have immature cognitive structures. The findings of the present research investigation suggest that the reception of abstract material has a limited effect also for adult learners who are less intelligent and less informed on the topic.

A recent study by Scandura and Wells (1967) on college subjects found some support regarding the facilitation of abstract mathematics by utilizing introductory material presented at a more concrete level than at a highly abstract level. They found that concrete model organizers (mathematical games) administered prior to the study of abstract mathematical concepts facilitated the learning and application of the principles inherent in the abstract mathematical material.

To be sure, the extent to which abstract or concrete introductory materials are facilitating is dependent upon such factors as the level and difficulty of the learning material as well as the

intelligence and relevant subject matter knowledge of the subject. To illustrate, if the substantive aspects of a learning topic are presented at an abstract level in the form of introductory materials, then persons with no prior knowledge of this topic would not be able to profit from the introductory material. According to Ausubel, they would not have an adequate cognitive structure for the incorporation of the information in the introductory material. It is assumed that if the introductory material does not enhance the clarity and stability of a learner's existing cognitive structure, then the subsequent learning of related material is also inhibited. Furthermore, persons with limited ability and familiarity with a topic would be handicapped to an even greater extent than would persons with similar familiarity but greater ability. More able adults might recognize subtle relationships between new information about the topic and relevant information that they had previously acquired.

This suggests that persons who do not have sufficient background in a subject matter or who have limited intelligence would probably benefit more from abstract introductory material if they were first exposed to introductory material presented at a more concrete level. This procedure would presumably provide a framework for the integration and incorporation of more abstract material. For example, if the subjects in the present study had received the base ten condition prior to either the base seven or principles

conditions, a greater facilitative effect of these conditions on the subsequent base four learning task would have been expected.

The second main effect study hypothesis, that performance on a learning task is positively related to the degree to which the task is sequentially arranged, was generally supported by the findings of the different analyses. All three analyses statistically supported the hypothesis at least at the .01 level of confidence for the trials and errors criterion measures.

The findings of the ANOVA analyses of the trials and errors data of Analyses One and Two indicated that the completely sequenced tasks differed significantly from the randomly and partially sequenced tasks. In other words, when the learning task was completely sequenced, subjects took significantly fewer trials and made fewer errors in learning the task than when the task was either partially or randomly presented.

The findings of the L tests of the trials and errors data in Analysis Three suggested that the acquisition of a learning task was directly related to the sequential arrangement of the learning task. The completely sequenced learning task required fewer trials and errors to learning criterion than the partially sequenced task, and the partial task required fewer trials and errors than the randomly presented task.

It was noted that in Analyses One and Two there was no apparent difference between the partial and random conditions on the

trials and errors measures; whereas in Analysis Three a slight difference was evident especially on the error data. Furthermore, in Analysis One a slight difference in the order of the learning task means was observed between the trials and errors measures. The ordering of the means for the learning task conditions on the errors measure was the same as that which was predicted. The highest mean errors value was associated with the random condition, the second highest mean errors value was associated with the partial condition, and the lowest mean errors value was associated with the completely sequenced condition. With the trials data the highest mean value was associated with the partial condition, the second highest mean trials value was associated with the random condition, and the lowest mean trials value was associated with the completely sequenced condition. Differences between conditions in this reverse ordering were nonsignificant. A different ordering would be expected because subjects prelearned the four basic symbols used in the learning task. It is hypothesized that if no prelearning of the basic symbols had been required, the effects of the partial condition would probably have been more centrally located between the random and completely sequenced conditions on the trials and errors measures. With the prelearning of the four basic symbols, the subject who was administered the partially sequenced task was not able to benefit fully from the sequential ordering of the first five symbols because the first four symbols were already familiar to him. Consequently the partial task was very similar to the random task.

The effects of the sequential arrangement of the learning task as measured by the total posttest criterion measure, however, indicated no statistically significant differences among the treatment conditions in Analyses One and Two. Findings of the Analysis Three total posttest and transfer data, on the other hand, provided some evidence to indicate that partially sequential arrangement of the learning task might have a greater facilitating effect on transfer than material which is completely ordered or unordered. These findings are similar but not as marked as those found in a similar study by Sjogren (Grotelueschen and Sjogren, 1967).

It was further hypothesized that the sequential arrangement of the learning task would not be independent of intelligence level. It was predicted that persons in the lower intelligence subgroups would benefit most from the completely sequenced learning material. In Analysis One there was no evidence to support this hypothesis on any of the three criterion measures. In Analysis Two no support for the hypothesis was obtained for the posttest data. However, on the trials to criterion data an ordinal interaction indicated that persons in the lower intelligence category appeared to do relatively better when the learning task material was completely sequenced. This noticeable finding was statistically significant at the .10 level of confidence. As was expected, the error data was similar to the trial data but the effect was less marked. Therefore, the support for the learning task by intelligence hypothesis, although not

conclusive, is of particular interest when contrasted with the previously discussed introductory material by intelligence interaction findings.

The noticeable interaction effects observed for the introductory material by intelligence and the learning task by intelligence classifications provide contrasting results. The facilitative effect of introductory materials that were differentially structured with respect to content appeared to be relatively better for adults of superior intelligence, whereas the facilitative effect of completely sequenced learning material appeared to be relatively better for adults of low intellectual ability.

Regarding the hypothesized interaction between the differentially structured introductory materials and the differentially sequenced learning tasks, the findings did not support this hypothesized interaction. It was expected that if the learning task itself was highly sequenced, then the facilitative effect of the introductory material would not have as great an effect as when the learning task was not sequentially presented. None of the ANOVA findings of Analysis One or Analysis Two of the different criterion measures provided any evidence to support this hypothesized interaction. Had the effects of the introductory material conditions (especially the base seven and principles conditions) been more facilitative in learning the base four learning task for all intelligence subgroups, the obtained findings might have been different. The tentative

conclusion that may be drawn from these findings is that a sequentially arranged learning task does not interact with the differentially structured introductory material that precedes it, especially when the subjects have no background knowledge with respect to the learning topic.

Although the ANOVA findings suggested that the introductory materials had a relatively better facilitative effect for the upper intelligence subgroup, the use of the L statistic to test the agreement between the predicted and observed rankings of the criterion measures for the two experimental treatments did not provide any information about the introductory material and learning task interaction. No ANOVA of the upper intelligence subgroup scores was conducted because the results would have been based on the performance of only two subjects in each of the introductory material by learning task analysis cells. To be sure, any findings from such an analysis would have been quite unstable, and not much confidence could be placed in them. Nevertheless, a plotting of each of the criterion measure mean scores for each learning task level at each introductory material level suggests that highly structured introductory material was as facilitative for an unsequenced task as it was for a sequenced task. But, if the content of the introductory material is less generalizable and inclusive, then the relative effects of the completely sequenced material would be more pronounced.

Naturally these interpretations regarding the interaction between differentially structured introductory materials and differentially sequenced learning tasks are tentative and are in need of further research.

A very consistent finding obtained in the ANOVA analyses presented in the preceding section on results was the statistically significant ($p < .01$) intelligence classification. This finding was observed to be significant for all three criterion measures. In Analysis One an inspection of the group means indicated an ordering which was similar to that which was predicted. Persons in the highest intelligence category had the highest mean value on the posttest measure and the lowest trials and errors mean values. Persons classified in the lowest intelligence category had the lowest mean posttest value and the highest trials and errors mean values. Persons classified in the second and third quarter intelligence categories had mean values on each of the criterion measures that were similar to their classification ordering. Because the two intelligence categories used in Analysis Two were the first and fourth intelligence categories of Analysis One, the upper intelligence group differed significantly from the lower subgroup.

Moreover, the evidence indicated that in Analysis One the fourth intelligence category differed significantly from the first, second, and third categories; and the first intelligence category differed significantly from the second and third categories.

Finally, it was hypothesized that men would perform better than women on the criterion measures. This hypothesis was generally supported in each of the analyses. In Analysis One highly reliable differences ($p < .01$) between men and women were obtained on the total posttest. Similar but not statistically significant findings were observed with the trials and errors data. In Analysis Two, a significant difference ($p < .05$) was observed between the performance of men and women on the posttest measure. No significant differences were observed, however, on the trials and errors measures. A separate ANOVA of the criterion scores of men and women in the upper intelligence subgroup utilized in Analysis Three indicated highly reliable differences between sexes on each of the criterion measures.

Although the observed sex effect differences provided evidence to suggest that men performed better than women in learning the base four task, it appeared that the observed differences were not independent of intelligence level. Analysis One disclosed a significant disordinal interaction between the intelligence and sex classifications on the total posttest measure. The same interaction was noted in Analysis Two on each of the criterion measures. Because the plottings of the means for each combination of the sex and intelligence variables indicated a disordinal interaction it was not possible to assert without making qualifications that men were superior in performance to women. It appeared, rather, that men performed

relatively better than women at all levels of intelligence with the exception of the lowest intelligence category.

It must be remembered that the significance test reflects on the reliability of obtained differences; it does not indicate what caused the observed difference. The validity of the significant interaction is questionable because the writer is unaware of any theoretical explanation which would account for this observed result. As a consequence one could assert that the interaction was a chance occurrence. But the fact that the findings were observed on each of the criterion measures makes it somewhat doubtful that the obtained results occurred by chance alone.

A second alternative explanation would perhaps suggest that a methodological bias had a differential effect on performance for the women in the lower intelligence classification. During the study, eight of the persons originally assigned at random to treatments had to be replaced for various reasons. This will be more fully explained in the next section on the validity of the study. Of these eight persons two were women in the lowest intelligence category. These two women were replaced because they became emotionally upset during the learning task. As a result this interfered with their performance on the learning task and they were unable to complete the task to criterion. One might reasonably expect, therefore, that the randomly selected replacements who completed the learning task were more motivated than the two that were unable to complete the task.

In conclusion, it appears reasonable to assume that the findings obtained for the sex main effect were relatively the same for all levels of intelligence, and that the observed interaction between the two variables was probably a result of motivational bias affecting the results. It is important to note that the obtained results in which men performed better than women in learning a mathematical topic were especially observed on the posttest where some application of the learned principles was required. The results suggest that differences might be due in part to attitudinal or nonintellectual variables rather than to any cognitive factors, because prior knowledge and intelligence were controlled in the study.

Validity of the Study

The extent to which the findings of this study are free from bias (i.e., *internally* valid) and generalizable (i.e., *externally* valid) are discussed in detail in this section. The intent of presenting a discussion of the possible and probable sources of validity and invalidity of this study should provide relevant information to assist educational researchers and practitioners. This discussion may be relevant to persons who might be interested in conducting similar studies or who might be interested in the application of research findings to their educational situation.

Because subjects (i.e., experimental units) were randomly assigned to experimental conditions and various controls were

utilized, it is reasonable to assume, in the probabilistic sense, that the observed effects were generally valid.

As was previously stated, the lack of significant differences among the introductory materials was probably due to the abstractness of the learning topic and the way the programs were written. It was reasoned that if the introductory materials (especially the principles program) had been presented at a more concrete level, or if a greater number of examples had been used to illustrate the concepts in the programs, then significant statistical differences might have been observed. Furthermore, if the introductory material effects had been significant, it is possible that the interaction of this variable with the learning task variable might have produced different results. This does not imply, however, that significant main effects are necessary for interactions to occur.

Perhaps a way to increase the effectiveness of these introductory materials in subsequent research projects would be to administer criterion tests at certain intervals in the programs. The subject would be required to attain a certain mastery level on a criterion test before he would be allowed to continue working through the program. If he did not obtain the desired mastery level, he would have to reread relevant portions so that he would obtain the desired behavior before continuing. This procedure would be especially desirable if the subjects have no prior knowledge regarding the learning topic.

Regarding the learning task variable, observed significant differences among the conditions were consistent with the predicted effects with one exception. It was not expected that the partial condition would have effects similar to the random condition. Considering the fact that four of the first five symbols in each trial under the partial condition had been prelearned prior to the actual presentation of the learning task, it is not surprising that this condition had effects similar to the random condition.

Although the rationale for prelearning the basic symbols was to isolate the effects of the sequential arrangement of the learning task from learning the symbols, it could be argued that the learning of task symbols and the sequential presentation of a task go hand in hand. A recent study by Sjogren (Groteluesche n and Sjogren, 1967), in which subjects did not prelearn the four basic symbols, resulted in the partial condition having a marked difference from the random condition.

The generalizability of the introductory material and learning task variables seems to vary with respect to the variables and the way in which the variables were manipulated. The experimentally manipulated introductory materials were all linear programed materials which presumably contained differentially structured substantive information regarding the learning of number bases. This learning of number bases is a topic of interest in current educational curricula. Each program was individually studied prior to

the study of a learning task. The learning task was administered by randomly assigned adults who were stratified according to sex so that experimenter bias would be reduced. Although the use of programed materials limits the generalizability of these materials to other materials of similar format and length, it was felt that the use of programed materials increased the internal validity of the study. This was done by controlling the sequential presentation of the different treatment conditions as well as assuring the attention of the learner to the material. It should be pointed out that all the study participants were familiar with the programed instruction format from the Sjogren and Knox study so that any novelty or practice effect was assumed to be nonexistent.

Similarly, the presentation of unfamiliar symbols that were differentially presented in paired associates form provides certain restrictions in generalizing to the classroom situation. But, again, the emphasis was on controlling the sequential presentation of the learning task material so that the effects of this manipulated variable might be observed.

Another limiting factor in the present study was the lack of variance associated with the posttest criterion measure. As was mentioned earlier, five of the 14 posttest items were represented in the learning task, and nine items were not learned in the learning task. The nine items were designed to measure the extent to which principles could be applied to constructing new base four symbols not specifically learned in the learning task.

What occurred was that nearly all subjects got all the learning task items correct (remember they had to learn the items to a criterion of two trials), and many subjects missed all or nearly all the transfer items. In other words, a ceiling effect was observed on the learning task item subscore, and a floor effect was observed on the transfer subscore. Had the principles introductory material been more facilitating for all intelligence levels, the observed floor effect on the transfer subscore would probably have been less pronounced. Nevertheless, the procedures for measuring knowledge in subsequent studies will have to be altered somewhat if existing differences among treatment groups are to be observed more reliably and validly.

A further source of invalidity observed in the study pertains to the procedures used in pretesting the subjects. A requirement for participation in this study was that the subject's knowledge regarding the learning topic would be negligible. To satisfy this requirement potential study participants were administered a pretest approximately six weeks prior to the time that they would actually participate in the experiment. It is possible that events occurring during the time interval between the administration of the pretest and the learning task could be a source of invalidity, especially if subjects learned any information about the learning topic prior to their participating in the actual experiment. If such were the case, generalizability of these findings to a group with no

knowledge of number base systems would be a source of external invalidity. It is doubtful whether this source of invalidity would affect the interval validity of the study because of the random assignment procedure. The possibility exists, however, that a person who obtained relevant information could perform rather well on a criterion measure with limited variance (e.g., posttest), and thus influence his treatment group's mean score considerably.

One would not expect, however, that the pretest administered in this study would have a sensitizing function which would limit generalizability to pretested groups only. This assumption appeared to be reasonable because the experimental treatments pertained to cognitive learnings and not to affective learnings. Also, the pretest was not administered directly before the learning experiment so that it would be considered a part of the treatment effect. In fact, many of the subjects thought that the pretest was a follow-up test on a related topic of sets that they had studied two years before in the Sjogren and Knox study.

Because the subjects had participated in a previous learning experiment and realized that they were participating in another experimental study, the findings of the present study might be limited in generalizability to an experimental setting. One source of invalidity that might limit the generalizability of the study findings is selection. Although selection would usually be considered a source of internal invalidity, it was not a factor in this study

because subjects were pretested and randomly assigned to experimental conditions. It is probable, however, that the study volunteers, who were paid a small honorarium of five dollars, are different from non-volunteers with regard to motivation.

The study sample was not a random sample of a particular adult population. Instead, it was a sample selected according to certain characteristics which appeared to be related to learning performance. It is reasonable to assume, therefore, that the sample in each cell was somewhat representative of adults possessing the combination of characteristics used to define the cell. As was previously stated, the assumption regarding the similarity between the study adults and the general adult population is probably less tenable when consideration is given to the selection bias of the study sample.

Nevertheless, it will be recalled that the age range of the subjects was typical of adults who participate in continuing educational programs. Furthermore, 69 per cent of the subjects had participated in a formal adult education activity within the previous five year period. Participating subjects in the study were from a midwestern urban community; there was no apparent evidence of serious bias with respect to vocational, educational, social, or ethnic backgrounds.

A second source of invalidity resulting from the fact that the subjects were aware that they were participating in an experimental

study is the reactive effects of experimental arrangements. Subjects participating in this study were not overly compliant with regard to experimental procedures as is sometimes the case when subjects are aware that an experiment is being performed. As in the previous Sjogren and Knox study in which they had participated, many of the subjects wanted to learn something about the subject matter that was presented. This was apparent when subjects who were not able to apply a principle to learning the base four number task expressed some dissatisfaction because they had not been able to learn and apply the information which was presented to them. Therefore, the extent to which the setting appeared to be artificial was perhaps offset by the expectations which the subjects had for themselves regarding the learning of the material.

As was previously mentioned in the Method section of this report, the rate of presenting the learning task in the paired associates form was empirically tested so that there would be no disadvantage for a particular group of subjects. There were some instances, however, in which the subjects in the lowest intelligence quarter exhibited some initial difficulty in adjusting to the rate of presentation; but it was felt that this factor was negligible as a source of internal invalidity.

The length of the learning task, however, seemed to produce a source of internal invalidity. To learn the 13 symbols to required criterion was an exceedingly difficult task for many of the persons

in the first intelligence subgroup, especially when the learning task was presented in an unordered or partially sequenced manner. As a result, two persons in this subgroup became emotionally upset and frustrated during the learning task so that there was substantial interference with the progress that they were making. These subjects, who were women, were randomly replaced with persons who had similar classification characteristics.

It appeared, however, that the two replacements were more highly motivated, because they did finish the learning task. Thus, it seems reasonable to explain the observed effect in which men performed relatively better than women at all but the lowest level of intelligence, as an artifact of internal invalidity due to motivational bias brought about by experimental mortality.

In addition to the two women who were replaced, six other subjects were replaced. The validity of the study was not seemingly affected by replacing these six subjects, because the reasons for replacing them were unrelated to performance on the learning task (e.g., moved out of the state, physical sickness, intra-session interruption, etc.). Each replacement was randomly selected from a group of potentially qualified subjects who had not been originally selected for participation in the study.

In this discussion regarding the validity of the study, certain findings are more generalizable to some learning outcomes, populations, situations, and variables than others. The representativeness of the findings are limited in a number of ways. The study

sample was not a random sample of a particular adult population; however, the characteristics of the adults who were used were typical to what one would expect in a continuing education program. The variables of the study were considered to be fixed effects and not random samples of larger populations of categories. Therefore, caution should be exhibited in generalizing to all types of introductory materials, especially if they are not in linear programed instructional format; to all learning topics; to differently sequenced learning tasks; to all levels of intelligence; to all age groups; and to persons with background knowledge regarding the learning topic.

Further Research

Although this study attempted to answer certain questions related to Ausubel's research on meaningful verbal reception learning and in effect test various aspects of this theory, the study did raise some additional questions that are in need of further research. Suggestive areas for additional research are listed as follows:

1. Future research is needed to ascertain the extent to which the amount of overlearning of the differentially structured introductory materials has an effect on the learning and retention of a conceptually related learning task. In Ausubel's words, what are the effects of overlearning on the relative stability of subsumers in cognitive structure and, therefore, on their relative ability to influence meaningful verbal learning?

2. Although previous investigations included measures of short term retention and the findings of this study are based on immediately administered criterion measures, it would be interesting to note the extent to which the facilitative effects of introductory materials are observed over longer time intervals.

3. Further studies are needed to ascertain the effects of differentially structured introductory materials and learning tasks on transfer of learning. The ability to transfer or apply abstract concepts is an interesting topic for research, especially with adults who seemingly operate at a concrete experiential level a great deal of the time in their day-to-day living.

4. A further consideration concerns the use of the learner's background knowledge regarding the learning topic as another variable to include in the design of future studies. It would be of particular interest to note the interaction of background knowledge and intelligence level. It is evident that for the person without an appropriate background, learning generally involves many trials, much repetition, and practice. For the person with appropriate background, some new material can be learned in a few trials and without much repetition.

5. Additional research is needed to ascertain the extent to which differentially structured introductory materials facilitate the learning of different topics or subject matters.

6. In the present study no statement was made regarding the relevancy of the introductory material to the learning task. It was

felt that the introduction of an attention directing statement would add another dimension to the study. Research is needed, however, to ascertain the effects of set inducing instructions, which seemingly provide guidance to the thinking process, and differentially structured introductory learning materials on a conceptually related learning task. The set inducing instructions may be cognitive or attitudinal and might be given prior to the study of the introductory material or prior to the learning task, or both. It would appear that the use of attitudinal instructions would be a significant variable to include with materials similar to that which were used in this study, particularly if the sample population includes women.

7. During the course of the experiment it became evident that future research activity might try to ascertain the relationship of differentially structured introductory materials and different cognitive learning styles of adults. It seems tenable to assume that certain introductory materials would be facilitative for some adults with certain learning styles and not with others.

8. A further research consideration would be to structure a long term learning activity (e.g., one semester) into units and to ascertain the effects on performance of administering introductory materials prior to each unit as compared with a control group which receives a placebo treatment prior to the study of each unit.

9. Finally, additional research is needed in which similar introductory materials are presented at different levels of abstraction or difficulty.

SUMMARY

Recent studies by Ausubel and his associates (Ausubel, 1960; Ausubel and Fitzgerald, 1961b, 1962; Ausubel and Youssef, 1963; Fitzgerald and Ausubel, 1963) have investigated the effects of the manipulation of various cognitive structure variables on the learning and retention of potentially meaningful verbal material. The procedure has been to introduce to the learner highly abstract and inclusive advance organizers prior to the study of new learning material. These organizers or introductory materials were differentially structured with regard to subject matter content and the sequential arrangement in which this content was presented. According to Ausubel (1963b), the structuring of introductory material in this manner satisfies the substantive and programmatic criteria which are necessary for influencing and enhancing the clarity, stability, and generalizability of the learner's existing cognitive structure. The results have indicated that the learning and retention of meaningful verbal material can be facilitated through the use of introductory materials which provide ideational anchorage and increased discriminability within the learner's cognitive structure. This conceptual framework and the increased discriminability that results from introductory materials is an important factor in enhancing the incorporability and retention of newly learned material.

This report presented evidence from an experimental study regarding the effects on learning of experimentally manipulating

two variables which, according to Ausubel, influence the cognitive structure of the learner.

The first variable was the structure or the content of the introductory material. The second variable was the sequencing of the learning task.

The experiment was designed to test the following general hypotheses:

1. Performance on a concept attainment task is positively related to the degree to which material studied prior to the learning task develops relevant principles in a generalized context.

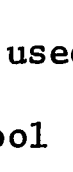
2. Performance on a concept attainment task is positively related to the degree to which the learning task is sequentially arranged.

Subjects who were selected for participation in this experiment had scores of six or less on a 15 item multiple choice pretest on the topic of number base systems as a way of satisfying the requirement of unfamiliarity regarding the general learning topic; ranged in age from 23 through 53; were classified according to two levels of sex and four levels of intelligence.

The basic experimental design of the study consisted of a 4 x 3 x 4 x 2 factorial design, with adult subjects who had no background information regarding the learning topic being randomly assigned to four introductory material and three learning task treatment conditions within intelligence and sex categories. The

variables in the design were considered to be fixed effects and not random samples from a population of categories.

The introductory material conditions were written in linear programed instructional format and were presented in booklet form to the learner prior to the study of a learning task. The different types of introductory material included (a) history of measurement, (b) base ten number system, (c) base seven number system, and (d) principles of number bases. The history of measurement material was intended primarily as a control treatment. The remaining programs on base ten, seven, and principles of number bases were written so that the sequential steps within each of the programs were parallel with the other treatment programs. Thus, obtained differences could be attributed to the content of the introductory materials which provided differentially structured substantive information and would be generalizable and relatable in varying degrees to the base number systems learning topic.

The learning task experimental condition consisted of three differentially sequenced sets of paired associates which corresponded to numbers in the base four number system. The number word was used as the stimulus and the required response was an unfamiliar symbol ( ,  ,  , or ) or combination of these symbols. These four basic symbols represented the number values of zero through three, respectively, or the basic symbols necessary for writing number values in the base four number system.

One of the learning tasks was completely sequenced. That is, the stimulus words were presented in order according to numerical value. The second learning task was partially sequenced. The first five stimulus words were presented in numerical order with the remaining stimulus words presented in random order. The third learning task was not sequentially arranged. The stimulus words were presented randomly. In each trial of the three different conditions, the paired items were always presented in the same prescribed order.

The criterion measures used to ascertain the effectiveness of the experimental conditions on learning were (a) number of correct responses on a completion type posttest administered immediately after the presentation of the learning task; (b) number of trials to criterion, with criterion meaning two perfect repetitions; and (c) number of total errors made to criterion.

The general procedures of the experimental session were as follows: Each subject attended an individually arranged session where a randomly selected set of introductory materials was administered to him. The subject made written responses in the programed booklet as he studied it. A record was kept of the time that it took the subject to complete the program and the number of response errors that the subject made while working the program.

After completing the introductory material, each subject was administered a prelearning task by a randomly assigned session

administrator. The purpose of the prelearning task was to have the subject learn the four basic symbols used in the subsequent learning task. Ten young adults, five men and five women, served as session administrators for randomly presenting the basic symbols to a specified criterion, and for administering the subsequent learning task and posttest.

Immediately after learning the four basic symbols, the subject was presented the randomly assigned learning task condition using a modified TMI-Grolier Min-Max Teaching Machine.

The subject was presented with a stimulus word (e.g., ZERO) in the aperture of the apparatus, and was expected to write the appropriate symbol (e.g.,) on the response tape in the attached answer-mate. After a nine second interval the stimulus number word appeared together with the correct response symbol in the aperture. After receiving feedback regarding the correctness of this response to the stimulus word for six seconds, the stimulus word and the correct symbol along with the subject's response disappeared from sight as the next stimulus word was presented.

Upon responding correctly to two perfect trials of the paired associates task the subject was administered the posttest. The subject was required to respond on the test with the symbols represented by the given number words. Some of the number words on the posttest were from the paired associates items contained in the learning task and some were transfer items which could be answered

correctly if the subject could generalize from the specific base four symbols learned in the learning task to other base four symbols not learned in the task. In addition to the posttest score, measures of trials and errors to criterion of two perfect trials were obtained.

The data were analyzed by use of the ANOVA and the *L* test. For each of the three criterion measures, two general ANOVA analyses were made. The first was an analysis of the total sample data, and the second was an analysis of the scores of the subjects in the first and fourth intelligence levels. A third analysis was based on the data obtained from each of the three criterion measures and an additional posttest transfer subscore from subjects who were categorized in the fourth intelligence subgroup. The data in this third analysis were analyzed by use of the *L* test.

The hypothesis that performance on a concept attainment learning task is positively related to the degree to which material studied prior to the learning task is generalizable to the content presented in the subsequent learning task was not statistically supported by the data in the ANOVA analyses, although findings were in the predicted direction. The results suggested, however, that the facilitative effects of differentially structured introductory materials appeared to have a relatively greater effect for adults with superior intelligence in learning a number base concept attainment task.

The hypothesis that performance on a learning task is related to the degree to which the task is sequentially arranged was supported by the findings of the different analyses. It was found that a completely sequenced learning task resulted in a more rapid acquisition of the learning material than when the task was partially or randomly presented. Some inconclusive evidence was obtained to suggest that the effect of the completely sequenced learning task appeared to be especially facilitative for adults with relatively low intellectual abilities. There was also some additional evidence presented, which is in need of further verification, that partially sequenced learning tasks have a facilitative effect on transfer.

No evidence was found to suggest that the effects of differentially structured introductory materials would be less facilitative for a completely sequenced learning task than a learning task presented in a completely unsequenced manner. There was, however, some evidence to suggest that the relative effect of the completely sequenced learning task would become greater as the introductory material became less substantive with regard to content.

Reliable differences among the intelligence categories and between sexes were observed among the criterion measures in the analyses. The evidence indicated a positive relationship between intelligence and performance on the learning task. Also, the data suggested that men performed consistently better than women, especially on the posttest measure where application of the learned number base principles was required.

An extensive discussion of these results along with a discussion of sources of validity and invalidity and suggestions for further research were also presented.

REFERENCES

Anderson, R. C., & Ausubel, D. P. (Eds.) *Readings in the psychology of cognition.* New York: Holt, Rinehart and Winston, 1965.

Ausubel, D. P. The use of advance organizers in the learning and retention of meaningful verbal material. *J. educ. Psychol.*, 1960, 51, 267-272.

Ausubel, D. P. In defense of verbal learning. *Educ. Theor.*, 1961, 11, 15-25.

Ausubel, D. P. A subsumption theory of meaningful verbal learning and retention. *J. gen. Psychol.*, 1962, 66, 213-224.

Ausubel, D. P. Cognitive structure and the facilitation of meaningful verbal learning. *J. teach. Educ.*, 1963, 14, 217-221. (a)

Ausubel, D. P. *Psychology of meaningful verbal learning.* New York: Grune and Stratton, 1963 (b)

Ausubel, D. P. Introduction. In R. C. Anderson & D. P. Ausubel (Eds.), *Readings in the psychology of cognition.* New York: Holt, Rinehart and Winston, 1965. Pp. 3-17.

Ausubel, D. P. Reception learning and the acquisition of concepts. In H. J. Klausmeier & C. W. Harris (Eds.), *Analyses of concept learning.* New York: Academic Press, 1966. Pp. 157-175.

Ausubel, D. P. & Fitzgerald D. Meaningful learning and retention: intrapersonal cognitive variables. *Rev. educ. Res.*, 1961, 31, 500-510. (a)

Ausubel, D. P., & Fitzgerald, D. The role of discriminability in meaningful verbal learning and retention. *J. educ. Psychol.*, 1961, 52, 266-274. (b)

Ausubel, D. P., & Fitzgerald, D. Organizer, general background, and antecedent learning variables in sequential verbal learning. *J. educ. Psychol.*, 1962, 53, 243-249.

Ausubel, D. P., & Youssef, M. Role of discriminability in meaningful parallel learning. *J. educ. Psychol.*, 1963, 54, 331-336.

Billings, M. L. Problem solving in different fields of endeavor. *Amer. J. Psychol.*, 1934, 46, 259-272.

Birren, J. E. Adult capacities to learn. In R. G. Kuhlen (Ed.), *Psychological backgrounds of adult education.* Chicago: Center for the Study of Liberal Education for Adults, 1963. Pp. 8-42.

Bruner, J. S. *The process of education.* Cambridge, Mass.: Harvard Univer. Press, 1960.

Bruner, J. S. Some theorems on instruction illustrated with reference to mathematics. In E. R. Hilgard (Ed.), *Theories of learning and instruction.* Chicago: National Society for the Study of Education, 1964. Pp. 306-335.

Carey, Gloria L. Sex differences in problem-solving performance as a function of attitude differences. *J. abnorm. soc. Psychol.*, 1958, 56, 256-260.

Fitzgerald, D., & Ausubel, D. P. Cognitive versus affective factors in the learning and retention of controversial material. *J. educ. Psychol.*, 1963, 54, 73-84.

Gagné, R. M. *The conditions of learning.* New York: Holt, Rinehart and Winston, 1965.

Glass, G. V. Multiple comparisons procedures. Paper distributed at Am. Educ. Res. Ass. Presession in Design and Analysis of Experiments, Grossinger, New York, February, 1967.

Green, B. F., & Tukey, J. W. Complex analyses of variance: general problems. *Psychometrika*, 1960, 25, 127-152.

Grotelueschen, A., & Sjogren, D. D. Introductory materials as facilitators of transfer. Paper read at Am. Educ. Res. Ass., New York, February, 1967.

Guetzkow, H. An analysis of the operation of set in problem-solving behavior. *J. gen. Psychol.*, 1951, 45, 219-244.

Inhelder, Bärbel, & Piaget, J. *The growth of logical thinking from childhood to adolescence.* New York: Basic Books, 1958.

Johnstone, J. W., & Rivera, R. *Volunteers for learning.* Chicago: Aldine Publishing Co., 1965.

Maier, N. R. F. Reasoning in humans. III. The mechanisms of equivalent stimuli and of reasoning. *J. exp. Psychol.*, 1945, 35, 349-360.

McDonald, F. J. Meaningful learning and retention: task and method variables. *Rev. educ. Res.*, 1964, 34, 530-544.

Milton, G. A. The effects of sex-role identification upon problem solving skill. *J. abnorm. soc. Psychol.*, 1957, 55, 219-244.

Nakamura, C. Y. Conformity and problem solving. *J. abnorm. soc. Psychol.*, 1958, 56, 315-320.

Page, E. B. Ordered hypotheses for multiple treatments: a significance test for linear ranks. *Am. Statist. Ass. J.*, 1963, 58, 216-230.

Scandura, J. M., & Wells, J. N. Advance organizers in learning abstract mathematics. *Am. educ. Res. J.*, 1967, in press.

Scheffé, H. *The analysis of variance.* New York: John Wiley and Sons, 1959.

Sjogren, D. D., & Knox, A. B. *The influence of speed and prior knowledge and experience on adult learning.* Lincoln, Nebr.: Office of Adult Education Research, Univer. of Nebraska, 1965. (Coop. Res. Proj. No. 2233)

Sjogren, D. D., & Knox, A. B. Adult learning in relation to prior participation in formal educational activities. Paper read at Am. Educ. Res. Ass., New York, February, 1967.

Skinner, B. F. Teaching machines. *Science*, 1958, 128, 969-977.

Sorenson, H. Adult ages as a factor in learning. *J. educ. Psychol.*, 1930, 21, 451-459.

Sweeney, E. J. *Sex differences in problem solving.* Stanford: Dept. Psychology, Stanford Univer., 1953. (Tech. Rep. No. 1, Contract N6onr 25125)

TMI-Grolier. *Programed introduction to modern math.* Chicago: Lakeside Press, 1962.

Wechsler, D. *Wechsler Adult Intelligence Scale manual.* New York: Psychological Corp., 1955.

APPENDIXES

Appendix A. Project Questionnaire

Project Questionnaire

Your responses to the following questions will provide the research staff with valuable information regarding your background and personal characteristics. Please answer each question as completely and accurately as you can. Your responses will be used only in summary form and names will not be associated with particular replies.

DO NOT WRITE

1. Name (Mr., Mrs., Miss) _____ ( )11
   (last) *(first)*

2. Address _____
   (street or RFD) *(city or town)* *(state)* *(zip code)*

3. Phone _____ Date _____
   (area code) *(number)* *(month)* *(day)* *(year)*

4. Please indicate your age to the nearest birthday. _____ ( )12 ( )13

5. Please check the category that includes the highest level of formal education that you have completed.

   8th grade and less.....1( ) 14
   9-11th grade.....2( )
   High school graduate.....3( )
   Trade, business, or technical school.....4( )
   Some college (1-3 years).....5( )
   College graduate (4 years).....6( )
   Graduate degree (Master's or Doctorate).....7( )

6. Since September, 1964, have you participated in any adult education activities? (for example, being a full-time or part-time student, attending an evening class, attending a lecture series, correspondence study, or anything similar)

   Yes.....1( ) 15
   No.....2( )

7. *(If yes)* What specific educational activities have you taken part in during each of the following two time periods?

   September 1964 - September 1965

   a. _____ ( )16 ( )17
   b. _____ ( )18 ( )19
   c. _____ ( )20 ( )21

DO NOT WRITE

September 1965 - present

a._____ ( )22

b._____ ( )23

c._____ ( )24

( )25

( )26

( )27

8. Check the number of years which have passed since your last formal classroom experience (organized sequential program of instruction on some subject matter).

Presently enrolled.....1( ) 28
Last semester.....2( )
1-2 years.....3( )
3-5 years.....4( )
6-10 years.....5( )
11-20 years.....6( )
21-30 years.....7( )
31 years or more.....8( )

9. Which one of the following categories best describes your marital and family status?

Single.....1( ) 29
Married, no children.....2( )
Married, all children under 16.....3( )
Married, all children under and over 16.....4( )
Married, all children over 16.....5( )
Widowed, divorced or separated.....6( )

QUESTIONS NUMBERED 10 THROUGH 15 ARE TO BE ANSWERED BY ALL MEN AND UNMARRIED WOMEN. QUESTIONS NUMBERED 16 THROUGH 21 ARE TO BE ANSWERED BY MARRIED WOMEN WHO MAY OR MAY NOT BE EMPLOYED OUTSIDE THE HOME.

MEN AND UNMARRIED WOMEN ANSWER QUESTIONS 10-15.

10. For what firm or organization are you employed? Give the firm name. (If self-employed, so indicate. If retired, indicate what occupation was. Farmers report type of land, whether irrigated or dry, number of acres, and whether you own, rent, or manage the farm.)

_____ ( )30

_____ ( )31

_____ ( )32

DO NOT WRITE

11. Briefly describe the nature of your major work activity. Give job title and specific duties.

_____ ( )33

_____ ( )34

_____ ( )35

12. Check the category which indicates the number of hours worked per week during your regular working season.

Less than 20.....1( ) 36
20-34.....2( )
35-44.....3( )
More than 44.....4( )

13. How many people are employed by you or are under your supervision?

None.....1( ) 37
1-2.....2( )
3-5.....3( )
6-10.....4( )
More than 10.....5( )

( )38
( )39
( )40
( )41
( )42
( )43

14. What was your father's occupation when he was about your age? (Give specific details as to type of industry, job title, and specific duties. If farmer, report type of land, whether irrigated or dry, number of acres, and whether he owned or rented the farm.)

( )44
_____ ( )45
( )46
_____ ( )47
( )48
_____ ( )49

15. Please indicate the highest level of formal education that your father completed.

6th grade and less.....1( ) 50
7-8th grade.....2( )
9-11th grade.....3( )
High school graduate.....4( )
Trade, business, or technical school.....5( )
Some college (1-3 years).....6( )
College graduate (4 years).....7( )
Graduate degree (Master's or Doctorate).....8( )

MEN AND UNMARRIED WOMEN SKIP TO QUESTION 22.

MARRIED WOMEN ANSWER QUESTIONS 16-21.

DO NOT WRITE

16. For what firm or organization does your husband work? Give firm name. (If he is self-employed, so indicate. If he is a farmer, report type of land, whether irrigated or dry, number of acres, and whether he owns, rents, or manages the farm.) If you are widowed or divorced or husband is retired, indicated what husband's occupation was.

_____ ( )51

_____ ( )52

_____ ( )53

17. Briefly describe the nature of his work. Give job title and specific duties.

_____ ( )54

_____ ( )55

_____ ( )56

18. Check the category which best indicates the number of hours worked per week during his regular working season.

Less than 20.....1( ) 57
21-34.....2( )
35-44.....3( )
More than 44.....4( )

19. How many people are employed by him or are under his supervision?

None.....1( ) 58
1-2.....2( )
3-5.....3( )
6-10.....4( )
More than 10.....5( )

( )59
( )60
( )61
( )62
( )63
( )64

20. What was your husband's father's occupation when he was about your age? (Give specific details as to type of industry, job title, and specific duties. If farmer, report type of land, whether irrigated or dry, number of acres, and whether he owned or rented the farm.)

( )65
_____ ( )66
( )67
_____ ( )68
( )69
_____ ( )70

21. Please indicate the highest level of formal education completed by your husband's father.

DO NOT WRITE

6th grade and less.....1( ) 71
7-8th grade.....2( )
9-11th grade.....3( )
High school graduate.....4( )
Trade, business, or technical school.....5( )
Some college (1-3 years).....6( )
College graduate (4 years).....7( )
Graduate degree (Master's or Doctorate).....8( )

MARRIED WOMEN CONTINUE TO QUESTION 22.

22. Check (X) all of those times that you would be available to attend sessions.

(1) Morning	(2) Afternoon	(4) Evening		
			Monday	72
			Tuesday	73
			Wednesday	74
			Thursday	75
			Friday	76
			Saturday	77

Appendix B. Number Base Systems Pretest

Number Base Systems Pretest Name_____

Directions: Circle the letter of the correct answer for the following:

1. In base eight the numeral 13 stands for the number
   a. four.
   b. fifteen.
   c. eleven.
   d. thirteen.
   e. nine.

2. If you write 124 in base five the numeral 1 stands for one
   a. one-hundred.
   b. twenty-five.
   c. fifty.
   d. ten.
   e. five.

3. The base of a number system is the
   a. face value of the right digit in a number.
   b. same as the amount of numerals used minus one.
   c. distance between each of the number values.
   d. same as the number of symbols used.
   e. place value of the right digit in a number.

4. In base twelve we group number ideas by
   a. six.
   b. twenty-four.
   c. four.
   d. twelve.
   e. two.

5. In base four, the place value of the third position from the right in a three digit numeral is
   a. twenty-four.
   b. sixteen.
   c. twelve.
   d. eight.
   e. four.

6. A numeral is the
   a. symbol for a number.
   b. name for a number.
   c. concrete representation of a number.
   d. figure used in denoting a number.
   e. all of the above.

7. In base three, the numeral "2" in 2,101 means two
   a. twenty-sevens.
   b. nines.
   c. ones.
   d. threes.
   e. eighteens.

8. In base two, the "1" in the numeral 10 is how many times the numeral 1 in the same base system?
   a. eight
   b. ten
   c. two
   d. one
   e. four

9. In our numeration system we group by
   a. tens.
   b. hundreds.
   c. ones.
   d. thousands.
   e. all of the above.

10. The value of the position of the "2" in the numeral 231 is the
   a. place value of the numeral.
   b. base of the number system.
   c. face and place values of the numeral.
   d. face value of the numeral.
   e. base of the number system combined with the face and place values of the numeral.

11. In base nine, the numeral 3,201 has how many nines?
   a. three
   b. six
   c. zero
   d. nine
   e. one

12. The "5" in the numeral 543 in base six means five
   a. ones.
   b. sixes.
   c. twelves.
   d. eighteens.
   e. thirty-sixes.

13. In base five, the 3 in 3,000 is how many times the 3 in 30?
   a. fifteen
   b. ten
   c. five
   d. twenty
   e. twenty-five

14. In base three the numeral 120 stands for the number
   a. fifteen.
   b. three.
   c. eighteen.
   d. twelve.
   e. nine.

15. The face value of the numeral 9 in base seven means
   a. nine nines.
   b. nine tens.
   c. nine sevens.
   d. nine ones.
   e. none of the above.

Appendix C. Means and Standard Deviations of Selected Variables by Intelligence Classification and Sex

Means and Standard Deviations of Selected Variables
by Intelligence Classification and Sex

			Scaled WAIS Information	Scaled WAIS Comprehension	Scaled WAIS Arithmetic
First Quarter	M	$\bar{X}$	10.75	11.58	10.25
		SD	1.30	2.40	2.42
	W	$\bar{X}$	10.33	10.42	9.75
		SD	1.37	1.11	2.45
Second Quarter	M	$\bar{X}$	12.33	12.33	12.58
		SD	1.25	2.95	2.14
	W	$\bar{X}$	12.17	12.58	10.75
		SD	1.28	1.75	1.83
Third Quarter	M	$\bar{X}$	13.75	15.08	14.25
		SD	1.96	1.93	1.16
	W	$\bar{X}$	12.58	14.83	13.17
		SD	1.32	1.28	2.30
Fourth Quarter	M	$\bar{X}$	14.00	15.17	14.92
		SD	1.68	2.67	1.26
	W	$\bar{X}$	13.67	16.33	13.25
		SD	1.49	1.18	1.23
All Intelligence Categories	M	$\bar{X}$	12.71	13.54	13.00
		SD	2.04	2.99	2.57
	W	$\bar{X}$	12.19	13.54	11.73
		SD	1.82	2.62	2.52
Total		$\bar{X}$	12.45	13.54	12.36
		SD	1.95	2.81	2.62

(Table continued on next page)

Table continued

Scaled WAIS Similarities	Scaled WAIS Digit Span	Scaled WAIS Vocabulary	Scaled WAIS Digit Symbol	Scaled WAIS Picture Completion
11.17	8.42	10.58	9.25	10.17
2.11	1.61	1.32	1.79	1.91
9.83	9.42	10.25	11.00	9.75
1.91	1.61	.60	1.83	1.69
12.17	10.50	12.00	11.08	11.83
1.21	1.89	1.78	2.40	1.57
12.75	10.67	12.33	11.83	11.50
1.64	1.93	1.37	2.61	1.32
13.17	11.58	14.00	10.92	11.58
1.52	2.50	2.35	2.22	1.11
12.75	11.92	14.33	13.08	12.42
1.16	2.81	1.18	2.14	1.80
13.00	13.33	14.17	12.25	13.67
1.63	2.66	2.79	2.01	1.55
14.67	12.42	15.58	13.83	13.67
1.80	2.90	1.93	2.54	2.39
12.38	10.96	12.69	10.88	11.81
1.83	2.84	2.60	2.37	2.00
12.50	11.10	13.13	12.44	11.83
2.39	2.65	2.44	2.55	2.33
12.44	11.03	12.91	11.66	11.82
2.13	2.74	2.53	2.58	2.17

(Table continued on next page)

Table continued

Scaled WAIS Block Design	Scaled WAIS Picture Arrangement	Scaled WAIS Object Assembly	Scaled WAIS Verbal	Scaled WAIS Performance
9.58	9.08	10.25	62.75	48.33
1.38	.95	3.09	5.73	4.11
9.92	9.75	10.00	60.00	50.33
2.53	1.48	2.89	3.27	4.59
11.83	10.50	11.17	70.25	56.42
1.82	2.22	1.95	4.40	4.11
10.75	11.00	10.33	71.25	55.42
1.36	2.52	1.89	5.32	4.15
12.75	11.42	12.33	81.83	59.00
1.92	2.63	2.17	4.58	3.89
12.42	12.42	10.75	79.25	61.08
1.85	2.02	2.17	4.11	3.30
13.83	13.00	13.92	84.58	66.67
2.23	2.08	2.10	8.13	4.85
13.17	12.83	13.83	85.08	67.33
2.30	2.30	1.52	4.15	4.57
12.00	11.00	11.92	74.85	57.60
2.43	2.51	2.74	10.61	7.81
11.56	11.50	11.23	73.90	58.54
2.43	2.44	2.66	10.33	7.60
11.78	11.25	11.57	74.38	58.07
2.44	2.49	2.72	10.48	7.72

(Table continued on next page)

Table continued

Scaled WAIS Full	WAIS Verbal IQ	WAIS Performance IQ	WAIS Total IQ	Quick Word Test Score
110.92	103.00	103.00	103.17	46.25
4.41	6.61	5.40	4.28	13.94
110.33	100.67	105.83	103.17	42.83
5.48	3.94	6.69	4.45	12.19
126.67	110.17	111.75	111.58	56.08
4.13	4.67	5.78	2.72	13.62
126.67	111.42	112.08	112.17	62.67
3.90	5.45	6.64	3.51	13.86
140.83	121.75	116.25	120.67	68.75
3.02	5.26	4.44	3.12	16.22
140.33	118.92	117.58	119.42	69.92
3.25	4.33	5.47	3.40	9.84
152.08	124.00	125.67	126.67	71.33
3.59	8.55	5.59	4.35	15.50
152.42	125.33	129.25	128.75	78.42
5.12	4.64	6.81	4.19	9.90
132.63	114.73	114.17	115.52	60.60
15.90	10.72	9.75	9.66	17.97
132.44	114.08	116.19	115.88	63.46
16.32	10.28	10.74	10.18	17.51
132.53	114.41	115.18	115.70	62.03
16.11	10.51	10.31	9.93	17.80

(Table continued on next page)

Table continued

CA	Level of Education	Number Base Pretest Score	Completion Time Introductory Material	Errors Made Introductory Material
41.08	13.25	2.67	54.58	14.33
8.66	2.38	1.31	16.83	8.34
39.83	12.58	2.00	50.75	12.83
10.38	1.19	1.22	13.69	9.75
37.00	14.33	3.08	40.67	7.25
8.58	1.80	1.32	12.48	4.93
37.92	13.92	3.00	49.17	8.92
9.38	1.93	1.15	25.70	8.08
38.75	14.50	3.25	38.50	8.67
9.35	2.14	1.23	16.64	8.53
36.75	13.08	3.33	38.83	6.50
8.82	1.61	1.55	8.39	5.74
37.67	14.25	3.00	35.17	3.83
7.26	2.05	1.53	9.17	2.37
41.42	14.25	3.42	34.75	5.67
8.79	1.92	1.32	7.19	4.80
38.63	14.08	3.00	42.23	8.52
8.64	2.16	1.37	15.96	7.58
38.98	13.46	2.94	43.38	8.48
9.53	1.81	1.43	16.98	7.86
38.80	13.77	2.97	42.80	8.50
9.10	2.02	1.40	16.49	7.72

(Table continued on next page)

Table continued

Posttest Task Score	Posttest Transfer Score	Posttest Total Score	Trials To Criterion	Errors To Criterion
3.67	.33	4.00	25.17	124.58
.94	.62	1.22	9.69	47.01
4.42	.42	4.83	22.08	102.50
.86	.76	.99	9.92	51.79
4.92	2.50	7.42	14.92	68.58
.28	3.15	3.23	11.81	59.03
4.50	.42	4.92	19.75	101.25
.50	1.11	1.11	7.89	37.42
4.83	1.42	6.25	15.83	76.50
.55	2.18	2.35	11.61	65.14
4.83	1.00	5.83	17.58	89.58
.55	.91	1.21	7.84	48.91
4.83	4.50	9.33	7.25	30.42
.55	3.45	3.66	2.62	15.98
4.50	.92	5.42	12.92	56.92
.76	1.71	1.80	6.73	34.03
4.56	2.19	6.75	15.79	75.02
.81	3.02	3.38	11.58	60.58
4.56	.69	5.25	18.08	87.56
.70	1.21	1.38	8.85	47.40
4.56	1.44	6.00	16.94	81.29
.76	2.42	2.69	10.37	54.75

History of Measurement Program

Base Ten Number System Program

Appendix D.

Base Seven Number System Program

Principles of Number Bases Program

To the Learner

The following programed learning material which you will be studying consists of a series of short steps, called "frames." Read each frame and make a response either by filling in a blank or by circling a choice among several alternatives. To the left on the frame that follows, you will find the correct response. You will always find the answer to a frame in the column to the left of the frame you are to do next. If your answer in any frame is incorrect make an "X" beside it

To the Learner

The following programed learning material which you will be studying consists of a series of short steps, called "frames." Read each frame and make a response either by filling in a blank or by circling a choice between two alternatives. To the left on the frame that follows, you will find the correct response. You will always find the answer to a frame in the column to the left of the frame you are to do next. If your answer in any frame is incorrect make an "X" beside it so

To the Learner

The following programed learning material which you will be studying consists of a series of short steps, called "frames." Read each frame and make a response either by filling in a blank or by circling a choice between two alternatives. To the left on the frame that follows you will find the correct response. You will always find the answer to a frame in the column to the left of the frame you are to do next. If your answer in any frame is incorrect make an "X" beside it so

To the Learner

The following programed learning material which you will be studying consists of a series of short steps, called "frames." Read each frame and make a response either by filling in a blank or by circling a choice between two alternatives. To the left on the frame that follows, you will find the correct response. You will always find the answer to a frame in the column to the left of the frame you are to do next. If your answer in any frame is incorrect make an "X" beside it so

so that we can tell where the program is not teaching adequately. If you answer an item incorrectly make sure that you go back and re-read the necessary portions so that you can answer the frame correctly. Although each frame requires you to answer a question or fill in a blank, this is not a test, but a way for you to learn efficiently on your own. Proceed from frame to frame at your own speed, but do not waste any time. Remember, it is important to write out your response, and to write it before looking at the correct response.

that we can tell where the program is not teaching adequately. If you answer an item incorrectly make sure that you go back and re-read the necessary portions so that you can answer the frame correctly. Although each frame requires you to answer a question or fill in a blank, this is not a test, but a way for you to learn efficiently on your own. Proceed from frame to frame at your own speed, but do not waste any time. Remember, it is important to write out your response, and to write it before looking at the correct response.

that we can tell where the program is not teaching adequately. If you answer an item incorrectly make sure that you go back and re-read the necessary portions so that you can answer the frame correctly. Although each frame requires you to answer a question or fill in a blank, this is not a test, but a way for you to learn efficiently on your own. Proceed from frame to frame at your own speed, but do not waste any time. Remember, it is important to write out your response, and to write it before looking at the correct response.

that we can tell where the program is not teaching adequately. If you answer an item incorrectly make sure that you go back and re-read the necessary portions so that you can answer the frame correctly. Although each frame requires you to answer a question or fill in a blank, this is not a test, but a way for you to learn efficiently on your own. Proceed from frame to frame at your own speed, but do not waste any time. Remember, it is important to write out your response, and to write it before looking at the correct response.

1. Early measures of length came from measurement of the human body. Which of these are part of the body? (finger, table top, both, neither)

1. We often speak and think about a group of things. A group of twelve months is one _____.

1. We often speak and think about a group of things. A group of twelve months is one _____.

1. We often speak and think about a group of things. A group of twelve months is one _____.

finger	2. Early measurement of length was based on measurements of parts of the human _ _ _ _.
year	2. One week is a g _ _ _ _ of seven days.
year	2. One week is a g _ _ _ _ of seven days.
year	2. One week is a g _ _ _ _ of seven days.

body	3. Turn to Supplementary Sheet 1 to see some early measurements. What part(s) of the body was (were) used in these measurements? (<u>hand, arm, both, neither</u>)
group	3. Our alphabet is a group of _____ (how many) letters.
group	3. Our alphabet is a group of _____ (how many) letters.
group	3. Our alphabet is a group of _____ (how many) letters.

both	4. Four early measurements that were based on the human hand and arm are the hand, the cubit, the digit, and the span. Look at Supplementary Sheet 1 and write the four measurements in order of size starting with the smallest. _____, _____, _____, _____
twenty-six or 26	4. Your family is a group of people. The United States is a _____ of fifty states.
twenty-six or 26	4. Your family is a group of people. The United States is a _____ of fifty states.
twenty-six or 26	4. Your family is a group of people. The United States is a _____ of fifty states.

digit, hand, span, cubit	5. The "digit" (pronounced DI-jit) is the width of the forefinger. If you had to guess, would you say that the "digit" is (<u>less than one inch, one inch, more than one inch</u>)?  1 inch
group	5. People since the beginning of time have used <u>numb</u> _ _ _ to tell how many things are in a group.
group	5. People since the beginning of time have used <u>numb</u> _ _ _ to tell how many things are in a group.
group	5. People since the beginning of time have used <u>numb</u> _ _ _ to tell how many things are in a group.

less than one inch	6. The "digit" is about 3/4 of an inch. Which of these would measure about one digit long? (<u>dictionary, elephant, banana, head of a pin, none of these</u>)
numbers	6. A _____ tells how many things are in a group.
numbers	6. A _____ tells how many things are in a group.
numbers	6. A _____ tells how many things are in a group.

none of these	7. The "digit" is the width of a _____ and is about (3/4, 1/2, 1/8) of an inch.
number	7. The amount in a group is expressed as a _____.
number	7. The amount in a group is expressed as a _____.
number	7. The amount in a group is expressed as a _____.

forefinger, 3/4	8. Look at Supplementary Sheet 1. The measurement one "hand" is (<u>smaller than, as large as, larger than</u>) the measurement one "digit."
number	8. The number of players on a basketball team is _____ (how many).
number	8. The number of players on a basketball team is _____ (how many).
number	8. The number of players on a basketball team is _____ (how many).

larger than	9. One "hand" is the measurement of the widest distance across the palm of the hand. In a man, a "hand" is about four inches. A measurement of three hands would be about _____ inches.
five or 5	9. <u>Number</u> refers to an amount of things, such as the number of fingers on a hand, or the _____ of letters in the alphabet.
five or 5	9. <u>Number</u> refers to an amount of things, such as the number of fingers on a hand, or the _____ of letters in the alphabet.
five or 5	9. <u>Number</u> refers to an amount of things, such as the number of fingers on a hand, or the _____ of letters in the alphabet.

12	10. The distance across the widest part of a hand (<u>is called a hand, measures about one inch, both, neither</u>).
number	10. The words <u>number</u> and <u>numeral</u> have different meanings. In everyday use, "32" is called a number, but in mathematics, "32" is correctly called a _____.
number	10. The words <u>number</u> and <u>numeral</u> have different meanings. In everyday use, "32" is called a number, but in mathematics, "32" is correctly called a _____.
number	10. The words <u>number</u> and <u>numeral</u> have different meanings. In everyday use, "32" is called a number, but in mathematics, "32" is correctly called a _____.

is called
a hand

11. The measurement "hand" is still used for measuring horses (from the horse's hoof up to his shoulder). A horse 15 hands high is 15 x 4 or _____ inches high.

numeral

11. A number is merely the thought or concept of an amount of things. You cannot see a number. A <u>numeral</u> is a symbol which stands for a number. You can see a _____ because it is a symbol for a number.

numeral

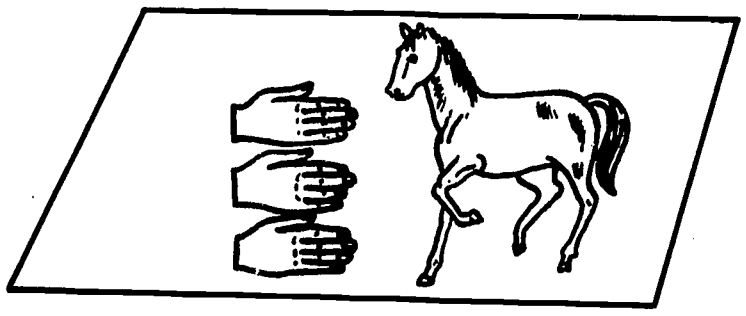
11. A number is merely the thought or concept of an amount of things. You cannot see a number. A <u>numeral</u> is a symbol which stands for a number. You can see a _____ because it is a symbol for a number.

numeral

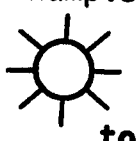
11. A number is merely the thought or concept of an amount of things. You cannot see a number. A <u>numeral</u> is a symbol which stands for a number. You can see a _____ because it is a symbol for a number.

60

12. This little horse never ate his vitamins so he only grew to be ________ inches high.



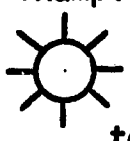
numeral

12. A <u>numeral</u> is a symbol. Symbols are not the "real thing." They stand for or represent something. For example, some weather maps may use this symbol  to represent sun, and this symbol  to represent ________.

numeral

12. A <u>numeral</u> is a symbol. Symbols are not the "real thing." They stand for or represent something. For example, some weather maps may use this symbol  to represent sun, and this symbol  to represent ________.

numeral

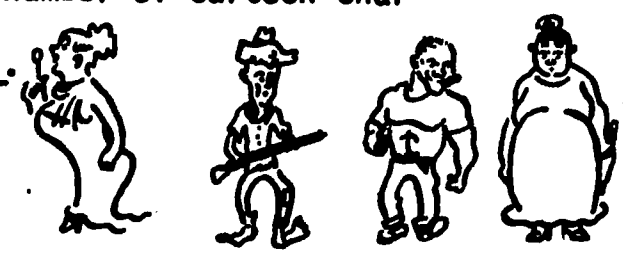
12. A <u>numeral</u> is a symbol. Symbols are not the "real thing." They stand for or represent something. For example, some weather maps may use this symbol  to represent sun, and this symbol  to represent ________.

12

13. A measurement of long ago that used the width of a forefinger (<u>was called a span, measured about 3/4 of an inch, both, neither</u>).

rain

13. The numeral is a symbol which represents a number. The numeral which represents the number of coins  is "3." The numeral which represents the number of cartoon characters below is _____.

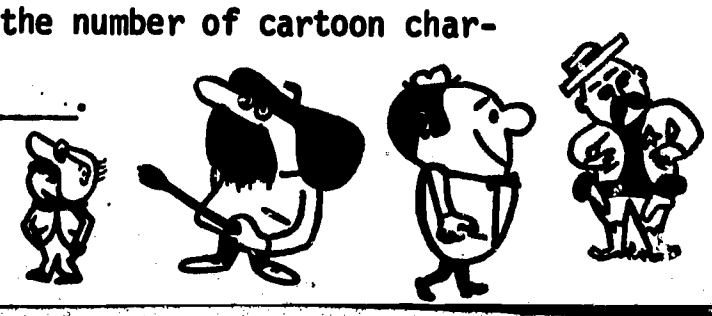


rain

13. The numeral is a symbol which represents a number. The numeral which represents the number of coins  is "3." The numeral which represents the number of cartoon characters below is _____.

rain

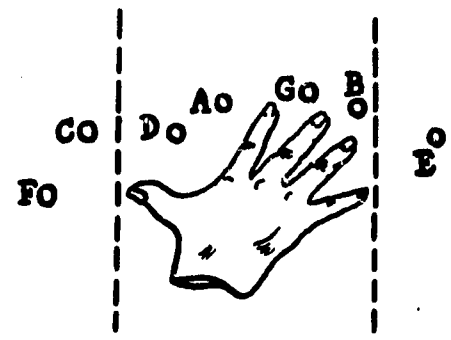
13. The numeral is a symbol which represents a number. The numeral which represents this number of coins  is "3." The numeral which represents the number of cartoon characters below is _____.



measured about 3/4 of an inch	14. Stretch your fingers out as far as you can. The measurement of the distance from the tip of your thumb to the tip of your little finger is called a _____. (See Supplementary Sheet 1.)
4	14. The name or symbol for a number is called a numeral. In our numeration system the numeral for the number six is _____.
4	14. The name or symbol for a number is called a numeral. In our numeration system the numeral for the number six is _____.
4	14. The name or symbol for a number is called a numeral. In our numeration system the numeral for the number nine is _____.

span

15. Suppose children were playing a game. All the marbles that roll into a span are safe. Which marbles are "out"? (A, B, C, D, E, F, G)



6

15. In our numeration system the _____ (name for a number) for the number three is 3.

6

15. In our numeration system the _____ (name for a number) for the number three is 3.

9

15. In our numeration system the _____ (name for a number) for the number three is 3.

F, C, E	16. Guess: The span of a man's hand is closest to (3/4 of an inch, 3 inches, 9 inches, 20 inches).  1 inch
numeral	16. A _____ is a symbol for a number.
numeral	16. A _____ is a symbol for a number.
numeral	16. A _____ is a symbol for a number.

9 inches	17. A span is the measurement between the tip of the outstretched _____ to the tip of the outstretched _____ _____.
numeral	17. You have learned that there is a difference between a number and a numeral. A numeral is a symbol which stands for a number. The thought or concept of the amount in a group is a _____.
numeral	17. You have learned that there is a difference between a number and a numeral. A numeral is a symbol which stands for a number. The thought or concept of the amount in a group is a _____.
numeral	17. You have learned that there is a difference between a number and a numeral. A numeral is a symbol which stands for a number. The thought or concept of the amount in a group is a _____.

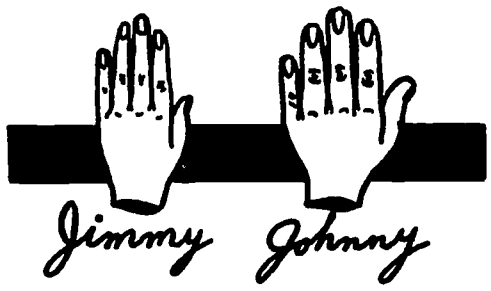
thumb, little finger	18. A span is about 9 inches. How many "hands" are there in a span? (4/9, 2 1/4, 36, 5)
number	18. As you proceed through this booklet, correct responses calling for a number should be written out, and correct responses calling for a numeral should be indicated by a symbol. For example, when you are asked to write the number eight, the answer should be "eight." If you are asked to write the numeral for this number eight, the answer should be _____.
number	18. As you proceed through this booklet, correct responses calling for a number should be written out, and correct responses calling for a numeral should be indicated by a symbol. For example, when you are asked to write the number four, the answer should be "four." If you are asked to write the numeral for this number four, the answer should be _____.
number	18. As you proceed through this booklet, correct responses calling for a number should be written out, and correct responses calling for a numeral should be indicated by a symbol. For example, when you are asked to write the number eight, the answer should be "eight." If you are asked to write the numeral for this number eight, the answer should be _____.

2 1/4	19. We have discussed three measurements based on a human hand. The Egyptians used a measurement based on the arm. What was it called? _____ (See Supplementary Sheet 1.)
8	19. The group of numerals or symbols for numbers that we use are 0, 1, ___, ___, ___, ___, ___, 7, ___, and ___.
4	19. We can form a symbol for any number using the numerals from a certain group. The numerals 0, 1, 2, 3, 4, 5, and 6 make up a _____ of seven numerals.
8	19. In writing numbers, a certain group of numerals is used. The standard group of numerals that depicts numbers with which we are most familiar consists of 0, 1, ___, ___, ___, ___, ___, 7, ___, and ___.

cubit

20. Your friend offers to give you a piece of cake one "hand" high. Whose hand would you use as a measure if you liked cake?

_____



0, 1, 2, 3, 4, 5, 6, 7, 8, and 9

20. The numerals 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 make up a _____ of ten numerals.

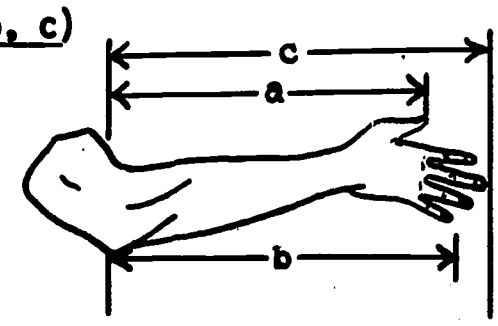
group

20. In the group of numerals 0, 1, 2, 3, 4, 5, and 6 the number of numerals used is _____.

0, 1, 2, 3, 4, 5, 6, 7, 8, 9

(Remember, the statement called for numerals.)

20. The number of numerals used is called the base, but the highest numeral used is one less than the base. In <u>base ten</u> (our numeration system) the number of numerals used is _____, but the highest numeral is ____.

Johnny's	21. A cubit is the length of a forearm (that is, the length between the elbow and the tip of the longest finger). Which measurement is a cubit? (<u>a, b, c</u>) 
group	21. In our number system the number of basic numerals that we use is _____.
seven (Remember, the statement called for a <u>number</u>.)	21. The number of numerals being used is called the base, but the highest numeral is one less than the base. In base seven there are _____ numerals, but the highest numeral is _____.
ten, (The statement asked for a number.) 9	21. Because we use a group of <u>ten</u> basic numerals to represent numbers, we say we are working in the <u>base</u> _____ numeration system.

c	22. Arrange these four measurements in order of size starting with the largest: cubit, digit, hand, span. _____, _____, _____, _____
ten (Remember, the statement called for a <u>number</u>.)	22. Our number system, of course, uses all ten numerals--0, 1, 2, 3, 4, 5, 6, 7, 8, 9. The smallest numeral, meaning <u>none</u>, is ____. The largest numeral is ____.
seven, 6	22. If we use seven numerals to make numbers, we say we are working in the <u>base seven</u> numeration system. The group of numerals or symbols for numbers that we use in the base _____ system are 0, 1, ___, ___, 4, ___, and 6.
ten	22. In <u>base six</u> there are six numerals--0, 1, 2, 3, 4, 5. Using the numerals with which we are familiar, the smallest numeral in base six, meaning <u>none</u>, is ____. The largest numeral is ____.

cubit, span, hand, digit	23. A cubit is a unit of measurement first used by the (American Indians, Egyptians, Chinese).
0, 9 (The statement asked for numerals.)	23. The number of numerals used is called the base, and the highest numeral used is one less than the base. In base ten of our numeration system there are _____ (how many) numerals, and the highest numeral is _____.
seven, 0, 1, 2, 3, 4, 5, 6	23. In the number system using base seven there are _____ basic numerals.
0, 5	23. The numerals 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 make up a g_____ of ten numerals. The numerals 0, 1, 2, 3, 4, and 5 make up a group of _____ numerals. Other groups of numerals may contain three numerals or eight numerals, or any other amount of numerals, depending on the number of the base in which we are working.

Egyptians	24. An Egyptian cubit could be anywhere from 18 to 21 inches depending on the length of the person's arm. If an Egyptian bought three cubits of wood, his wood would measure (24-30 inches, 54-63 inches, 80-100 inches).
ten, 9	24. Because we use a group of ten numerals to represent numbers, we say that we are working in the base _____ numeration system.
seven	24. In base seven there are seven numerals. The smallest numeral, meaning none, is _____. The largest numeral is _____.
group, six	24. The number of numerals in the group we use determines the number of the base in which we are working. For example, if we are using a group of three standard numerals in forming numbers, we are working in base three. If we are using a group of five standard or accepted numerals, we are working in b_____ five.

54-63 inches	25. Ramses, the Egyptian builder, wants to buy a new stone for his pyramid. Stones cost three drachmas (an Egyptian coin) a cubit, measured along their base. To save money, should he buy his stone from a man with a long or a short forearm? _____
ten	25. There is no <u>single</u> numeral for the concept of the number by which we are grouping or the number of the b_____ in which we are working.
0, 6 (The statement asked for numerals.)	25. Each of these seven basic numerals symbolizes a _____. So when we look at each numeral we think of the value that is represented by that numeral.
base	25. When we use all of the ten numerals with which we are familiar (0, 1, 2, 3, 4, 5, 6, 7, 8, and 9) we are working with base _____.

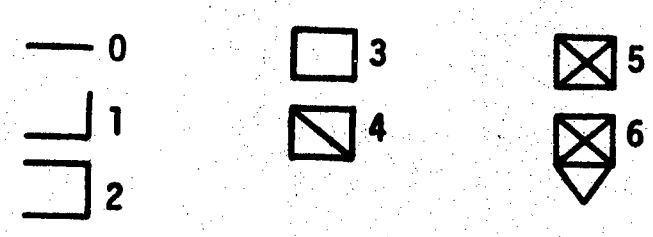
long	26. Cleopatra sent her maid to buy 10 cubits of linen for a dress. When the maid returned, Cleopatra said, "You have cheated me. This linen measures much less than 10 cubits." But the maid hadn't cheated. Explain this. _____ _____
base	26. In base ten we write the numeral for the concept of ten as _____.
number	26. In other words, the symbol "1" stands for the value one, the symbol "2" for the value two, the symbol "3" for the value _____, and so on up through six. This value that each numeral stands for is called the <u>face value</u> of the numeral.
ten	26. If we are symbolizing numbers with the numerals 0 and 1, we are using base _____.

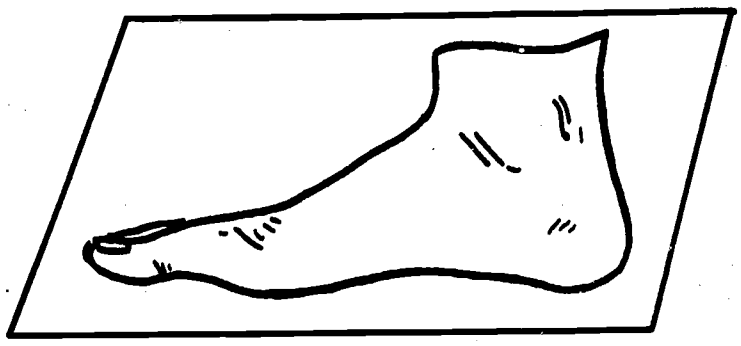
The maid's (or linen dealer's) arm was shorter than Cleopatra's.	27. A digit is the width of a person's _____.
10	27. In our number system we use <u>ten</u> basic numerals. Because we use <u>ten</u> basic numerals to express number ideas we say we are working in base _____.
three	27. Each numeral is a symbol for a number idea. This value of the numeral or symbol is called the <u>f</u>_____ <u>v</u>_____ of the numeral.
two	27. The number of numerals in the group we use determines the number of the _____ in which we are working.

forefinger (finger)	28. The cubit is (<u>longer than, shorter than, equal to</u>) a span.
ten	28. Each of the ten basic numerals symbolizes a _____. So when we look at each numeral we think of the value that is represented by that numeral.
face value	28. The face value of the numeral 6 is _____. Here the numeral 6 is used to represent the concept of the number idea of six.
base	28. Each numeral in a numeration system symbolizes a _____. So when we look at each numeral we think of the value that is represented by that numeral.

longer than	29. The cubit is the first unit of length recorded in history. Is the next statement true or false? The earliest recorded unit was one that measured the width of a hand. _____
number	29. In other words, the symbol "1" stands for the value one, the symbol "2" for the value two, the symbol "3" for the value _____, and so on up through nine. This value that each numeral stands for is called the <u>face value</u> of the numeral.
six	29. The <u>face value</u> of the numeral 3 in the numeric symbol 32 is three. In the numeric symbol 21 what is the face value of the numeral 2? _____
number	29. In other words, when we use the ten numerals with which we are familiar, the numeral "1" stands for the value one, the numeral "2" for the value two, and the numeral "3" for the value _____, and so on up through nine. This value that each numeral stands for is called the <u>face value</u> of the numeral.

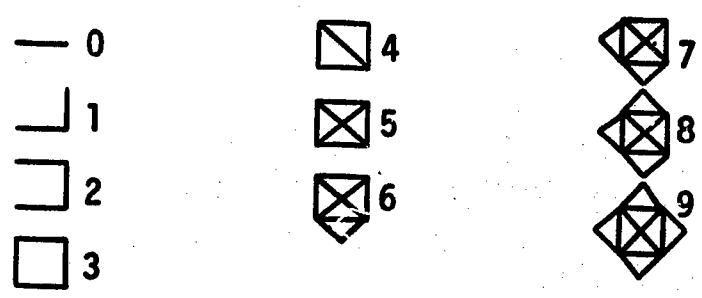
false	30. The Greek cubit averaged 18.24 inches; the Egyptian cubit 20.64 inches. Which country had men with longer arms, Greece or Egypt? _____
three	30. Each numeral is a symbol for a number idea. This value of the numeral or symbol is called the f_____ v_____ of the numeral.
two	30. Other number systems may use symbols that are different from the numerals used in base seven. However, no matter what s_____ are used, the same numbers are always represented.
three	30. Each numeral is a symbol for a number idea. This value of the numeral or symbol is called the f_____ v_____ of the numeral.

Egypt	31. Four measures of length depending on the hand and arm were _____, _____, _____, and _____.
face value	31. The face value of the numeral 7 is _____. Here the numeral 7 is used to represent the concept of the number idea of seven.
symbols	31. For example, the symbols in the country of Nilania are written below with the _____ for base seven which symbolize the same numbers. 
face value	31. Various number systems use different symbols to depict numbers. Some symbols may be very different from the numerals which we use. However, no matter what _____ are used, the same numbers are always represented.

digit, hand, span, cubit (any order)	32. As far as we know, the Egyptians used measurements based on the hand and arm <u>only</u>. Other countries used another part of the body for measurements. What part of the body was it? _____ 
seven	32. The <u>face value</u> of the numeral 7 in the numeric symbol 73 is seven. In the numeric symbol 98 what is the face value of the numeral 9? _____
numerals (preferred) or symbols	32. So you see, the number five does not have to be represented by the numeral _____. It may be represented by the Nilanian symbol ☒ or by any other symbol, such as the Roman numeral V.
symbols	32. For example, the accepted symbols used in the country of Nilania are written below with the n_____ which they represent.

___	zero	☐	three	___	___ six
___	one	☒	four	___	___ seven
___	two	☒	five	___	___ eight

foot	33. The ancient Greeks and Romans both used the "foot" as a unit of measure. The "foot" was the actual measurement of a human foot. If the Greek foot averaged 11.6 inches and the Roman foot 12.6 inches, which nation had people with smaller feet? _____
nine	33. Other systems may use <u>symbols</u> that are very different from our numerals. However, no matter what _____ are used, they represent the same numbers as our numerals.
5	33. The symbols "6" and "VI" are (<u>the same, different</u>) numerals, but they represent (<u>the same, a different</u>) number(s).
numbers	33. So you see, the number five can be represented by many _____, such as the numeral we use (5), the Nilanian symbol (⊠), or the Roman numeral (V). In other words, each of these three symbols has the same <u>face value</u>; that <u>face value</u> is _____.

Greece	34. When we say a board is seven feet long, we are using a measurement that originally came from what part of the body? _____
symbols	34. For example, the symbols in the country of Nilania are written below with our _____ which symbolize the same numbers. 
different, the same	34. No matter what name or symbol is given to the group of birds below, the number idea, or the <u>face value</u> of the number in the group is still _____ (how many). 
symbols (preferred) or numerals, five	34. The symbols "6" and "VI" are (<u>the same, different</u>) numerals, but they represent (<u>the same, a different</u>) number(s).

foot	35. Which of the following nations were known to have used measurements depending upon the length of a foot? (<u>Greeks, Romans, both, neither</u>)
numerals (preferred) or symbols	35. So you see, the number five does not have to be represented by our numeral _____. It may be represented by the Nilanian symbol ☒ or by any other symbol, such as the Roman Numberal V.
three	35. A number may have many _____ to depict it.
different, the same	35. No matter what name or symbol is given to the group of birds below, the number idea, or the <u>face value</u> of the number in the group is still _____ (how many). 

both	36. The Romans sometimes needed a measurement smaller than a foot. So they divided a foot into twelve parts called "unciae," or twelfths. Which of the following English measurement words would you guess came from the word "unciae"? (<u>yards, inches, miles</u>)
5	36. The symbols "6" and "VI" are (<u>the same, different</u>) numerals, but they represent (<u>the same, different</u>) number(s).
symbols (preferred) or numerals	36. By combining the seven numerals in base seven in different ways, we can write the symbol of any number. We can combine the numerals 1 and 0 to write the numeric symbol _____.
three	36. A number may have many _____ to depict it.

inches	37. The English word "inches" came from the Roman "unciae" which were (<u>tenths, twelfths</u>) of a foot.
different, the same	37. No matter what name or symbol is given to the group of birds below, the number idea, or the <u>face value</u> of the number in the group is still _____ (how many). 
10	37. In base <u>seven</u>, numbers greater than six are represented by combinations of numerals. Thus, 45 is a combination of the numerals 4 and _____.
symbols (preferred) or numerals	37. By combining numerals in different ways we can write the symbol of any number. The numerals 1 and 0 can be combined to write the numeric symbol _____.

twelfths	38. Twelve unciae make (one, two, three) (cubit(s), foot (feet), span(s)). (Choose one number and one unit.)
three	38. A number may have many _____ to depict it.
5	38. We combine the numerals 4 and 0 to write the numeric symbol _____.
10	38. The numerals 4 and 0 can be combined to write the numeric symbol _____.

one, foot	39. A cubit is (larger, smaller) than a span. A foot is (larger, smaller) than a digit.
symbols (preferred) or numerals	39. By combining our ten numerals in different ways we can write the symbol of any number. We combine the numerals 1 and 0 to write the numeric symbol _____.
40	39. In combining numerals to write numeric symbols in base seven, we group the number ideas or values by sevens. The value of each group is indicated by the column in which the numeral is placed. For example, in base seven the numeric symbol 24 has four groups of one indicated in the right column and two groups of sev[illegible] indicated in the _____ column.
40	39. In combining numerals to write numeric symbols we group number values or number ideas. The number by which we group is the same as the number of the base in which we are working. When combining numerals in base ten we group number ideas by tens. When working with base three we group number ideas by _____.

larger, larger

40. Two more Roman measures of length that depend on the foot are the "pace" and the "mile."

1. Who used the "pace" and the "mile"? _____

2. What did "pace" and "mile" measure? (weight, length, temperature)

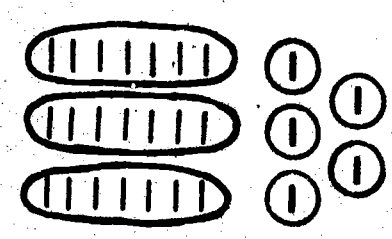
3. On what part of the human body did they depend? _____

10

40. Numbers greater than nine are represented by combinations of numerals. Thus, 45 is a combination of the numerals 4 and _____.

left

40. In the numeric symbol 35 of the base seven system there are three groups of s _ _ _ _ in the left column of the number and five groups of one in the right column.



threes

40. In base eight we are working with groups of _____ (how many).

Romans, length, foot

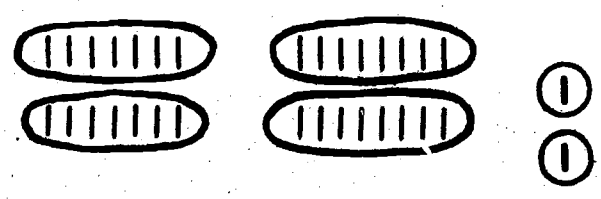
41. A pace is a unit of length which is about five feet long, and is based on the length of two steps. A room two paces wide would be about (five feet, two feet, ten feet) wide.

5

41. We combine the numerals 4 and 0 to write the numeric symbol _____.

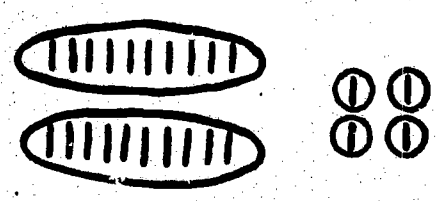
seven

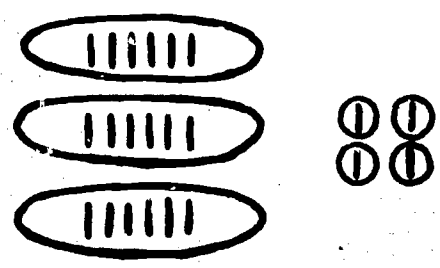
41. In base seven the numeric symbol 42 means four groups of s_____ and two groups of o_____.



eight

41. In combining numerals to write numeric symbols we group number ideas or values by the number of the base in which we are working. So in base six, we combine number ideas in groups of _____.

ten feet	42. Would it be more convenient to measure the length of a room using paces or cubits? _____
40	42. In combining numerals to write numeric symbols in base ten, we group the number ideas or values by tens. For example, the numeric symbol 24 has two groups of ten and four groups of one. Three groups of ten and five groups of one is the numeric symbol _____.
seven, one	42. There is no <u>single</u> numeral for the concept of the number by which we are grouping or the number of the b_____ in which we are working.
six	42. When we combine numerals to symbolize a number each column has a certain value, depending on the base in which we are working. For example, in base ten the numeric symbol 24 has four groups of one indicated in the right column and two groups of ten indicated in the _____ column. 

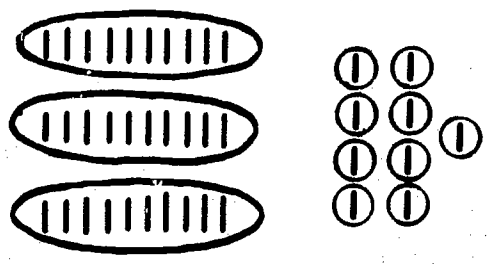
paces	43. If you were a Roman who was measuring cloth, and didn't want to have footprints on the expensive white silk you were selling, you would use the (<u>foot, cubit, pace</u>).
35	43. We group number values by ten since we use base _____. The value of each group is indicated by the column in which the numeral is placed.
base	43. In the base seven system there is no single numeral for the concept of seven. Because, in the base seven system, we group number ideas by sevens, we think: the number seven has one group of seven and no ones, so it is written _____.
left	43. In the numeric symbol 34 in the base six system there are three groups of <u>s</u> _ _ in the left column of the number and four groups of <u>one</u> in the right column. 

cubit

44. Name any two measures of length previously mentioned that used the foot. _____, _____

ten

44. The numeric symbol 39 has nine groups of one indicated in the <u>right</u> column and three groups of ten indicated in the _____ column.



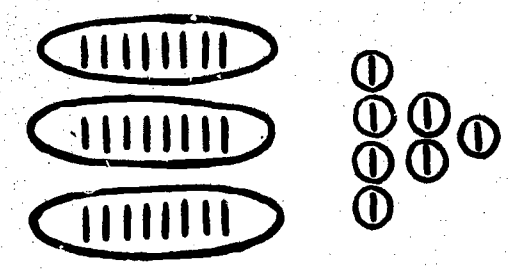
10

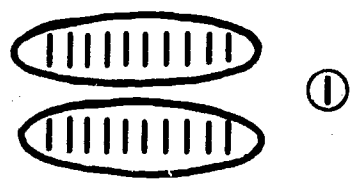
44. Group by sevens and write the numeric symbol that represents three sevens and no ones.

_____

six

44. Notice that the first column to the right always indicates the amount of <u>ones</u> and the second column always indicates the amount of <u>bases</u> there are. In base <u>eight</u> the numeric symbol 37 means three groups of _____ and seven groups of _____.



unciae, foot, pace, mile (any two)	45. The pace was about five feet. The Roman mile was 1,000 paces. So the Roman mile was about (<u>50 feet, 1,000 feet, 200 feet, none of these</u>).
left	45. The numeric symbol 21 means two groups of <u>t</u> _ _ and one group of <u>o</u> _ _ _. 
30	45. Write the numeric symbol in the base seven system with five sevens and no ones. _____
eight, one	45. In base ten the numeric symbol 93 means nine groups of <u>t</u>_____ and <u>th</u>_____ groups of one.

none of these

46. The Roman mile was 1,000 paces or 5,000 feet. If the distance between two Roman cities was 20,000 feet, the cities were about _____ miles apart.

ten, ones

46. In base ten the numeric symbol 93 means nine groups of t_____ and th_____ groups of one.

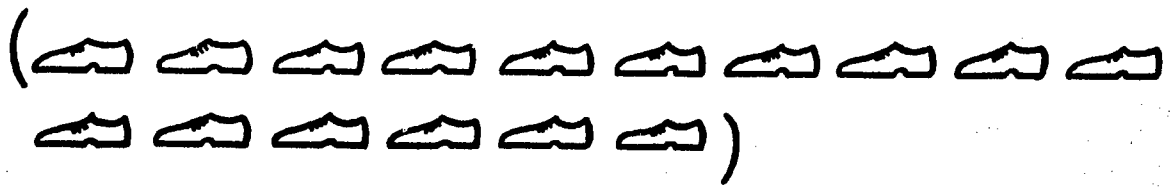
50

46. In the numeration system based on seven we combine number ideas or values in groups of _____.

ten, three

46. There is no single numeral for the concept of the number by which we are grouping or the number of the b_____ in which we are working.

four	47. The Romans divided a foot into _____ parts called unciae.
ten, three	47. There is no single numeral for the concept of ten. Because we group number ideas by <u>tens</u>, we think: the number ten has one group of tens and no ones, so the numeric symbol is written _____.
seven	47. When we combine number ideas in groups of <u>seven</u>, we say we are working in base _____.
base	47. So if we are grouping number ideas by ten and wish to write the number ten, we think: the number ten has <u>o</u> _ _ group of tens and no <u>o</u> _ _ _, so it is written 10.

12	48. In the sixteenth century the "rod" was used. This was the length of the left feet of _____ men lined up as they left church on Sunday morning. 
10	48. Group by tens and write the numeric symbol that represents three tens and no ones. _____
seven	48. The numerals 2 and 3 may be combined to form two numeric symbols, _____ and _____.
one, ones	48. In base ten, we write the concept of ten as _____. The same follows in any other base. For example, group by <u>sevens</u> and write the numeric symbol that represents <u>one</u> seven and <u>no</u> ones. _____ Remember the first column to the right indicates the number of ones and the second column indicated the number of bases, or the number by which we are grouping.

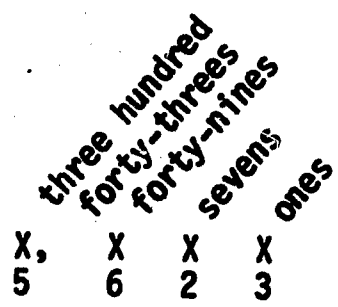
16	49. The length measurement "rod" was introduced (<u>before, after</u>) the measurement pace.
30	49. Write the numeric symbol with seven tens and no ones. _____
23, 32 (any order)	49. So you can see that the <u>place</u> where we write the numeral in the numeric symbol is important. The numeric symbols 23 and 32 (<u>are, are not</u>) the same.
10, 10	49. Group by sixes and write the numeric symbol that represents three sixes and no ones. _____

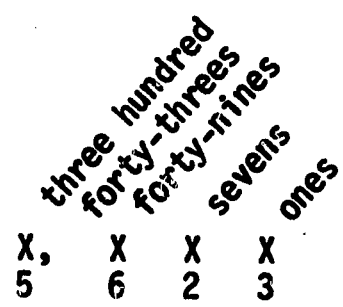
after	50. The rod was a measure based on the length of the _____ _____ of 16 men.
70	50. In our numeration system we combine number ideas or values in groups of _____.
are not	50. Each numeral takes up one place. The numeric symbol 23 has two places. The number of places in the numeric symbol 1,023 is _____.
30	50. When we use numerals to write numbers we group number ideas. In writing numbers it is important to know the number by which you are grouping or the _____ in which you are working.

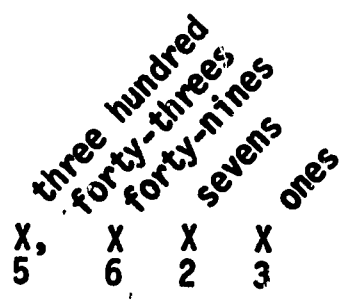
left feet	51. The Roman _____ was about five feet long. The Roman _____ was about 5,000 feet long.
ten	51. Because we combine number ideas in groups of <u>ten</u>, we say we are working in base _____.
four	51. The location or place of a numeral within a numeric symbol tells us what that numeral means. It is important where the _____ is <u>placed</u> in the numeric symbol. This value of the position of the numeral is called its <u>place value</u>.
base	51. The numerals 2 and 3 may be combined to form two numeric symbols, _____ and _____.

pace, mile	52. The rod was a measure based on the length of the (left, right) feet of (14, 16, 19) men lined up as they left (school, the zoo, church) on a Sunday morning.
ten	52. The numerals 2 and 3 may be combined to form two numeric symbols, _____ and _____.
numeral	52. The value of a numeral is partially determined by its _____ in a sequence of numerals. This value of the position of a numeral is called the p_____ v_____ of the numeral.
23, 32 (any order)	52. So you can see that the place where we write the numeral in the numeric symbol is important. The numeric symbols 23 and 32 (are, are not) the same.

left, 16, church	53. The measurement one rod will be closest to (<u>16 inches, 16 feet, 16 miles, none of these</u>).
23, 32 (any order)	53. So you can see that the <u>place</u> where we write the numeral in the numeric symbol is important. The numeric symbols 23 and 32 (<u>are, are not</u>) the same.
position or location or place, place value	53. The following diagram shows the place values of the first four positions in the system which is based on grouping number ideas by seven. three hundred forty-threes, forty-nines, sevens, ones X, X X X A "6" in the sevens' place means six sevens. A "6" in the forty-nines' place means six forty-nines. A "6" in the three hundred forty-threes' place means six _____.
are not	53. Each numeral takes up one place. The numeric symbol 23 has two places. The number of places in the symbol 1,023 is _____.

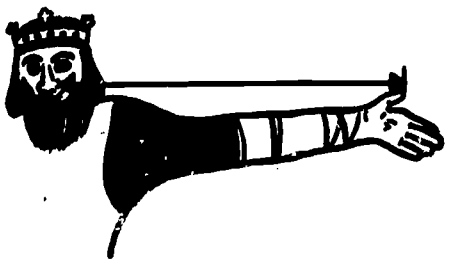
16 feet	54. The Roman mile was about _____ feet long. The Roman pace was about _____ feet long.
are not	54. Each numeral takes up one place. The numeric symbol 23 has two places. The numeric symbol 1,023 has _____ places.
three hundred forty-threes	54.  When a numeric symbol has more than one place, each numeral is given a value depending on the place it is in. The above diagram shows the four-place numeric symbol 5,623. The numeral in the ones' place is _____.
four	54. The location or the place of a numeral within a numeric symbol tells us what that numeral means. It is important where each _____ is <u>placed</u> in a numeric symbol. This value of the position of the numeral is called its <u>place value</u>.

5,000, five	55. One of the following measurements does not depend on the length of all or part of the human hand or arm: hand, cubit, rod, digit. Which of the measurements is it? _____
four	55. The location or place of a numeral within a numeric symbol tells us what the numeral means. It is important where the _____ is <u>placed</u> in the numeric symbol. This value of the position of the numeral is called its <u>place value</u>.
3	55.  The place with the lowest value is at the right in the numeric symbol. It is the _____ place.
numeral	55. The value of a numeral is partially determined by its _____ in a sequence of numerals. This value of the position of a numeral is called the p_____ v_____ of the numeral.

rod	56. We use a word for measurements of length that came from the Roman measurement word "unciae." Which modern measurement of length is it? _____
numeral	56. The value of a numeral is partially determined by its _____ in a sequence of numerals. This value of the <u>position</u> of a numeral is called the p_____ v_____ of the numeral.
ones'	56.  In the above diagram, the next position to the left of the ones' place is called the _____ place.
position or location or place, place value	56. The following diagram shows the <u>place value</u> of the first seven positions in the number systems which have characteristics similar to our numeration system. B^6 B^5 B^4 B^3 B^2 B^1 B^0 X, X X X, X X X B^0 is the base to the zero power or one, (1) B^1 is the base to the first power or base, (B) B^2 is the base to the second power or base squared, (BxB) B^3 is the base to the _____ power or base cubed, and so on. (BxBxB)

inch

57. The picture shows another measurement of length, the "yard," that was started at the time of King Henry I. The yard was the distance from the point of his _____ to the end of his _____, when his arm was outstretched.



position
or
location
or
place,

place value

57. The following diagram shows the place values of the first seven positions in our system which is based on grouping number ideas by ten.

millions	100 thousands	10 thousands	thousands	hundreds	tens	ones
X,	X	X	X,	X	X	X

An "8" in the thousands' place means eight thousands.
An "8" in the tens' place means eight _____.
An "8" in the _____ place means eight ones.

sevens'

57. According to the previous diagram, if you see the numeral 2, you know the 2 means two ones. If you see 20 you know that the 2 means two sevens. The position of the 2 tells you what number it represents. The 2 in 200 in base seven means two _____.

third

57.

B^6	B^5	B^4	B^3	B^2	B^1	B^0
X,	X	X	X,	X	X	X

A numeral in the first place to the right will have the value of base to the zero power or ones. The second column is valued at base to the first power or the base in which you are working. The third column is valued at base to the s_____ power or base squared.

nose, thumb

58. King Henry I lived from 1068 to 1135 A. D. The measurement "yard" was first used (before, after) the measurement cubit.

tens, ones'

58.

100 thousands	10 thousands	thousands	hundreds	tens	ones
X	X	X,	X	X	X
		5	6	2	3

When a numeric symbol has more than one place, each numeral is given a value depending on the place it is in. The above diagram shows the four-place numeric symbol 5,623. The numeral in the ones' place is _____.

forty-nines

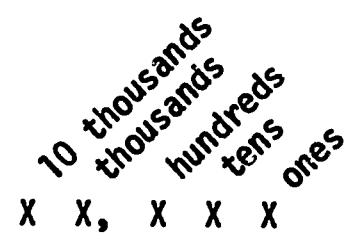
58. Each place in the base seven number system has a value. Ones, sevens, forty-nines, three hundred forty-threes and so on are the place v_____ of the base seven number system.

second

58.

B^6	B^5	B^4	B^3	B^2	B^1	B^0
X,	X	X	X,	X	X	X

We have stated that the first place to the right will have the value of the base to the 0 power or ones. Because any number to the zero power is always one, the first column of any number system which uses place values will be called the ones' column or have a place value of _____.

after	59. The yard and the cubit had one thing in common. They were both measurements of all or part of the human (<u>hand, arm, leg</u>).
3	59.  The place with the lowest value is at the right in the numeric symbol. It is the _____ place.
values	59. The ones' place is at the right in the numeric symbol. As we move left, to sevens, then forty-nines, etc., the place values get (<u>lower, higher</u>).
one	59. In base eight or in any base, the column farthest to the right has a place value of _____ (base to the zero power).

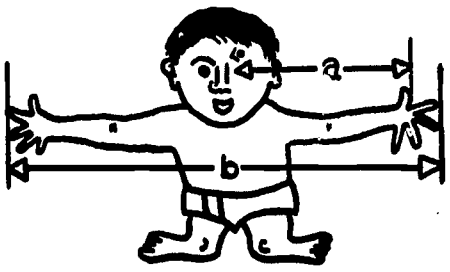
arm	60. The measurement "yard" as used in King Henry I's time was approximately (<u>24 inches, 36 inches, 48 inches</u>).
ones'	60. 10 thousands, thousands, hundreds, tens, ones X X, X X X The next position to the left of the ones' place is called the _____ place.
higher	60. In the base seven number system, the ones' place is at the right, and the places to the left are sevens, forty-nines, three hundred forty-threes and so on. As we move left, the value of each place is how many times greater than the value of the place before it? _____
one	60. B^6 B^5 B^4 B^3 B^2 B^1 B^0 X, X X X, X X X The second column from the right always has the place value of the base to the first power or, simply, the b_____.

36 inches	61. The measurement hand is still used today in measuring the height of _____.
tens'	61. According to the previous diagram, if you see the numeral 2, you know the 2 means two ones. If you see 20 you know that the 2 means two tens. The position of the 2 tells you what number it represents. The 2 in 200 means two _____.
seven	61. In other words, in base seven each column of numerals has seven times the value of the column to the right. The column where the 6 is in the numeric symbol 63 has _____ times the value of the column where the 3 is.
base	61. In base nine the second column from the right has the value of the base or _____. In base ten this column has a place value of _____.

horses	62. A measurement based on the length of King Henry I's outstretched arm was the _____.
hundreds	62. Each place in our number system has a value. Ones, tens, hundreds, thousands, ten-thousands and so on are the place v_____ of our number system.
seven	62. The reason each column has a value seven times greater than the column to the right is that we are working with base seven and are grouping number ideas by _____.
nine, ten	62. B^6 B^5 B^4 B^3 B^2 B^1 B^0 X, X X X, X X X The third column from the right always has the place value of the base squared or the base times itself. In base ten this column has the place value of ten squared (ten times ten) or _____.

yard	63. A digit is the width of a (<u>horse, arm, nose, none of these</u>).
values	63. The ones' place is the place farthest to the right in the numeric symbol. As we move left to tens, then hundreds, etc., the place values get (<u>lower, higher</u>).
seven	63. Ones, sevens, forty-nines, three hundred forty-threes and so on are the p_____ v_____ of the base seven number system.
hundred	63. B^6 B^5 B^4 B^3 B^2 B^1 B^0 X, X X X, X X X The fourth column from the right always has the place value of the base cubed (base times base times base). For instance, in base two this column has a place value of two x two x two or _____.

none of these	64. A "fathom" is a measure of length based on the distance between the tips of two hands when arms are outstretched. A fathom would be approximately (<u>one yard, two yards, three yards, 1/2 yard</u>).
higher	64. In our number system the ones' place is at the right, and the places to the left are tens, hundreds, thousands, ten-thousands and so on. As we move left, the value of each place is how many times greater than the value of the place before it? _____
place values	64. In the numeric symbol 324 in base seven the place value of the numeral 4 is <u>ones</u>; the place value of the numeral 2 is <u>sevens</u>; and the place value of the numeral 3 is _____.
eight	64. Each place in our number system has a value. Ones, <u>tens</u>, hundreds, thousands, ten-thousands, and so on are the place values of the base _____ number system.

two yards	65. "a" shows the measurement of (cubit, fathom, both, neither). "b" shows the measurement of (yard, fathom, both, neither). 
ten	65. In other words, each column of numerals has ten times the value of the column to the right. The column where the 7 is in the numeric symbol 73 has _____ times the value of the column where the 3 is.
forty-nines	65. The numerals tell how many times each place value is to be used. Each place can be used from 0 to 6 times or according to the face value of the numeral. In the numeric symbol 2,504 in base seven the three hundred forty-threes' place is used two times, the sevens' place is used zero times, and the ones' place is used _____ times.
ten	65. Ones, threes, nines, twenty-sevens, eighty-ones, and so on are the place values of the base _____ number system.

neither, fathom	66. A fathom is the distance between the tips of hands when the arms are _____.
ten	66. The reason each column has a value <u>ten</u> times greater than the column to the right is that we are working with base <u>ten</u> and are grouping number ideas by _____.
four	66. In the numeric symbol 625 in base seven, the numeral 2 means that we have two sevens or that the sevens' place is to be used _____ times.
three	66. It can be seen that as we move left from column to column, the place values get (<u>lower, higher</u>).

outstretched	67. A span is (<u>larger than a digit, smaller than a cubit, both of these, none of these.</u>)
ten	67. Ones, tens, hundreds, thousands and so on are the _____ _____ of our number system, the base ten system.
two	67. The numerals in 4,444 tell us that we have <u>four</u> three hundred forty-threes + <u>four</u> forty-nines + <u>four</u> sevens + <u>four</u> ones, or that each place is to be used _____ times.
higher	67. You may have noticed that each column has the value of the base times the value of the column to its right. In base <u>ten</u> (see below) the value of the second column is <u>ten</u> times the value of the ones' column, column three is _____ times the value of the second column, and so on. <u>Base Ten</u> hundred-thousands, ten-thousands, thousands, hundreds, tens, ones X X X, X X X

both of these	68. A fathom is a measurement that is used on ships for navigation. Which of the following would be most likely to use the measurement fathom? (soldier, plumber, teacher, sailor)
place values	68. In the numeric symbol 394, the place value of the numeral 4 is ones; the place value of the numeral 9 is tens; and the place value of the numeral 3 is _____.
four	68. The numeric symbol 624 in base seven can be "stretched out" to show the place values of each numeral: six forty-nines + two sevens + four ones. A synonym for "stretched out" is expanded, so we call six forty-nines + two sevens + four ones an e_____ numeric symbol.
ten	68. In base five the value of the second column from the right is five times the value of the first column. The value of the third column is _____ times the value of the second column. What is the place value of the third column in base five? _____ Base Five one-hundred twenty-fives twenty-fives fives ones X, X X X

sailor	69. Measurement based on length of parts of the human body are not satisfactory because (<u>not all blond people have blue eyes, different people have different measurements, both of these, neither of these</u>).
hundreds	69. The numerals tell us how many times each place value is to be used. Each place can be used from 0 to 9 times or according to the face value of the numeral. In the numeric symbol 2,503 the thousands' place is used two times, the tens' place is used zero times, and the ones' place is used _____ times.
expanded	69. 624 = 6x49 + 2x7 + 4x1 624 = 294 + 14 + 4 Since forty-nine is the <u>place value</u> of the numeral 6, we are showing that each numeral's total value is found by multiplying the face value of the numeral by its _____ _____.
five, twenty-five	69. B^4 B^3 B^2 B^1 B^0 3 2, 1 0 <u>2</u> In any base system when a numeric symbol has more than one place, each numeral is given a value depending on the place it is in. The above diagram shows the five-place numeric symbol 32, 102. The numeral in the ones' column is _____.

different people have different measurements

70. The standardized measurement is one that has these properties:

a. It is set up or established by someone in authority like a king or congress.

b. It is the same for everyone (that is, it depends on a fixed standard).

The span (<u>was, was not</u>) a standardized unit of measurement.

---

three

70. In the numeric symbol 863, the numeral 6 means that we have six tens or that the tens' place is to be used _____ times.

---

place value

70. An expanded numeric symbol shows that each symbol or _____ will be multiplied by its place value.

2

70.

B^4	B^3,	B^2	B^1	B^0
3	2,	1	0	2

The numeral in the second column from the right is 0. So we can say this numeral has a face value of zero and a place value of the base. For example, if we were working in base <u>five</u> this 0 would have a <u>face</u> value of z_____ and a <u>place</u> value of the base to the first power or _____.

was not	71. A king (<u>could, could not</u>) set up a standardized measurement for his country.
six	71. The numerals in 4,444 tell us that we have four thousands + four hundreds + four tens + four ones, or that each place is to be used _____ times.
numeral	71. In base seven when you see a numeric symbol such as 35, you know that it means three _____ and five _____.
zero, five	71. B^4 B^3 B^2 B^1 B^0 3 2, <u>1</u> 0 2 In the third column from the right the numeral 1 means one base squared. In base ten this 1 would stand for one ten squared or one one-hundred. If we were working in base three this one would mean one three squared or one _____.

could	72. A measurement that is set up by someone in authority and is the same for anyone using it is called a _____ measurement.
four	72. The numeric symbol 824 can be "stretched out" to show the place values of each numeral: eight hundreds + two tens + four ones. A synonym for "stretched out" is <u>expanded</u>, so we call eight hundreds + two tens + four ones an e_____ numeric symbol.
sevens, ones	72. In base seven the 3 in the 35 has a face value of three and a place value of sevens. It symbolizes three sevens. The 5 has a _____ _____ of five and a place value of _____. It symbolizes _____ ones.
nine	72. In other words the numerals you see tell how many times each place value is to be used. Each place is used as many times as the f_____ value of the numeral indicates.

standardized	73. The earliest unit to be standardized was the yard. This was done at the time of King Henry I. This means that the earliest standardized length was set up by a (British, Chinese, Egyptian) king and measured exactly (24 inches, 30 inches, 36 inches) in length.
expanded	73. 824 = 8x100 + 2x10 + 4x1 824 = 800 + 20 + 4 Since hundreds is the place value of the numeral 8, we are showing that each numeral's total value is found by multiplying the face value of the numeral by its _____ _____.
face value, ones, five	73. In base seven the numeral 1 in the numeric symbol 134 has a face value of one and a place value of forty-nines. In the base seven system the 2 in 216 has a face value of _____ and a _____ _____ of forty-nines. So the numeral 2 symbolizes two forty-nines.
face	73. In the numeric symbol 342 the 2 means two _____, the 4 means four bases, and the 3 means three base squares.

British, 36 inches	74. The first actual standard yard was set up in the thirteenth century. This yardstick was made of iron, which was the strongest and toughest material of that time. An iron yardstick would (<u>last a long time, not break very easily, both of these, none of these</u>).
place value	74. An expanded numeric symbol shows that each symbol or _____ will be multiplied by its place value.
two, place value	74. The numeral 1 in the numeric symbol 216 (in base seven) means this numeric symbol has one group of _____.
ones	74. In the numeric symbol 645 in base seven the numeral 4 means that we have four sevens or that the sevens' place is to be used _____ times.

both of these	75. The earliest standardized measurement of length was the _____.
numeral	75. Ordinarily, when you see a numeric symbol such as 35, you read it as "thirty-five," and you mean three _____ and five _____.
sevens	75. The numeral 6 in the numeric symbol 216 has a place value of _____ and a _____ _____ of six.
four	75. The numerals in the numeric symbol 2,222 (base three) tell us that we have two ones, two threes, two nines, and two twenty-sevens, or that each place is to be used _____ times.

yard	76. Since the time of King Edward I in the thirteenth century, there have been many standardized yard bars in Great Britain. Some were lost and some destroyed by fire. The yard measurement that is standard in Great Britain today was completed in 1855. This means that the (British, French, Russian) measurement of (weight, time, length) is a little over (5,000 years, 200 years, 100 years) old.
tens, ones	76. The 3 in 35 has a face value of three and a place value of tens. So it symbolizes three tens or thirty. The 5 has a face _____ of five and a place value of _____, so it symbolizes _____ ones or five. The value of the two numerals combined is then thirty-five.
ones, face value	76. Each numeral has a face value and a _____ _____. In the base seven number system each place has _____ times the value of the column to its right.
two	76. The numeric symbol 412 in base five can be "stretched out" to show the place values of each numeral: four twenty-fives + one five + two ones. A synonym for "stretched out" is expanded, so we call four twenty-fives + one five + two ones an e_____ numeric symbol.

British, length, 100 years	77. Suppose there was a unit of length used today that was called a "glub." If the "glub" were legally defined as 1/2 yard, and the yard measured 36 inches, the glub would be _____ inches long.
value, ones, five	77. The numeral 1 in the numeric symbol 193 has a face value of one and a place value of hundreds. The 2 in 216 has a face value of _____ and a _____ _____ of hundreds. So the numeral 2 symbolizes two hundreds or two hundred.
place value, seven	77. In base seven the 4 in the numeral 4 means four _____.
expanded	77. In base seven $624 = 6x49 + 2x7 + 4x1$ $624 = 294 + 14 + 4$ Since forty-nine is the <u>place value</u> of the numeral 6, we are showing that each numeral's total value is found by multiplying the face value of the <u>numeral</u> by its _____ _____.

18	78. Two measurements of length that are used today in the United States that depend on the yard are the foot and inch. Everyone in the United States agrees that the foot is 1/3 of a yard because (<u>your foot is 1/3 the length of your arm, somebody in authority defined it that way, both, neither</u>).
two, place value	78. The numeral 1 in the numeric symbol 216 means this numeric symbol has one group of _____.
ones	78. In base seven the 4 in the numeric symbol 40 means four _____.
place value	78. An expanded numeric symbol shows that each symbol or _____ will be multiplied by its place value.

someone in authority defined it that way

79. Great Britain and the United States use measurements depending on the yard. Most of the rest of the world uses the system of measurement depending on the length of one "meter." This system is called "metric." The metric system (<u>would, would not</u>) be used in France today.

---

tens

79. The numeral 6 in the numeric symbol 216 has a place value of _____ and a _____ _____ of six.

---

sevens

79. In base seven the 4 in the numeric symbol 400 means four _____.

---

numeral

79.

B^3	B^2	B^1	B^0
X,	X	X	X

In the above diagram if you see the numeral 2 in the right column you know it means two ones. If you see 20 you know that the 2 means two bases. For example, if we were working with base nine the 2 in 20 would mean two nines. If we were working with base three the 2 in the numeric symbol 20 would mean two _____. In base ten the 2 in 20 means two _____.

would	80. Today both the meter and the yard are standardized measurements in different countries. This means that they (<u>were adopted by the governments of the countries, are fixed in length, both, neither</u>).
ones, face value	80. Each numeral has a face value and a _____ _____. In the base ten system each place has _____ times the value of the column to the right.
forty-nines	80. You can see that the 4 in 4,000 is seven times the 4 in 400. Since 400 means four forty-nines we can say the 4,000 means four _____.
threes, tens	80. If we were working with base five the 3 in 300 means three base squares or three twenty-fives. When working with <u>base three</u> the 2 in the numeric symbol 200 means two base squares or two _____.

both	81. The standardized meter is 39.37 inches long. This means that the meter is closest in length to which of the following measures? (<u>foot, inch, mile, yard</u>)
place value, ten	81. The 9 in the numeral 9 means nine _____.
three hundred forty-threes	81. In base seven the numeral 4 in 1,542 tells how many _____ you have.
nines	81. Notice that each column of numerals has a number of the base times the value of the column on the right. For example, you know that in base ten each column of numerals has ten times the value of the column on the right. So in base ten the column where the numeral 7 is in the numeric symbol 73 has _____ times the value of the column where the 3 is.

yard	82. A measure of length that is used at sea is the (cubit, fathom, both, neither).
ones	82. The 9 in the numeric symbol 90 means nine _____.
sevens	82. In base seven the numeral 3 in 4,361 represents three _____.
ten	82. Using the same numeric symbol (73) and working with base nine the column where the 7 is has _____ times the value of the column where the 3 is.

fathom	83. About 100 years ago the United States received a copy of the standardized yard from Great Britain and the standardized meter from France. The standardized yard is slightly (larger, smaller) than the standardized meter.
tens	83. The 9 in the numeric symbol 900 means nine _____.
forty-nines	83. The numeral 2 in 325 in base seven shows that the sevens' place is to be used _____ times.
nine	83. When you are working in base five and you see the numeric symbol 34 you know it means four ones and three fives. The 3 in 34 has a face value of three and a place value of five. So it symbolizes three fives. The 4 has a _____ of four and a place value of _____. So it symbolizes _____ ones. The value of the two numerals combined is then three fives plus four ones.

smaller	84. The United States received a copy of the standardized yard from _____ and the standardized meter from _____.
hundreds	84. You can see that the 9 in 9,000 is ten times the 9 in 900. Since 900 means nine hundreds, we can say that 9,000 means nine _____.
two	84. Write the numeric symbol in the base seven system with six sevens and three ones. _____
face value, one, four	84. In each numeration system every numeral has face value and _____ _____. Each place has the number of the base times the value of the column to the _____.

Great Britain, France	85. The United States received the standard yard bar from England and the standard French meter from France about _____ years ago.
thousands	85. The numeral 4 in 1,432 tells how many _____ we have.
63	85. In base seven a seven is indicated by the numeric symbol _____.
place value, right	85. In base eight the 6 in the numeral 6 means six _____ (notice the 6 is in the first column to the right).

100	86. In 1866 Congress legalized the metric system as the standard measurement for the United States. But for everyday use, this country still prefers to use the system of measurements based on the English (mile, yard, gallon).
hundreds	86. The numeral 3 in 3,471 represents three _____.
10	86. Write the numeric symbol in base seven with five forty-nines, three sevens and six ones. _____
ones	86. In base eight the 6 in the numeric symbol 60 means six _____.

yard	87. List any three nonstandardized measurements used in the past that depended upon measurements of the length of various parts of the human body. _____, _____, _____
thousands	87. The numeral 9 in 897 shows that the tens' place is to be used _____ times.
536	87. A symbol or _____ is a way of expressing a number.
eights	87. In base five the 4 in the numeric symbol 400 means four bases squared or four _____.

fathom, yard, digit, hand, span, cubit, or rod (any three)	88. Two of the following have become standardized measurements of length. Which two are they? _____, _____ digit span yard fathom meter rod
nine	88. A symbol or _____ is a way of expressing a number.
numeral	88. You have learned that _____ tell how many things or ideas are in a group.
twenty-fives	88. In base two you can see that the 1 in 1,000 is two times the 1 in 100. Since 100 means one four, we can say that 1,000 means one _____.

yard, meter

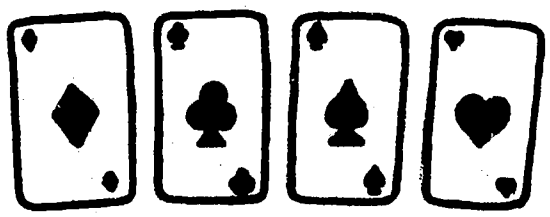
89. Although there is only one standardized yard bar in the United States, many copies of this are available throughout the country. A man in the state of Washington who wanted to measure a yard of cloth (would, would not) have to go to Washington, D. C. to do this measuring.

numeral

89. You have learned that _____ tell how many things or ideas are in a group.

numbers

89. The number in the group below is indicated by the numeral _____.



eight

89. In base seven the numeral 4 in 1,432 tells how many _____ you have.

Base Seven

forty-nines
sevens
X X X ones

would not	90. Although the yard is <u>not</u> a unit of the metric system, it <u>is</u> defined in terms of a metric unit. One yard = .9144 meters. In other words, the yard is defined to be (<u>about one-half a meter, about nine times a meter, both, neither</u>).
numbers	90. A number may be represented by (<u>one, many</u>) symbol(s).
4	90. A number may be represented by (<u>one, many</u>) symbol(s).
forty-nines	90. In base three the numeral 2 in 2,110 represents two _____. <u>Base Three</u> X, X X X twenty-sevens nines threes ones

neither	91. For about 100 years, the standard length for a meter was the length between two marks on a platinum and iridium bar. Very recently, the new definition of a meter has been set as 1,650,763.73 times the wave length of orange light from a certain <u>element</u>. Scientists are using this measurement because it is (<u>more, less</u>) accurate than the measurement previously used.
many	91. In forming numbers with our number system we combine number ideas or values in groups of _____.
many	91. In forming numbers in the base seven system we combine number ideas or values in groups of _____.
twenty-sevens	91. The numeral 2 in 325 in base seven shows that the sevens' place is to be used _____ times.

more	92. The new standard measurement for a meter depends on the wave length of orange light emitted by a certain _____.
ten	92. Each place in our number system has a value. Ones, tens, hundreds, thousands, ten-thousands, and so on are the place values of our number system which is the base _____ number system.
seven	92. The place values ones, sevens, forty-nines, three hundred forty-threes, and so on are the place values of the base _____ number system.
two	92. You have learned that a symbol or _____ is a way of expressing a number.

element (chemical)	93. The units of length most commonly used in the United States such as the _____ (name any one) are legally defined in terms of units in the (cubic, metric, trick) system.
ten	93. As we move left from column to column, the place values get (lower, higher).
seven	93. Number ideas are always grouped according to the number of the _____ in which we are working.
numeral	93. A _____ tells how many things or ideas are in a group.

yard, (or inch or foot) metric	94. The _____ system is the legal system of measurement of length in the United States today.
higher	94. The _____ _____ and the _____ _____ of a numeral determine the value of the numeral.
base	94. As we move left from column to column, the place values get (<u>lower, higher</u>).
number	94. A number may be represented by (<u>one, many</u>) symbol(s).

metric	
face value, place value (either order)	
higher	95. The _____ _____ and the _____ _____ of a numeral determine the value of the numeral.
many	95. In forming numbers we combine number ideas or values into groups. The standard number of ideas that are represented in a basic group is called the _____ in which we are working.

face value, place value (any order)	
base	96. Besides keeping in mind the base in which you are working the _____ _____ and the _____ _____ of a numeral determines the value of the numeral.

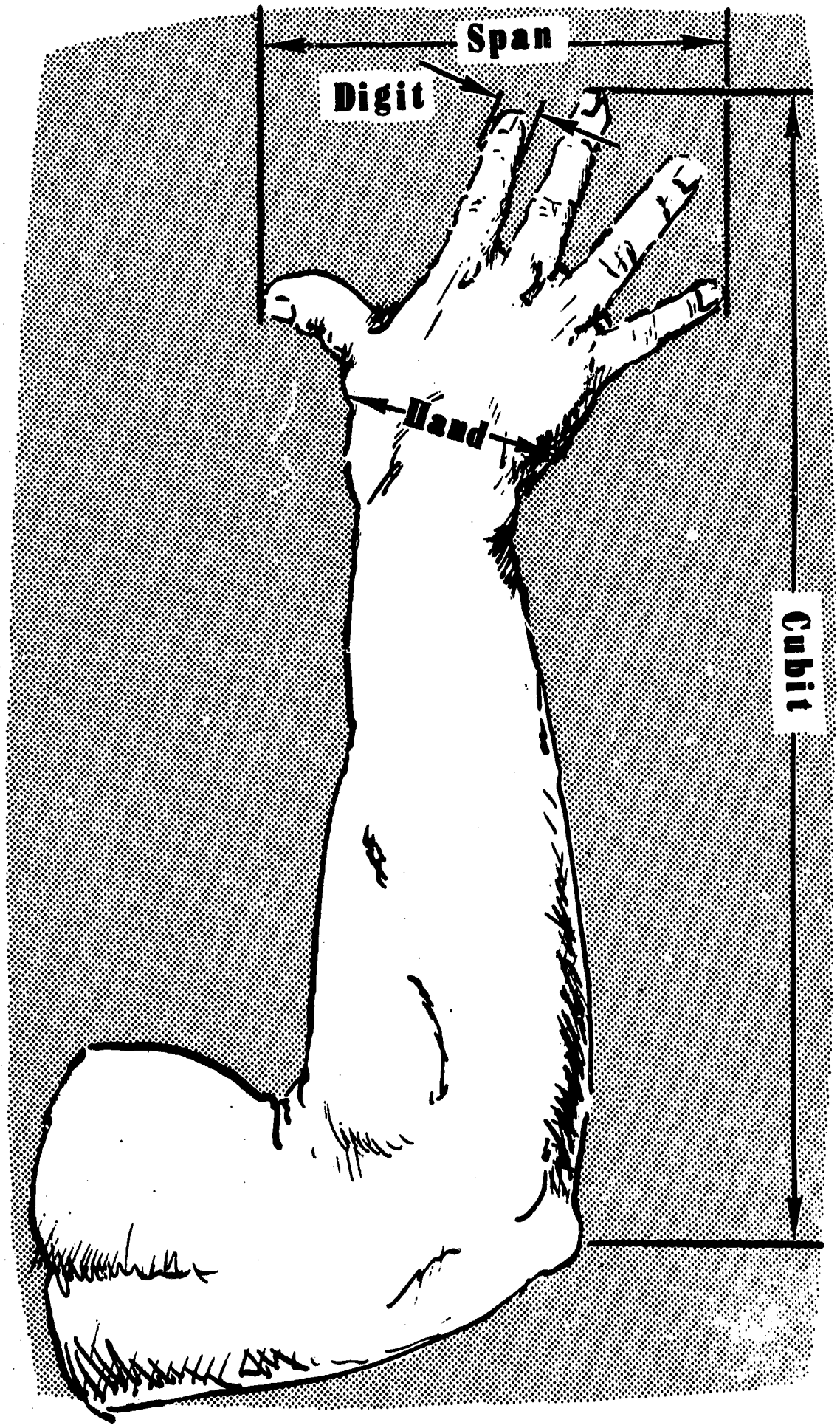
place value,

face value

(any order)

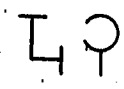
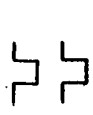
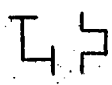
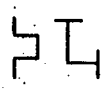
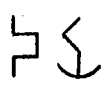
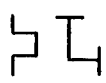
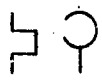
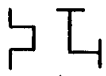
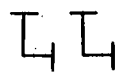
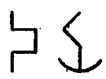
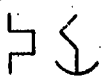
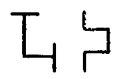
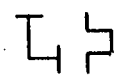
Appendix E. History of Measurement Program Supplementary Sheet 1

SUPPLEMENTARY SHEET 1



Appendix F. Differentially Sequenced Learning Tasks

Differentially Sequenced Learning Tasks

Sequenced		Partially Sequenced		Randomly Sequenced	
Number	Symbol	Number	Symbol	Number	Symbol
ZERO		ZERO		SEVEN	
ONE		ONE		TWO	
TWO		TWO		TWELVE	
THREE		THREE		ONE	
FOUR		FOUR		TEN	
FIVE		TEN		FOUR	
SIX		NINE		ELEVEN	
SEVEN		TWELVE		NINE	
EIGHT		SEVEN		THREE	
NINE		FIVE		FIVE	
TEN		ELEVEN		ZERO	
ELEVEN		EIGHT		SIX	
TWELVE		SIX		EIGHT	

Appendix G. Posttest

Posttest Name_____

Directions: This is a test on the material which you have just learned. For each of the following numbers write the appropriate symbol of the number in the blank space. Some of the numbers will be unfamiliar, but try your best to answer them.

Number	Symbol
1. ELEVEN	_____
2. ONE	_____
3. THIRTEEN	_____
4. SIXTEEN	_____
5. SIXTY-FOUR	_____
6. EIGHTEEN	_____
7. TWENTY	_____
8. ZERO	_____
9. THIRTY	_____
10. SIX	_____
11. TWENTY-FIVE	_____
12. FIFTEEN	_____
13. EIGHT	_____
14. THIRTY-THREE	_____

Appendix H. Instructions for Administration of Materials

Instructions for Administration of Materials

Programed Booklet. Give subject introductory programed booklet which has been randomly assigned to him. Make sure his name, "Starting Time," and "Finishing Time" are written on the cover of the booklet. Proceed by saying: YOU WILL PERFORM SEVERAL TASKS IN THIS SESSION. FIRST, YOU WILL WORK THIS PROGRAMED BOOKLET. NO DOUBT YOU ARE QUITE FAMILIAR WITH THIS TYPE OF LEARNING PROCEDURE, BECAUSE IT IS SIMILAR IN FORMAT TO THE MATERIAL THAT YOU STUDIED IN THE ALP PROJECT. ON EACH PAGE YOU WILL COMPLETE A STATEMENT BY WRITING THE APPROPRIATE RESPONSE OR BY CHOOSING BETWEEN TWO ALTERNATIVES. Demonstrate the first two frames. AFTER WRITING YOUR ANSWER, TURN THE PAGE; ON THE LEFT SIDE OF THE PAGE TO WHICH YOU TURNED YOU WILL FIND THE CORRECT RESPONSE TO THE PRECEDING STATEMENT. IF YOUR ANSWER IS CORRECT, GO ON TO THE NEXT STATEMENT. IF, HOWEVER, YOUR ANSWER IS NOT CORRECT, MARK AN "X" BY YOUR INCORRECT ANSWER AND REVIEW THE FRAME THAT YOU MISSED. GO ON TO THE NEXT PAGE, ONLY AFTER YOU FULLY UNDERSTAND THE STATEMENT WHICH YOU MISSED. THIS IS NOT A TEST, BUT A LEARNING DEVICE, AND YOUR MARKING AN "X" BY AN INCORRECT RESPONSE WILL HELP US DETERMINE WHERE THE PROGRAM IS NOT TEACHING EFFECTIVELY. ALTHOUGH THERE IS NO TIME LIMIT, WE WOULD LIKE TO KNOW HOW MUCH TIME YOU SPEND WORKING THE PROGRAM. THEREFORE, PLEASE WRITE YOUR STARTING TIME AND FINISHING TIME ON THE COVER OF THE PROGRAM. FIRST, READ THE INSTRUCTIONS IN THE BOOK, THEN GO AHEAD. When the subject has completed the program, record on the Subject Record Sheet the number of errors he made and the total time it took him to complete the program.

Prelearning Task. IN THIS PART OF THE EXPERIMENT YOU ARE GOING TO LEARN TO ASSOCIATE FOUR BASIC SYMBOLS WITH SOME NUMBERS. I WILL PRESENT TO YOU A WRITTEN NUMBER ON A THREE BY FIVE CARD. YOU ARE TO WRITE THE APPROPRIATE SYMBOL FOR THIS NUMBER ON THIS RESPONSE PAD. AFTER YOU HAVE RESPONDED, I WILL SHOW YOU THE CORRECT SYMBOL FOR THE WRITTEN NUMBER. WHEN YOU HAVE RESPONDED CORRECTLY TO TWO TRIALS ON THE FOUR SYMBOLS YOU WILL PROCEED TO THE LEARNING TASK. I WILL TELL YOU WHEN YOU HAVE GONE THROUGH ONE TRIAL CORRECTLY. In presenting the cards to the subject, hold the four symbol cards together so that the person cannot see the symbol through the card. Prior to each trial, shuffle the cards so that the four symbols are presented randomly. After each trial, remove the sheet on which the subject's responses were written. It is permissible for the subject to practice writing the symbol after he has received feedback regarding the correctness of his response. Keep a tally of the subject's performance for each trial on the Subject Record Sheet.

Learning Task. Select appropriate learning task material which has been assigned and is indicated on the record sheet. Write subject's name on the beginning of the response tape. IN THIS PART OF THE EXPERIMENT YOU ARE GOING TO LEARN TO ASSOCIATE SYMBOLS WITH NUMBERS. THE PRESENTATION OF THE MATERIAL THAT YOU WILL LEARN WILL BE DONE BY THIS MACHINE. YOU WILL SEE A NUMBER ON THE LEFT (show subject), AND A BLANK SPACE ON THE RIGHT (show subject). THE BLANK SPACE INDICATES THAT YOU SHOULD MAKE A RESPONSE HERE. Indicate to subject where the response is to be made. THERE IS NO PENALTY FOR GUESSING. YOU WILL THEN SEE THE SAME NUMBER AGAIN, BUT THIS TIME THE APPROPRIATE SYMBOL

WILL APPEAR IN THE RIGHT HAND SPACE (indicate to subject). THIS PROCEDURE ENABLES YOU TO SEE WHETHER YOU MADE THE CORRECT RESPONSE. REMEMBER, YOU WILL FIRST SEE A NUMBER TO WHICH YOU ARE TO WRITE THE APPROPRIATE SYMBOL; THEN YOU WILL SEE THE NUMBER AGAIN WITH THE APPROPRIATE SYMBOL TO ITS RIGHT. THE RATE OF PRESENTATION WILL BE CONSTANT. IF YOU WORK RIGHT ALONG, THERE WILL BE ENOUGH TIME FOR YOU TO MAKE YOUR RESPONSE AND TO CHECK IT. ARE THERE ANY QUESTIONS?

Proceed with the first set of the first trial. THIS IS THE FIRST NUMBER TO WHICH YOU WILL WRITE A RESPONSE. WRITE THE APPROPRIATE SYMBOL. THIS IS THE NUMBER AND THE CORRECT SYMBOL. This demonstration of the first set of the first trial is untimed. Proceed similarly for the second word and symbol and begin a constant rate of presentation. Turn to the word frame when the red light blinks, after nine seconds, when the blue light blinks, turn to the word-symbol frame for six seconds and then back through the cycle.

After the first trial (presentation of 13 sets of word symbols) say to the subject: WE HAVE GONE THROUGH ONE TRIAL. WHEN YOU HAVE GONE THROUGH TWO TRIALS SIMILAR TO THE ONE WHICH WE JUST COMPLETED WITHOUT MAKING ANY ERRORS, YOU WILL HAVE COMPLETED THIS PHASE OF THE STUDY. I WILL TELL YOU WHEN YOU HAVE GONE THROUGH ONE TRIAL CORRECTLY. ARE THERE ANY QUESTIONS? Proceed with timed second trial. After each trial draw a line across the response tape to separate trials. Keep a record of the incorrect responses for each trial. Record this information on the Subject Record Form. If the subject does not appear to be associating the symbols and the numbers, or if he is not responding, say: ASSOCIATE A SYMBOL WITH THE NUMBER AND MAKE YOUR RESPONSE

HERE (indicate), or INDICATE THE APPROPRIATE SYMBOL FOR THE NUMBER. YOU MAY GUESS. After the first successful trial, YOU HAVE JUST COMPLETED A TRIAL PERFECTLY. NOW WE WILL SEE IF YOU CAN DO IT AGAIN. After the second perfect repetition, give the untimed posttest. Record the posttest task, transfer, and total scores on the Subject Record Sheet.

Post Experiment Procedure. Thank the subject for this participation, and tell him that within the next six months he will receive a summary of the findings of the study. Pay the subject. Inform the subject that he is not to tell any specific information about the experiment to other participants. Because of the many different conditions in the study, specific information may inhibit performance as well as facilitate it.

Appendix I. Intercorrelation Matrix of Selected Variables

Intercorrelation Matrix of Selected Variables

(N = 96)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Information	---																											
2	Comprehension	40	---																										
3	Arithmetic	54	48	---																									
4	Similarities	53	52	37	---																								
5	Digit Span	24	22	40	18	---																							
6	Vocabulary	72	64	47	62	28	---																						
7	Digit Symbol	15	05	20	05	29	11	---																					
8	Picture Completion	40	32	33	39	31	35	37	---																				
9	Block Design	33	32	32	26	21	25	22	37	---																			
10	Picture Arrangement	17	26	15	23	23	25	11	28	28	---																		
11	Object Assembly	16	29	13	16	21	24	01	18	32	24	---																	
12	Verbal Scaled Score	74	74	74	71	54	81	22	47	40	30	29	---																
13	Performance Scaled Score	38	39	36	34	40	38	55	68	70	62	59	54	---															
14	Full Scaled Score	67	66	65	62	54	71	42	64	61	50	47	90	84	---														
15	Verbal IQ	75	73	73	72	52	83	20	45	38	29	27	99	50	88	---													
16	Performance IQ	44	46	39	41	35	52	47	62	62	54	54	59	89	82	60	---												
17	Full Scale IQ	69	67	65	64	49	77	36	59	55	46	44	90	76	96	91	87	---											
18	QWT Score	58	55	35	59	24	85	14	41	20	32	24	70	41	65	71	55	71	---										
19	Age	13	16	07	15	-13	30	-19	-07	-16	-14	-06	12	-20	-02	20	23	23	33	---									
20	Education Level	32	14	16	23	09	26	10	16	10	14	-03	27	15	24	28	19	26	26	14	---								
21	Number Base Pretest	11	29	24	24	13	19	-04	06	07	25	11	24	15	21	23	13	20	18	00	15	---							
22	Intro. Material Time	-34	-21	-22	-12	-24	-30	-30	-24	-34	-18	-14	-31	-39	-40	-29	-32	-34	-26	21	-28	-16	---						
23	Intro. Material Errors	-35	-26	-28	-17	-21	-30	-28	-29	-34	-20	-09	-35	-38	-41	-32	-28	-34	-19	22	-31	-14	52	---					
24	Posttest Task Score	28	0[illegible]	30	-02	22	17	06	04	30	24	18	24	26	29	21	16	21	11	-24	10	06	-18	-29	---				
25	Posttest Transfer Score	29	20	43	22	28	24	-02	19	35	08	09	38	21	35	37	19	33	16	-04	16	22	-22	-21	22	---			
26	Posttest Total Score	34	20	47	19	32	26	-01	18	40	14	13	41	27	40	39	22	35	18	-10	17	22	-25	-27	48	96	---		
27	Trials to Criterion	-35	-22	-45	-22	-39	-23	-33	-36	-45	-18	-19	-41	-48	-50	-39	-42	-45	-17	13	-18	-20	25	36	-29	-50	-54	---	
28	Errors to Criterion	-34	-21	-44	-21	-39	-20	-34	-32	-46	-13	-20	-40	-47	-49	-38	-40	-43	-12	14	-14	-15	26	36	-32	-49	-53	97	---

Note.-- Decimal points omitted. Pearson r of .20 and .26 significant at .05 level and .01 level, respectively.