THE EFFECTS OF AN ADVANCE ORGANIZER ON STUDENTS DIFFERING IN PREREQUISITE SKILLS AND KNOWLEDGE

By

GEORGE ROBERT MOORE II

Bachelor of Science in Education
Southwestern Oklahoma State University
Weatherford, Oklahoma
1964

Master of Teaching
Southwestern Oklahoma State University
Weatherford, Oklahoma
1966

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of the Oklahoma State University
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CHAPTER I

A GENERAL STATEMENT OF THE PROBLEM

Introduction

Of the many variables that influence learning in science, the learner's relevant background knowledge is one of the most important. Thus, it is not surprising that science educators have shown considerable interest in Ausubel's proposal that the learner's prior knowledge plays an organizing or subsuming role in facilitating meaningful learning (Ausubel, 1968). A primary tenet of Ausubel's theory is that an individual's existing cognitive structure is a key variable in determining what new information will be learned and what meaning will be established for it. In order for new ideas and information to be meaningful, the learner must possess knowledge structures to which new knowledge can be related in a nonarbitrary, nonverbatim manner. Ausubel (1960) calls these knowledge structures subsumers.

Ausubel (1960) originally tested his subsumption theory by the prediction that deliberately introducing relevant and appropriately inclusive subsuming concepts into cognitive structure would provide a "helpful ideational structure" and so enhance learning and retention. Such subsumers are defined as advance organizers.

Ausubel's model (Ausubel, 1968; Ausubel, Novak and Hanesian, 1978) thus proposes that meaningful learning can occur by two processess:

1. the use of relevant and irrelevant subsumers in the

prior knowledge,

2. the use of advance organizer subsumers.

Previous research has shown that learning may be enhanced by the use of appropriate advance organizers (Ausubel, 1960; Ausubel and Fitzgerald, 1961, 1962; Ausubel, Stager and Gaite, 1968; Allen, 1970). Most of the empirical studies of Ausubel's theory have concentrated on advance organizers. Such studies can be readily misinterpreted if it is assumed that the only process of meaningful learning is the use of advance organizers. In the idealized situation, the learner who does not possess any relevant prior knowledge to use as a subsumer must use the advance organizer to learn meaningfully. Under these circumstances the failure of an advance organizer to show any advantage over a control could be considered as evidence against advance organizers. But when is such an ideal situation ever realized? In the real situation what is to prevent a learner from using relevant and irrelevant prior knowledge subsumers and completely ignoring the advance organizer? With regard to this some studies indicate that only those with relatively low verbal ability or a low level of related knowledge are aided by the presence of advance organizers. Other learners, it is speculated, are capable of providing their own subsuming structure while undertaking the learning task (Ausubel, 1960; Ausubel and Fitzgerald, 1961, 1962). However, the literature related to this problem is unclear.

The purpose of this study was to determine the following: For three groups of students differing in prerequisite skills and knowledge, each given an advance organizer, will the group with high prerequisite skills and knowledge benefit from the advance organizer, or will the group with middle prerequisite skills and knowledge benefit from the

advance organizer, or will the group with low prerequisite skills and knowledge benefit from the advance organizer. If prior knowledge of the learner plays a subsuming role as Ausubel (1968) suggests, then the writer can predict that learners who are deficient in relevant prior knowledge should benefit from an advance organizer while those whose relevant prior knowledge is high would not.

Justification of the Study

Much educational research has had little or no impact on applied human learning or the solving of educational problems (Ausubel, 1963). More research needs to be done that can go beyond the laboratory situation and have a direct influence on the structure of learning situations (Anderson, 1966, 1969). In many cases teachers, and the learning materials they have to use, promote meaningful verbal learning as rote in character and use predominantly rote procedures. The proper application of the subsumption theory could change much of this (Ausubel, 1962). Using the model proposed of Ausubel's theory, one can hypothesize that if the learner does not possess relevant or irrelevant subsumers of prior knowledge, then the learner must use the advance organizer to learn meaningfully. Research related to advance organizers, however, has revealed conflicting results on their facilitative effects (Schulz, 1966; Barron, 1971; Lucas, 1972; Clawson and Barnes, 1972). The failure of an advance organizer treatment to show a significant advantage over a control treatment may result, not because advance organizers do not assist learning, but because most of the learners possessed sufficient prior knowledge subsumers for meaningful learning of the particular tasks involved (West and Fensham, 1974).

In trying to assess prior knowledge, some researchers have used pretests. However, these usually have measured prior knowledge of the concepts to be learned, not of subsumers that could be used in the process of learning. By definition the prior knowledge subsumers will never be the same as the concepts to be learned. So such pretests give no indication of the possibility of a learner using prior knowledge subsumers as an alternative to advance organizers (Ausubel, 1968; West and Fensham, 1974).

A recent study by West and Fensham (1976) yielded supportive evidence of Ausubel's theory concerning the subsuming role of advance organizers and the role played by the learner's prior knowledge structure in meaningful learning. This research, three different studies, involved eleventh and twelfth-grade chemistry students in Australia. In study one eleventh-grade students were given a prior knowledge pretest then immediately assigned randomly to the advance organizer treatment. In study two eleventh-grade students were given the pretest then all the students received remedial teaching of the necessary prior knowledge. Then the students were assigned randomly to the advance organizer treatment. Study three was a repeat of study one using twelfth-grade students. After classroom instruction lasting several days, the students were given a performance test.

The prediction for studies one and three was that the role played by an advance organizer was equivalent to the role played by prior knowledge. This prediction was confirmed. In study two the prediction stated that if Ausubel's theory was true, then remedial teaching of relevant prior knowledge would tend to remove the facilitating effect of the advance organizer. This prediction was also confirmed.

There is no supporting evidence that the materials called advance organizers being used in the studies are advance organizers. Futhermore, the students were not grouped according to their prior knowledge scores then randomly assigned to the advance organizer treatment, but rather they were randomly assigned to the treatment regardless of the pretest scores. At the end of the studies, students' results, for statistical treatment, were grouped into five cells. Therefore, there is no significant difference in prior knowledge between students with high and low scores in prior knowledge.

However, because of the theoretical promise of West and Fensham's first study, the writer followed up the premise of this study at different grade levels.

Limitations of the Study

This study investigated the specific application of a general principle that may be a valuable implement used to enhance learning. There was no attempt to investigate the motivational or methodological aspects of associated learning experiences. With respect to external validity, the enclosed nature of the classrooms from which the experimental and control subjects were drawn will not permit the study to be generalized beyond those classrooms.

Terms Defined

1. Cognitive Structure. Cognitive structure is the organization, clarity, and stability of one's knowledge (Ausubel, 1963).
2. Cognitive Subsumption. Cognitive subsumption refers to

the anchoring of new information to more inclusive concepts previously established in cognitive structure (Ausubel, 1963).

3. Meaningful Learning. Meaningful learning may be directly contrasted with rote learning. Rotely learned information is isolated from cognitive structure and easily forgotten as it becomes confused with other similarly learned information. Meaningfully processed information is subsumed under related general concepts and more resistant to forgetting because it becomes a part of concepts that are a part of existing cognitive structure (Ausubel, 1963).

4. Subsumer. A subsumer is any vehicle or procedure that allows new learning material to be more easily and more meaningfully incorporated into an individual's existing cognitive structure.

5. Advance Organizer. An advance organizer is an introductory experience that is more general, more abstract, and more inclusive than the principal learning material and administered just prior to it.

6. Non Organizer. The non organizer refers to an introductory experience designed as a control for testing the advance organizer.

7. High Prerequisite Skills and Knowledge Students. High prerequisite skills and knowledge students are those students that score in upper one-fourth on the prerequisite skills and knowledge test. There will be a

significant difference in the test scores as measured by a t-test between these students and those defined as low prerequisite skills and knowledge students.

8. Low Prerequisite Skills and Knowledge Students. Low prerequisite skills and knowledge students are those students that score in lower one-fourth on the prerequisite skills and knowledge test. There will be a significant difference in the test scores as measured by a t-test between these students and those defined as high prerequisite skills and knowledge students.

9. Middle Prerequisite Skills and Knowledge Students. Middle prerequisite skills and knowledge students are those students that score in middle one-half on the prerequisite skills and knowledge test.

10. Prior Knowledge. Prior knowledge is the prerequisite skills and knowledge necessary to learn a new unfamiliar concept. These subsumers will never be the same as the concepts to be learned.

CHAPTER II

SELECTED REVIEW OF THE LITERATURE

Previous Research

Initial recognition of Ausubel's work with advance organizers came from a study designed to determine if retention of unfamiliar material could be facilitated by the use of advance organizers (Ausubel, 1960). The subjects were undergraduate students enrolled in an educational psychology course. The principal learning material was a 2500 word passage on the metallurgical properties of carbon steel. The unfamiliarity criterion was proven empirically by testing a group of students comparable to the experimental group. Their scores on the retention test, taken without exposure to the learning materials, did not vary significantly from chance. Prior to the study, two groups were equated on ability to learn from an unfamiliar scientific passage. The two groups in the study were each given 500 word introductory passages two days before and immediately before being given the principal learning passage. The control group received an historical introduction similar to that frequently found at the beginning of each chapter in many science texts. It included no conceptual details; only historical information such as the evolution of iron and steel processing was included. Introductory material was necessary for the control group in order to ascertain that any benefits realized by the experimental group could not be attributed to the mere presence of the introductory material. The experimental

group received an introductory passage carefully constructed at a high level of abstraction, generality, and inclusiveness and designed to promote the formation of a structure around which relevant concepts about the steelmaking process could be formed. Care was taken so that neither introduction could allow a direct advantage to answers on test questions. This quality was empirically demonstrated by determining that a group comparable to the experimental goup did not score significantly better than chance after exposure to the introductory material alone.

Statistical analysis of the test score means of the two groups revealed that the experimental group performed significantly better than the control group at a level of confidence between .01 and .05.

Ausubel (1960, 1968) suggests that two factors contributed to the apparent success of the advance organizer at facilitating meaningful learning. First, those concepts already existing in cognitive structure capable of providing a focus for the subsumption of new material were "mobilized." Second, carefully chosen new and relevant subsuming concepts allowed "optimal anchorage" for the internalization of new material. Ausubel (1968) concludes

> . . . that the greater use of appropriate (substantive rather than historical) advance organizers in the teaching of meaningful verbal material could lead to more effective retention. This procedure would also render unnecessary much of the rote memorization to which students resort because they are required to learn the details of a discipline before having available a sufficient number of key subsuming concepts (p. 174).

In a follow-up study, Ausubel and Fitzgerald (1961) hypothesized that the learning and retention of unfamiliar material could be enhanced by the use of a comparative organizer. This type of organizer would relate precisely to differences and similarities existing between the new material and concepts already existing in cognitive structure. As

differentiable properties are contrasted and compared, the established concept serves as a focus for the subsumption of related ideational material.

The most revealing aspect of this experiment, however, is that all of the difference was found within those who scored below the median on the Christianity test. Ausubellian theory would suggest several possible reasons for this occurrence. It is possible that those with a strong conceptual background in Christianity were able to provide their own cognitive subsumers concurrently without the aid of an advance organizer. The data supports this since in each organizer group those with Christianity scores above the median scored higher on the post-test but were not significantly different across treatment groups. Perhaps their superior knowledge of Christianity provided a basis for discriminability regardless of the introduction used. It is also possible that advance organizers realize more effectiveness when no strong conceptual background previously exists in cognitive structure. As the experimenters explained (1961):

> . . . in the learning and retention of unfamiliar ideational material that is relatable to established concepts in the learner's cognitive structure, both comparative and expository organizers appear to be effective only in those instances where existing discriminability between the two sets of ideas is inadequate as a consequence of the instability or ambiguity of established concepts (p. 274).

Investigation by Anderson (1967), however, would lend credence to the expectation that students at the lower level of knowledge would benefit most from the utilization of a well structured subsuming organizer. He has shown that highly structured programmed lessons facilitate learning more so than programmed lessons with a low degree of structure. Subjects with higher IQ scores appear to suffer less from a reduction of

structure, however. Perhaps they are more capable of the mental amendment of such materials with internal structure of their own. If an advance organizer can be seen as promoting structure, its benefits should be realized most by those unable to provide their own--those with less pertinent or discriminable knowledge, for example.

Additional research has further added to this controversy. Grotelueschen and Sjogren (1968) performed experiments to determine the effects of varying the structure of introductory materials and varying the sequence of learning tasks. They hypothesized that the degree of structure possessed by introductory materials and the degree to which the principal learning materials are sequentially arranged are positively related to performance on a related retention test. Subjects were paid adults of "superior intelligence." The topics of the introductory and principal learning materials were over the general concepts of number base systems. Experimental results offered support for the assertion that subjects from this population could have the learning of number base concepts facilitated by introductory material.

> Because the facilitative effects of introductory materials were observed with adults of superior intelligence, it appears that the observed differences between the findings of previous research . . . and the present experiments suggest that the complexity of the learning topic is a variable to consider in ascertaining the extent to which introductory materials facilitate subsequent learning and transfer. Moreover, given a 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 task (Grotelueschen and Sjogren, 1968, p. 200).

Again there is evidence that different categories of subjects do not benefit equally from the same advance organizer.

> While both categories of students may use hierarchically structured concepts as subsumers for new learning the less able students may utilize more concrete, specific, and less generalizable organizers. This is a reasonable expectation

> since the organizers can only be usable if they relate directly to existing cognitive structure (Allen, 1970, p. 338).

Allen (1970) further speculates that students with different abilities may differ in the manner in which useful information is arranged in cognitive structure; and therefore, different qualities are required of potential advance organizers if facilitation is to be realized in each case.

Other research studies (Koran and Koran, 1973; Merrill and Stolurow, 1966; Newton and Hickey, 1965; Nordland and Kahle with Randak and Watt, 1975; Scandura and Wells, 1967) have obtained similar results. However, it has been found in some instances that the facilitating effect of purely expository organizers seems to be limited to learners who have low verbal (Ausubel and Fitzgerald, 1962) and low analytic (Mayer, 1978; Schulz, 1966) ability and hence presumably less ability to develop an adequate scheme of their own for organizing new material in relation to existing cognitive structure. It should be noted, however, that when the learning task is particularly difficult, organizers may differentially benefit high ability students (Grotelueschen and Sjogren, 1968) and those with more background knowledge (Ausubel and Fitzgerald, 1962) by making it possible for them to learn material that would in any case be beyond the capacity of less able and less sophisticated students.

The crucial element of an advance organizer is that it serves to link the new information to be learned with existing concepts in cognitive structure. Rarely have researchers taken into account the nature of the learner's cognitive structure and the potential meaningfulness of the new material to be learned. Thus the formulation of advance

organizers without first assessing what relevant concepts and information already exist in a learner's cognitive structure may be expected to provide little useful information. Such is indeed the case.

Studies (Graber, Means, and Johnsten, 1972; Lucas, 1972) using advance organizers with no attempt to assess the learner's existing cognitive structure have reported no significant differences between experimental and control groups, and among experimental groups receiving different forms of advance organizers. On the other hand, when such assessment was made (Talisayon, 1973) and when the resulting information was used in designing instructional material, relevant cognitive content in a learner's cognitive store was found to facilitate new learning in an increasing, nonlinear manner. The more the preexisting, relevant concepts present, the greater the facilitation effort. Relevant preexisting concepts were also found to prolong retention time as shown by posttests administered three to four months after instruction (Talisayon, 1973). The failure of an advance organizer treatment to show a significant advantage over a control treatment may result, not because advance organizers do not assist learning, but because most of the learners possessed sufficient prior knowledge subsumers for meaningful learning of the particular tasks involved (West and Fensham, 1974). Some experimenters have used pretests, but these usually measured prior knowledge of the concepts to be learned, not of subsumers that could be used in the process of learning. By definition the prior knowledge subsumers will never be the same as the concepts to be learned; therefore, such pretests give no indication of the possibility of a learner using prior knowledge subsumers as an alternative to advance organizers (Ausubel, 1968; West and Fensham, 1974). Toth (1975) investigated the

variables of critical thinking and of prior knowledge and their effects upon an advance organizer. He found that ninth-grade students high in prior knowledge also scored significantly higher on the criterion test. There was no significant difference in advance organizer/historical passage groups. In this research the prior knowledge test measured the concepts to be learned not the prerequisite knowledge and skills necessary for mastery of the upcoming concepts. And again there is no indication that the advance organizer was an advance organizer.

A recent study by West and Fensham (1976) has supportive evidence of Ausubel's theory concerning the subsuming role of advance organizers and the role played by the learner's prior knowledge structure in meaningful learning. This research involved eleventh and twelfth-grade students in Australia in three different studies. In study one eleventh-grade students were given a prior knowledge pretest then immediately assigned randomly to either the advance organizer or non organizer treatment. In study two eleventh-grade students were given the pretest then all received remedial teaching of the necessary prior knowledge. Then one-half of the students were assigned randomly to the advance organizer and the others took the non organizer. Study three was a repeat of study one using twelfth-grade students.

The prediction for studies one and three was that the role played by an advance organizer was equivalent to the role played by prior knowledge. This prediction was confirmed. In study two the prediction stated that if Ausubel's theory is true then remedial teaching of relevant prior knowledge would tend to remove the facilitating effect of the advance organizer. This prediction was also confirmed. There is no supporting evidence that the materials called advance organizers being

used in the studies are actually advance organizers. Also the students were not grouped according to their prior knowledge scores then randomly assigned to advance organizer or non organizer treatments, but rather they were randomly assigned the treatments regardless of the pretest scores. At the end of the studies, students' results, for statistical treatment, were grouped into five cells. Therefore, there was no significant difference between those students with high and low scores in prior knowledge. In a more recent study involving college students, Schwartz (1979), using a 2 x 2 (high and low prior knowledge, advance organizer and non organizer) factorial analysis of variance design, found significant main effects for treatment and subsumer levels but no significant interaction was found. The significant main effects do provide support for Ausubel's theory regarding the "ideational scaffolding" provided by the advance organizer and the facilitation of learning new material when relevant prior knowledge subsumers are available. However, there is no indication in the study that the pretest used to measure prior knowledge is, in fact, measuring the prerequisite skills and knowledge rather than the concepts to be learned.

West and Kellett (1981) have followed up on the studies of West and Fensham (1974, 1976). The research project consisted of two studies. One study used subjects who were deficient in relevant prior knowledge of the intellectual skill to be learned and predicted that these subjects should benefit from an external organizing aid. The second study used subjects who had been taught the relevant prior knowledge ("not all students were included in the analysis--only those who had demonstrated mastery of the task." [West and Kellett, 1981, p. 210]) and predicted that these subjects should not show any benefit from an external

organizing aid. The subjects in each study were given ten minutes to review the learning materials they had completed before taking the performance test. In each study the prediction was confirmed. West and Kellett (1981) state:

> The choice of subjects for the experiment was critical. As stated previously, it was required that the subjects chosen be naive in the relevant prior knowledge that would generally be considered an important theoretical framework within which to subsume the skill to be learned. To meet this requirement, eleventh grade students (the first year of formal chemistry) were chosen, with the experiment timed to be after they had experienced one term (12 weeks) of introductory chemistry. These students would be familiar with some basic chemistry and would not be 'frightened' by new terminology, jargon, etc. However they had not learned the intellectual skill chosen, nor had they studied the principles of chemical equilibrium, which is the closely related area of theoretical knowledge--in fact it would be a full year before they would study these areas in the normal curriculum (p. 212).

The identification of relevant prior knowledge possessed by the learners was so important in testing the predictions made and yet the subjects were assumed to be devoid of relevant prior knowledge without statistical evidence of any kind.

Summary

According to Ausubel (1963, 1968), meaningful learning requires a nonarbitrary and substantive relationship between knowledge in the learner's cognitive structure and the new knowledge to be learned. He contends that the cognitive structure is comprised of hierarchically organized facts, concepts, and propositions. The learner is expected to process facts and low-order concepts so that this information becomes subsumed by high-order concepts and propositions. To ensure that meaningful learning occurs, it is necessary that the cognitive structure has the potential to act as a subsuming structure of ideas and that the

knowledge has the potential of being related in some sensible fashion to the cognitive structure. Ausubel (1968, 1978) makes it quite clear that the critical agent in learning is the learner, who must attempt to relate new ideas to those possessed. If "any of these conditions fail to exist, subsequent learning will be relatively rote" (Ausubel and Robinson, 1969, p. 46). To facilitate meaningful learning, Ausubel (1963, 1968) advocates the use of deliberately prepared sets of related concepts and/or propositions organized at a higher level than subsequent learning materials. The high-level subject-matter concepts and propositions are sometimes referred to as subsumers, whereas the term organizer is used to describe the prepared set of such concepts and propositions.

The aspect of Ausubel's learning model which has been used most frequently as a framework for research involves the construct of facilitating learning by use of advance organizers. An advance organizer is a more general, more inclusive, more abstract statement which precedes new information that is being presented as a learning task. Seemingly, an advance organizer serves as a conceptual "anchor" for the new information.

The crucial element of an advance organizer is that it serves to link the new information to be learned with existing concepts in the cognitive structure. West and Fensham (1974) present an excellent resume of the evidence for subsumption under advance organizers. They point out that most empirical studies concerned with the effects of advance organizers can be easily misinterpreted, if it is assumed that meaningful learning can only occur following an advance organizer. "In the real situation what is to prevent a learner using relevant prior knowledge subsumers . . . " (West and Fensham, 1974, p. 71). Thus, the

lack of significant results between advance organizer and control treatments may result because the learners possessed sufficient prior knowledge to do equally well on a subsequent task. West and Fensham (1974) make several other important points. First, there is no guarantee that the learner will use relevant subsumers. As previously noted, Ausubel (1963, 1968) uses the identifying term, "potential," and recognizes that an important role of the advance organizer is to alert the cognitive structure to appropriate prior knowledge subsumption. Second, pretests, which measure prior knowledge of concepts to be learned, but do not measure subsumers to be used in the learning process, give no indication of the probability that a learner will use some existing subsumers (relevant or otherwise) as an alternative to the subsumers presented in an advance organizer. Finally, "comparisons between studies are also open to misinterpretation unless the relative use of subsumer and organizers is carefully considered or, ideally, measured as part of the study" (West and Fensham, 1974, pp. 71-72).

In most of the studies reviewed by the writer, three major problems have become evident. First, materials used are being called advance organizers without statistical evidence either from a pilot study or from previous research. In lieu of statistical evidence,

> One can obtain consensus among judges that the advance organizer <u>actually</u> fulfills its purported criteria in relation to the learning passage, and one can map existing concepts in cognitive structure either through pretests or by means of Piagetian clinical interviews (Ausubel, 1978, p. 252).

But neither has this technique been used. Second, the operational definition of prior knowledge remains elusive, Prior knowledge cannot be defined as knowledge of the concept to be learned (West and Fensham, 1974).

> Most studies do not attempt any systematic appraisal of already available relevant concepts in the learner's cognitive structure that might be employed through an appropriately constructed advance organizer (Ausubel, 1978, pp. 254-255).

And finally, there has been consistent use of categories defined as high and low prior knowledge students without an operational definition of prior knowledge and without any statistical evidence of significant difference between the categories.

The writer in designing this research project has addressed these three concerns.

CHAPTER III

METHODOLOGY AND DESIGN

Introduction

The purpose of this study was to determine answers the following questions: if three groups differing in prerequisite skills and knowledge are given an advance organizer, (a) will the group with the high prerequisite skills and knowledge benefit from an advance organizer or (b) will the group with middle prerequisite skills and knowledge benefit from an advance organizer or (c) will the group with low prerequisite skills and knowledge benefit from an advance organizer? If prior knowledge of the learner plays a subsuming role as Ausubel suggests, then the writer can predict that learners who are deficient in relevant prior knowledge should benefit from an advance organizer while those whose relevant prior knowledge is high would not.

Null Hypotheses

The null hypotheses were tested at .01 level of significance.

Null Hypothesis 1:

H_0: $\bar{X}_{HAO} = \bar{X}_{HNO}$ H_1: $\bar{X}_{HAO} \neq \bar{X}_{HNO}$

H_0: For high prerequisite skills and knowledge students there will be no significant difference between the criterion test scores of those who receive the advance organizer (HAO) and those that do not (HNO).

H_1: For high prerequisite skills and knowledge students there

will be a significant difference between the criterion test scores of those who receive the advance organizer (HAO) and those that do not (HNO).

Null Hypothesis 2:

H_0: $\bar{X}_{MAO} = \bar{X}_{MNO}$ H_1: $\bar{X}_{MAO} > \bar{X}_{MNO}$

H_0: For middle prerequisite skills and knowledge students there will be no significant difference between the criterion test scores of those who receive the advance organizer (MAO) and those that do not (MNO).

H_1: For middle prerequisite skills and knowledge students there will be a significant difference between the criterion test scores of those who receive the advance organizer (MAO) and those that do not (MNO).

Null Hypothesis 3:

H_0: $\bar{X}_{LAO} = \bar{X}_{LNO}$ H_1: $\bar{X}_{LAO} > \bar{X}_{LNO}$

H_0: For low prerequisite skills and knowledge students there will be no significant difference between the criterion test scores of those who receive the advance organizer (LAO) and those that do not (LNO).

H_1: For low prerequisite skills and knowledge students there will be a significant difference between the criterion test scores of those who receive the advance organizer (LAO) and those that do not (LNO) in favor of the advance organizer treatment.

A 2 x 3 factorial analysis of variance also was run on the criterion test scores to check for any significant effects due to interaction or to levels.

There were some additional hypotheses stated at the beginning of this research project; however, they are not directly related to the focus of this study and therefore are included in the Appendix for reference.

Organismic Variable

The organismic variable for this research consists of the categories of students referred to as low prerequisite skills and knowledge students, middle prerequisite skills and knowledge students, and high prerequisite skills and knowledge students. All of the subjects were seventh and eighth students. Placements into the categories were determined by use of a prerequisite skills and knowledge test. This test was prepared, by task analysis, using the prerequisite skills and knowledge that a panel of ten science educators suggested as necessary for a student to understand the concept of "specific gravity." This concept was chosen because of its lack of familiarity to seventh and eighth grade students. The completed test items were submitted back to the panel in order to establish validity of the test. Because some parts of the test measured skill areas and some parts measured knowledge areas, this test must be assumed to be heterogeneous rather than homogeneous. Guilford (1973) states that the only meaningful estimate of reliability for a heterogeneous test is test-retest. The reliabilty for the prerequisite skills and knowledge test was checked using test-retest techniques.

Independent Variables

The independent variables are referred to as an advance organizer and a non organizer. These were introductions to the study of the concept "specific gravity." Both were slide/tape presentations (complete transcripts in Appendix A). Each was prepared and recorded by the writer. The photographic work was also done by the writer.

Because of the nature of adequately defining and producing an advance organizer, the writer ran a pilot study five years ago using

the advance organizer and non organizer. In the pilot study two classes of ninth grade students were used. Half of the students were randomly assigned to the advance organizer presentation; the remaining students were presented the non organizer. Significant difference in means (.05) were obtained in favor of the advance organizer group. In the pilot study the advance organizer did act like an advance organizer.

Dependent Variable

The dependent variable was the test scores on a twenty item multiple choice criterion test with five possible answers per item. All of the test items were prepared by the writer. All of the items were conceptually oriented to minimize the benefits of rote learning procedures and contained no specific references to anything contained in either the advance organizer or non organizer.

The validity of the criterion test was verified as appropriate for the testing of the concept "specific gravity" by a panel of ten science educators. The reliability of the criterion test was checked using split half techniques. A pilot study of the criterion test was conducted using similar grade students in two different schools. A sample mean of 5.89 was obtained.

Research Design

Three seventh and four eighth grade science classes were available for the study. All of these students were administered the prerequisite skills and knowledge test. A t-test was run on the scores of students in the upper one-fourth of the test scores and on the scores of students in the lower one-fourth of the test scores. It the results had not

been significant at the .05 level using the t-test, then the upper one-fourth of the students would have been given instruction in the prerequisite skills and knowledge, retested, and the above procedure implemented. However, the results were significant. In each level the subjects were matched in pairs according to prerequisite skills and knowledge test scores then randomly assigned (drawn from hat) to the treatment (advance organizer). Those remaining students scoring in the middle one-half on the prerequisite skills and knowledge test also were matched in pairs and randomly assigned to the treatment.

Experimental Procedure

Each of the classes followed a similar procedure. On a Friday at the beginning of each class period, students were given the prerequisite skills and knowledge test. On the following Monday at the beginning of each class period students were told that audio-visual introductions had been developed for the next part of the course and that they would be presented one such audio-visual introduction. Each student was then directed to go to one of two rooms (advance organizer or non organizer) where the presentations were made. No opportunity was provided for discussion either before or after the presentation. Then on Tuesday, Wednesday, and Thursday, classes received instruction and participated in activities that related to the concept of "specific gravity." On Friday the students present took the criterion test which was unannounced.

The writer did not refer to any part of the organizer, non organizer or prerequisite skills and knowledge during the teaching procedure. If, during class discussion, a student referred to content from the organizer, the non organizer or prerequisite skills and

knowledge, the writer acknowledged the appropriateness of the student's comment but did not elaborate on it or promote further discussion of it. It was felt that this was necessary in order to minimize any benefit that the non organizer group of students might gain.

Statistical Analysis

The stated three null hypotheses were tested using t-test techniques on the criterion test scores. They were tested at the .01 level of significance with Hypothesis 1 being subjected to a two-tailed test and Hypotheses 2 and 3 a one-tailed test. Additionally for the study, the criterion test scores were subjected to a 2 x 3 factorial analysis of variance to determine if there were any effects attributable to levels and to interaction.

CHAPTER IV

INTERPRETATION OF THE STATISTICAL ANALYSIS

Introduction

The following statistical analysis is divided into four main parts. In parts one and two, correlation coefficients were determined for the prerequisite skills and knowledge test and for the criterion test so that a measure of reliability for each could be determined. In part three, a t-test was run on the high prerequisite skills and knowledge students' test scores and the low prerequisite skills and knowledge students' test scores to determine if a significant difference existed. For part four, t-test techniques were utilized to test the null hypotheses stated in Chapter III, and analysis of variance techniques was used to check effects of levels and of interaction.

Prerequisite Skills and Knowledge Test

The heterogeneous makeup of the prerequisite skills and knowledge test made test-retest techniques most appropriate to use. Eighteen seventh grade subjects and twelve eighth grade subjects (subjects similar to the experimental groups) at another school were administered the test. Three separate test-retest reliability tests were performed. For seventh grade subjects' scores, a Pearson product-moment correlation coefficient was computed and found to be $\underline{r} = .75$. The correlation coefficient for eighth grade subjects' scores was $\underline{r} = .69$. Both groups'

scores were combined and the computed r was .70.

Criterion Test

For reliability, the criterion test was administered to subjects without prior exposure to learning materials on the concept of specific gravity or to any of the introductory materials. The test was given to twenty-six seventh and eighth grade subjects (similar subjects to experimental groups). A Pearson product-moment correlation coefficient was computed on the split-half scores and found to be $r = .64$. Correcting for the shortened form caused by the split-half techniques yielded a correlation coefficient of $r = .78$.

Analysis of Prerequisite Skills and Knowledge Test Scores

It was stated in the design section of this report that there must be a significant difference between the prerequisite skills and knowledge test scores of the upper one-fourth of the students that took the test and the test scores of the lower one-fourth of the students that took the test. A t-test was run on the prerequisite skills and knowledge test scores of these two groups. The computed t-value was 26.05 (df = 1/77). This value was significant at the .001 level (critical value = 3.460, df = 1/60).

Criterion Test Analysis

The results of the criterion test scores are shown in Table I. Perusal of the table indicates a definite lack of support of the model under investigation. In each category the non organizer groups have higher mean scores than the advance organizer groups.

TABLE I

CRITERION TEST RESULTS FOR EXPERIMENTAL GROUPS

Subjects	Statistic	Advance Organizer	Non Organizer
High Prerequisite Skills and Knowledge Students	$\bar{X}$	10.95	11.50
	sd	2.98	3.15
	N	20	20
Middle Prerequisite Skills and Knowledge Students	$\bar{X}$	7.24	7.98
	sd	2.33	2.80
	N	37	40
Low Prerequisite Skills and Knowledge Students	$\bar{X}$	6.30	7.29
	sd	2.03	2.54
	N	20	17

Each of the three null hypotheses was tested using t-test techniques. The results are shown in Tables II, III and IV.

For the first null hypothesis, results shown in Table II, the computed t-value was 0.57. The null hypothesis is not rejected.

For the second null hypothesis, results shown in Table III, the computed t-value was 1.07. The second null hypothesis is not rejected.

For the third null hypothesis, results shown in Table IV, the computed t-value was 1.32. The third null hypothesis was not rejected.

A 2 x 3 factorial analysis of variance was performed as is shown in Table V. The only significant F-ratio ($p < .001$) was that of the levels. The other non-significant F-ratio was that of interactions effects. Of course, the t-tests had already indicated that the F-ratio

TABLE II

THE t-TEST RESULTS FOR HIGH PREREQUISITE SKILLS AND KNOWLEDGE STUDENTS' TEST CRITERION SCORES

	N	$\overline{X}$	Σx	Σx^2	df	Computed t-value	Critical Value (.01, 2-tail, df = 30)	ρ
AO	20	10.95	219	2567				
					38	0.57	2.750	n.s.
NO	20	11.5	230	2834				

TABLE III

THE t-TEST RESULTS FOR MIDDLE PREREQUISITE SKILLS AND KNOWLEDGE STUDENTS' CRITERION TEST SCORES

	N	$\overline{X}$	Σx	Σx^2	df	Computed t-value	Critical Value (.01, 1-tail, df = 60)	ρ
AO	37	7.24	268	2142				
					75	1.07	2.390	n.s.
NO	40	7.98	319	2849				

TABLE IV

THE t-TEST RESULTS FOR LOW PREREQUISITE SKILLS AND KNOWLEDGE STUDENTS' CRITERION TEST SCORES

	N	$\bar{X}$	Σx	Σx^2	df	Computed t-value	Critical Value (.01, 1-tail, df = 60)	ρ
AO	20	6.3	126	872				
					35	1.32	2.457	n.s.
NO	17	7.29	124	1008				

TABLE V

F TEST RESULTS FOR CRITERION TEST SCORES

Source	SS	df	ms	F	p	Critical Value
Total	1533.06	153	--	--	--	--
PRSK	465.20	2	232.60	32.95	.001	7.31
AONO	23.37	1	23.37	3.31	n.s.	6.85
PxAN	-0.98	2	-0.49	0.07	n.s.	4.79
Error	1045.47	148	7.06	--	--	--

for the treatments would not be significant.

Summary

This research was done to see if groups differing in prerequisite skills and knowledge would benefit from an advance organizer. Three levels of students, high, middle and low, were presented either an advance organizer audio-visual presentation or a non organizer audio-visual presentation. Then students were presented the learning materials, and after the learning materials were completed, an unannounced criterion test was given.

The results obtained from the criterion tests were then subjected to both t-test and analysis of variance statistical techniques.

The statistical analysis of part four of this chapter was performed to test the three null hypotheses stated at the beginning of Chapter III. For maximum support of the model under consideration, it was necessary that null Hypothesis 1 not be rejected and null Hypotheses 2 and 3 be rejected. In the following paragraphs the condition of each hypothesis is summarized as tested by statistical analysis.

Null Hypothesis 1

H_0: For high prerequisite skill and knowledge students there will be no significant difference between the criterion test scores of those who receive the advance organizer and those that do not.

H_1: For high prerequisite skills and knowledge students there will be a significant difference between the criterion test scores of those who receive the advance organizer and those that do not.

Table II indicates a computed t-value of 0.57 (df = 38). The

critical value (.01, 2-tailed test, df = 30) was 2.750. The null hypothesis was not rejected.

The failure to reject the null hypothesis does support the proposed model that if students have high prerequisite skills and knowledge, they will not show any benefit from an advance organizer.

Null Hypothesis 2

H_0: For middle prerequisite skills and knowledge students there will be no significant difference between the criterion test scores of those who receive the advance organizer and those that do not.

H_1: For middle prerequisite skills and knowledge students there will be a significant difference between the criterion test scores of those who receive the advance organizer and those that do not.

Table III indicates a computed t-value of 1.07 (df = 75). The critical value (.01, 1-tailed, df = 60) was 2.390. The null hypothesis was not rejected.

The failure to reject the null hypothesis does not support the model suggested because if students lack prerequisite skills and knowledge, then they should benefit from an advance organizer. The sample mean of the advance organizer group was lower than the non organizer group. Therefore, the results do not show any movement in the direction dictated by the model.

Null Hypothesis 3

H_0: For low prerequisite skills and knowledge students there will be no significant difference between the criterion test scores of those who receive the advance organizer and those that do not.

H_1: For low prerequisite skills and knowledge students there will be a significant difference between the criterion test scores of those who receive the advance organizer and those that do not.

Table IV indicates a computed t-value of 1.32 (df = 35). The critical value (.01, 1-tailed, df = 30) was 2.457. The null hypothesis was not rejected.

The failure to reject the null hypothesis does not support the proposed model because if students lack prerequisite skills and knowledge, then they should show benefit from an advance organizer. Again, the sample mean of the advance organizer group was lower than the non organizer group. The results of the statistical analysis did not show any movement in the direction dictated by the model.

None of the three null hypotheses was rejected. The failure to reject null Hypothesis 1 fits the suggested model; however, the failure to reject null Hypotheses 2 and 3 suggests some serious questions about the proposed model.

According to the statistical analysis performed, the level of the subject's prerequisite skills and knowledge was the only determining factor in the student's criterion test score.

CHAPTER V

SUMMARY AND CONCLUSIONS

Restatement of the Problem

A primary tenet of Ausubel's model is that an individual's existing cognitive structure is a key variable in determining what new information will be learned and what meaning will be established for it. In order for new ideas and information to be meaningful, the learner must possess knowledge structures to which new knowledge can be related in a nonarbitrary, nonverbatim manner. Ausubel (1960) calls these knowledge structures subsumers.

Ausubel (1960) originally tested his subsumption theory by the prediction that deliberately introducing relevant and appropriately inclusive subsuming concepts into cognitive structure would provide a "helpful ideational structure" and so enhance learning and retention. Such subsumers are defined as advance organizers.

Most of the research studies of Ausubel's theory have concentrated on advance organizers. Such studies can be readily misinterpreted if it is assumed that the only process of meaningful learning is the use of advance organizers. In the idealized situation, the learner who does not possess any relevant prior knowledge to use as a subsumer must use the advance organizer in order to learn meaningfully. Under these circumstances the failure of an advance organizer to show any advantage over a control could be considered as evidence against advance

organizers. In the real situation what is to prevent a learner from using relevant prior knowledge subsumers and completely ignoring the advance organizer? With regard to this some reports indicate that only those with relatively low verbal ability or a low level of related knowledge are aided by the presence of advance organizers. Other learners, it is speculated, are capable of concurrently providing their own subsuming structure while undertaking the learning task (Ausubel, 1960; Ausubel and Fitzgerald, 1961, 1962). However, the literature related to this problem is unclear. The failure of an advance organizer treatment to show a significant advantage over a control treatment may result not because advance organizers do not assist learning, but because most of the learners possessed sufficient prior knowledge subsumers for meaningful learning of the particular tasks involved (West and Fensham, 1974). Some researchers have tried to measure the prior knowledge subsumers with pretests, but these tests usually measured prior knowledge of the concepts to be learned, not the subsumers (prior relevant and irrelevant concepts) that could be used in the process of learning. By definition the prior knowledge subsumers will never be the same as the concepts to be learned; therefore, such pretests give no indication of the possibility of a learner using prior knowledge subsumers as an alternative to advance organizers (Ausubel, 1968; West and Fensham, 1974).

> As pointed out earlier, the rationale for using organizers is based primarily on: (a) the importance of having relevant and otherwise appropriate established ideas 'already' available in cognitive structure to make logically meaningful new ideas potentially meaningful and to give them stable anchorage; (b) the advantages of using the more general and inclusive ideas of a discipline as the anchoring ideas or subsumers . . . (c) the fact that they themselves attempt both to identify already existing relevant content in cognitive structure (and to be explicitly related to it) and to indicate

> explicitly both the relevance of the latter content and their own relevance for new learning material. In short, the principal function of the organizer is to bridge the gap between what the learner already knows and what he needs to know before he can successfully learn the task at hand (Ausubel, 1968, p. 148).

Three major problems have existed with much of the research reviewed by the writer. First, most of the advance organizers have not been proven either by pilot study or through previous research. Second, prior knowledge has been defined inconsistently with regard to Ausubel's model. Prior knowledge measures cannot be of the concepts to be learned. Third, categories of prior knowledge students have been established either by incorrect definition of prior knowledge or by grouping students without statistical evidence to prove that there is any significant difference among them with regard to the necessary prior concepts.

The purpose of this research problem was to determine for whether three groups differing in prerequisite skills and knowledge (a) the high prerequisite skills and knowledge group will benefit from an advance organizer or (b) the middle prerequisite skills and knowledge group will benefit from an advance organizer or (c) the low prerequisite skills and knowledge group will benefit from an advance organizer.

Summary of Procedures

Three levels of students, high prerequisite skills and knowledge students, middle prerequisite skills and knowledge students, and low prerequisite skills and knowledge students, had been determined by use of a prerequisite skills and knowledge test. Within each level the students were pair matched and then randomly assigned to the treatment (advance organizer presentation).

Students were told that audio-visual introductions had been developed for the next part of the course and that they would be presented one such introduction. One of the audio-visual introductions was the advance organizer, and the other was the non organizer presentation. The audio-visual presentations were given in two different rooms, and the students were directed to the correct room for the introductory presentation. After the presentations the students returned to their respective classrooms. No opportunity was provided for discussion either before or after the presentations. In the following three days students received classroom instruction that covered the concept of "specific gravity." During the teaching procedure, the writer did not refer to any part of the advance organizer, non organizer or any of the necessary prerequisite skills and knowledge. At the completion of the instructional activities all students present took the criterion test which was unannounced.

Results and Conclusions

In this section the writer will again present the results and offer commentary with regard to possible conclusions as well as possible problems with those conclusions.

The research results offer very little support for the model under investigation. This model proposes that meaningful learning occurs by one of two processess:

1. the use of relevant and irrelevant subsumers in the prior knowledge, or
2. the use of advance organizer subsumers.

Null Hypothesis 1 was not rejected which lends support to the

proposed model that if students have high prerequisite skills and knowledge, they will not show any benefit from an advance organizer.

Null Hypothesis 2 was not rejected. This finding does not support the the model because if students lack prerequisite skills and knowledge, then they should benefit from an advance organizer.

Null Hypothesis 3 was not rejected. This finding does not support the model under consideration because if students lack prerequisite skills and knowledge, then they should benefit from an advance organizer.

In the factorial analysis of variance, only the levels of the students' prerequisite skills and knowledge indicated significance.

As the writer developed the advance organizer for testing, he tried to keep in focus some of Ausubel's (1968) admonitions: learnable, stated in familiar terms, appropriate illustrations and analogies if developmentally necessary, the level of abstraction, and concepts familiar to students. The pilot study for the advance organizer presentation was run five years ago using ninth grade subjects. The statistical analysis did show the presentation to be an advance organizer. However, the present research problem was investigated using seventh and eighth grade subjects. What had been appropriate structure for ninth grade subjects may not have been appropriate for seventh and eighth grade subjects. Appropriate structure takes into account the developmental level of the student's dent's cognitive functioning and his degree of subject matter sophistication. Structure that is too elaborate in these terms constitutes more of a handicap than a facilitating device (Binter, 1963). Premature acquisition of inappropriate structures may result in "closure" that inhibits the acquisition of more appropriate structures (Smedslund, 1961). Furthermore, Ausubel (1968) writes that organizers that are

intended for elementary students should be presented at a lower level of abstraction, making more extensive use of concrete-empirical props, and taking into account rather than ignoring preexisting organizing principles in the learner's cognitive structure.

Another possible cause for a lack of support from the research data is the topic chosen for use in the investigation. The topic of specific gravity is briefly introduced at the eighth grade level in most earth science textbooks as one tool for the identification of rocks. It is also mentioned in physical science textbooks at the ninth grade level in buoyancy experiments.

One of the necessary prerequisite skills and knowledge requirements for understanding specific gravity is knowledge of the concept of density. From the works of Piaget (1930) and many others, there is evidence that this concept does not fully develop in children until an age range of 12 to 14. The middle school students involved in this empirical research were in the age range of 11 to 13.

The nature and presentation of the learning materials which took place after the advance organizer and non organizer treatments may have masked any possible effects that the advance organizer may have otherwise shown. Ausubel (1969) states:

> Moreover the pedagogic value of organizers would depend upon how well organized the learning material itself is. If it already contains built-in organizers and proceeds from regions of lesser to greater differentiation (higher to lower inclusiveness) . . . much of the potential benefit derivable from advance organizers will be actualized (p. 166).

He goes on to explain:

> Regardless of how well organized learning material is, however, it seems reasonable to expect that learning and retention can still be facilitated by use of organizers at an appropriate level of inclusiveness (p. 166).

In the original research problem the writer had not checked this possibility. As a post hoc procedure the writer ran a test of the learning materials alone. The criterion test was used as both a pretest and as a posttest. Twenty seventh grade subjects and sixty-seven eighth grade subjects participated in this post hoc procedure. The pretest mean was 7.90 and the posttest mean was 8.44. A t-test was utilized. The computed t-value was 1.33 (.05, critical value = 1.960, df = 1/170). The results of this post hoc analysis indicate that no masking effect existed.

Two additional possible sources of error include a conflict in the level of significance chosen in the pilot study (.05) and in the research study (.01) as well as the possible failure of the chosen topic for advance organizer development to meet the inclusiveness test.

Analysis of the data shows that the level of significance chosen certainly did not affect the outcome of the hypotheses tested.

Whether or not the topic chosen for study meets Ausubel's (1968) inclusiveness description will in the writer's mind be open to debate from many. Finally, it should be noted that both of my test instruments are "borderline" in terms of their coefficients of reliability.

Implications

The results of this research project suggest to this writer very clear implications.

First, at the middle school level the advance organizer model as presented for facilitating learning is severely damaged.

Second, because of the elusive nature of the advance organizer, adequately defining and then testing this proposed advance organizer for

use with middle school students involves a prohibitive amount of time.

Finally, the results of this research show that the prerequisite skills and knowledge that a middle school student possesses or does not possess plays the primary role of facilitating learning.

Recommendations for Further Research

The recommendations that this writer would propose involve more in the way of experimental design considerations than research topics. It is important that proven advance organizers be tested with a number of different groups and that a "true" measure of prior skills and knowledge (should not be the same as concepts to be learned) be determined and utilized in the experimental design.

More general recommendations would be to choose topics of study that related more closely with developmental levels of the students and to check very carefully the inclusiveness of the topics chosen.

A specific recommendation for this research problem and its implications is that the materials and experimental design should be tried with ninth grade subjects with the research data collected serving as the guide to determine whether other grade levels should also be tested.

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APPENDICES

APPENDIX A

TRANSCRIPTS OF ORGANIZERS

Advance Organizer

Some materials such as wood and wax float on water, others such as iron and glass sink in water. The density of wood is less than that of water, therefore, it floats. An iron bolt sinks because the density of iron is greater than that of water. You might be tempted to conclude that floating or sinking is a question of density alone. However you have certainly seen steel boats that float, and* submarines which float or sink.*

This then is the story of specific gravity. Specific gravity is an important property. If you throw a stone into a pond, it sinks. Probably if someone asked you why the stone sinks, you would say, "Because it's heavier." Just what do you mean by that? The weight of the stone might be about a pound. Does the water in the pond, then, weigh less than a pound. It probably weighs many tons. The trouble comes in comparing the weight of a small stone with the weight of a much larger volume of water. For the comparison to be meaningful, you must compare the weights of equal volumes of the stone and the water.* The specific gravity of any material tells how its density compares with the density of water.*

A cubic foot of water weighs 62.4 pounds, while a cubic foot of aluminum weighs 168.5 pounds. Aluminum is 2.7 times as heavy as water. This is called its specific gravity. Or one cubic centimeter (one milliliter) of water weighs one gram, while one cubic centimeter of aluminum weighs 2.7 grams.*

The specific gravity of any material tells how its density compares

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* Denotes slide change

with the density of water. How was all this discovered? Several hundred years ago Archimedes discovered the facts of specific gravity. Archimedes lived in the Greek colony of Syracuse, in Sicily, and was a close friend of Hieron, the king of Syracuse. Hieron had given a goldsmith a certain weight of gold with which to make a crown. He suspected, however, that the goldsmith might have used an equal weight of a gold and silver mixture, keeping the leftover gold for himself.* Hieron asked Archimedes to test the quality of the gold without destroying the crown. According to the legend, Archimedes was pondering the problem one day at the public baths.* As he stepped into full tub and noticed the water spilling over, a solution suddenly came to him. He leaped out of the tub and, without bothering to dress, ran home to try his idea, shouting "Eureka!" as he ran. The cause for his elation was this:* He had realized that just as his body displaced water from the tub, so might he determine the volume of the King's crown by seeing how much water it would displace from a full container. Since silver is less dense than gold, he knew that a crown made of gold and silver would displace more water than an equal weight of pure gold. Thus he would be able to expose the goldsmith's possible fraud.*

Archimedes' principle gives us an easy way to find the specific gravity of a substance.* Weigh the object in air.* Then weigh it in water.* This apparent loss of mass is equal to the mass of the water displaced. Since the volume of the object and the volume of the water displaced are equal, this may be expressed in equation form*

specific gravity = mass of the material (in air)/apparent loss of mass in water*

Recall Archimedes' principle.* Suppose an object floats in an unknown

liquid. A floating object will sink into the liquid in which it is floating until it displaces an amount of liquid equal to its own mass. Now let us suppose we measure the volume of that part of the object which is submerged in the unknown liquid.* Next the object is allowed to float in water. Again we measure the volume of the submerged part. We can now calculate the specific gravity as follows:*

$$\text{specific gravity} = \frac{\text{volume of displaced water}}{\text{volume of displaced unknown liquid}}*$$

A floating object used to measure specific gravity by this method is called a hydrometer. Finding the specific gravity of a liquid can be done without using Archimedes' principle. A specific gravity bottle is commonly used.* Scientists call such a bottle a pycnometer.*

$$\text{specific gravity} = \text{mass of liquid/mass of equal volume of water}*$$

Substances with specific gravities less than 1 float. If the specific gravity is greater than 1 they sink. Some with a specific gravity of exactly 1 remain exactly where you place them in water.*

$$\text{specific gravity} = \text{density of material/density of standard}*$$

$$\text{density} = \text{mass/volume}*$$

$$\text{specific gravity} = \frac{[\text{mass of substance/volume of substance}]}{[\text{mass of water/volume water}]}*$$

If the volumes are the same specific gravity becomes:*

$$\text{specific gravity} = \text{mass of substance/mass of water}*$$

If the masses are equal then:*

$$\text{specific gravity} = \text{volume of water/volume of substance.}$$

Non Organizer

Everybody knows that some substances are heavier than others. This difference gives them different specific gravities.* What is specific gravity? We have previously studied the densities of substances and the specific gravity of any material tells how its density compares with the density of water. Specific gravities of substances are determined experimentally in the laboratory.* Here is a table which gives the specific gravities of some common substances.* Archimedes discovered the facts of specific gravity when he was asked to find out if King Hieron's crown was actually made of solid gold.* Archimedes' principle gives us a way of finding the specific gravity of solids.* Scientists today use special bottles called pycnometers to find the specific gravity of liquids.* The easiest way to find the specific gravity of a liquid is to use a floating device called a hydrometer. Hydrometers are hollow, glass instruments weighted at the lower end so that they float upright.* They sink until they displace their own weight of the liquid,* hence they sink deep in liquids of lesser density. You read the specific gravity directly from the scale on the stem of the hydrometer.* Service station workers use hydrometers to check the concentration of sulfuric acid in car batteries and of the antifreeze in the radiators of cars.* By reading the scale on the hydrometer, the service station attendant can tell you how cold it can get before the liquid in your car radiator will freeze. The specific gravity determination has many other practical uses.* The specific gravity of substances allows us to determine whether substances will float or sink.* The chemist may use it to help

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* Denotes slide change

identify a substance or to determine its purity.* The purity of liquids may be checked by comparing the specific gravity with that of a known standard.* Many industrial companies such as those producing petroleum products* and gasolines, salts, sugars and soaps make constant use of specific gravity determinations for quality control purposes.* Doctors also test various body fluids using specific gravities.* And one final, frivolous note, bartenders can even use specific gravities to make multi-colored drinks.

APPENDIX B

PREREQUISITE SKILLS AND KNOWLEDGE TEST

1. The standard unit of mass in the metric system is the
   a. kilogram b. gram c. pound d. ounce e. none of these

2. The standard unit of volume in the metric system is the
   a. milliliter b. quart c. dram d. liter e. none of these

3. The relation involving the mass, volume and density of a substance is expressed by the formula
   a. dm = v b. v = d/m c. d = vm d. d = m/v e. none of these

4. Solve for 1.6 ÷ 2
   a. 8.0 b. 80.0 c. 0.8 d. 0.08 e. 1.6

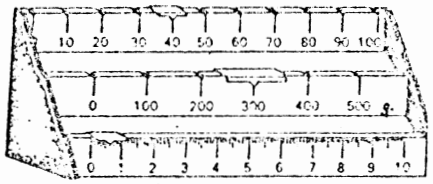
5. Solve for 7.25 ÷ 0.25
   a. 29.0 b. 290.0 c. 2.9 d. 0.29 e. 0.029

6. Solve for 2 x 0.1
   a. 20.0 b. 2.0 c. 0.2 d. 0.02 e. 0.002

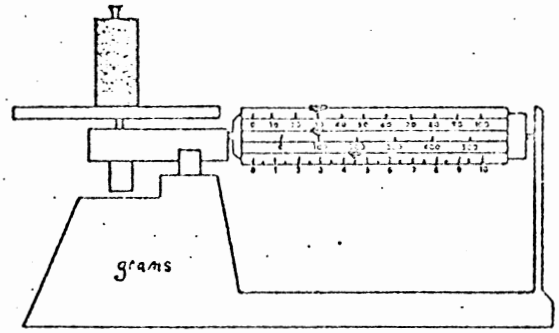
7. Solve for 1.1 x 0.2
   a. 220 b. 22.0 c. 2.2 d. 0.22 e. 0.022

8. Solve for 44 ÷ 2.2
   a. 2.0 b. 20.0 c. 0.2 d. 0.02 e. 22.0

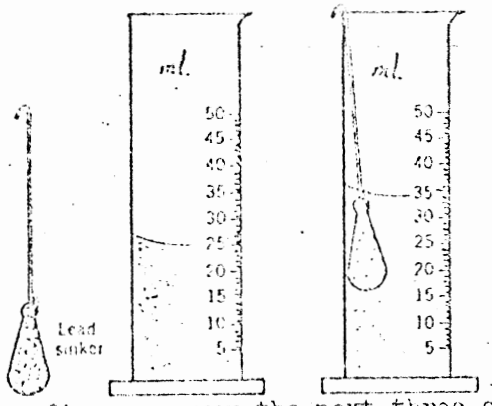
9. Solve for 2.2 x 0.89
   a. 195.8 b. 19.58 c. 1.958 d. 0.1958 e. 0.01958



10. What is the mass shown by the riders on the beam balance in the above figure?
    a. 340.6 g b. 3.406 g c. 34.06 g d. 300.46 g e. 12000.6 g



11. What is the mass of the object shown in the above figure?
    a. 1.345 g b. 13.045 g c. 134.5 g d. 3000.45 g e. 100.345 g

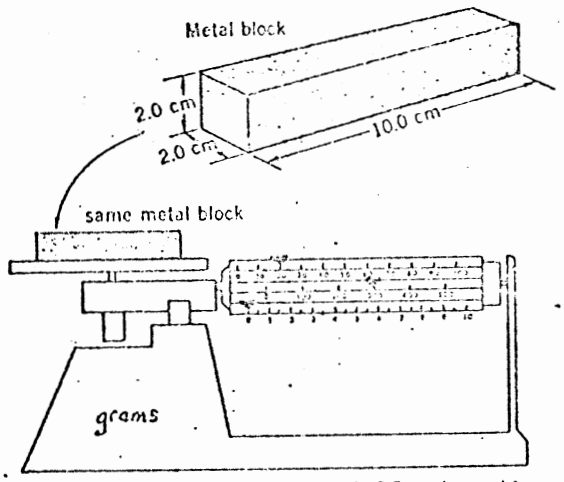


Using the above figure answer the next three questions:

12. What is the volume of the liquid in the cylinder before the sinker is added?
a. 25.0 ml b. 25.5 ml c. 2.5 ml d. 2.55 ml e. 250 ml

13. What is the volume of the liquid and sinker after the sinker is added?
a. 34.9 ml b. 35.2 ml c. 34.0 ml d. 3.49 ml e. 340 ml

14. What is the volume of the sinker?
a. 9.9 ml b. 90.0 ml c. 9.0 ml d. 10.2 ml e. 0.99 ml



Using the above figure answer the following three questions:

15. What is the volume of the metal block?
a. 0.4 cm^3 b. 20 cm^3 c. 40 cm^3 d. 2.5 cm^3 e. 10 cm^3

16. What is the mass of the block?
a. 320 g b. 300.20 g c.302 g d. 6000 g e. 500 g

17. What is the density of the block?
a. 8 g/cm^3 b. 32 g/cm^3 c. 12.5 g/cm^3 d. 0.125 g/cm^3 e.0.08 g/cm^3

18. If a cube has a volume of 3 cm^3 and a mass of 6 g, its density is
a. 0.5 g/cm^3 b. 2 g/cm^3 c. 9 g/cm^3 d. 18 g/cm^3 e. none of these

19. A block of aluminum has a volume of 50 cm^3 and a mass of 200 g. What is its density?
a. 0.25 g/cm^3 b. 4 g/cm^3 c. 5 g/cm^3 d. 40 g/cm^3 e. none of these

20. The block of aluminum from the above question is cut into half therefore its density is
a. twice as much b. four times as much c. half as much
d. the same e. none of these

APPENDIX C

PREREQUISITE SKILLS AND KNOWLEDGE TEST SCORES

RAW SCORES

Test-Retest Reliability Scores for Prerequisite Skills and Knowledge Test

Seventh Grade

Subjects	Test	Retest
1	5	5
2	9	8
3	9	8
4	11	5
5	11	10
6	6	6
7	10	9
8	13	10
9	12	10
10	8	8
11	10	8
12	10	9
13	8	7
14	7	6
15	15	10
16	9	9
17	7	4
18	12	10

Eighth Grade

Subjects	Test	Retest
1	15	14
2	6	3
3	14	12
4	10	5
5	12	9
6	9	8
7	16	15
8	12	6
9	15	13
10	14	4
11	10	10
12	11	11

RAW SCORES

Test Scores of Students Classified as High Prerequisite Skills and Knowledge Students

Advance Organizer		Non Organizer	
Subject	PRSKT	Subject	PRSKT
1	19	1	19
2	19	2	18
3	18	3	18
4	17	4	17
5	16	5	16
6	16	6	16
7	16	7	15
8	15	8	15
9	15	9	15
10	15	10	15
11	14	11	14
12	14	12	14
13	14	13	14
14	14	14	14
15	14	15	14
16	13	16	13
17	13	17	13
18	13	18	13
19	13	19	12
20	12	20	12

RAW SCORES

Test Scores of Students Classified as Middle Prerequisite Skills and Knowledge Students

Advance Organizer		Non Organizer	
Subject	PRSKT	Subject	PRSKT
1	12	1	12
2	12	2	12
3	12	3	12
4	12	4	12
5	12	5	12
6	11	6	11
7	11	7	11
8	11	8	11
9	11	9	11
10	11	10	11
11	11	11	11
12	11	12	10
13	10	13	10
14	10	14	10
15	10	15	10
16	10	16	10
17	10	17	10
18	10	18	10
19	10	19	10
20	9	20	9
21	9	21	9
22	9	22	9
23	9	23	9
24	9	24	9
25	9	25	9
26	9	26	9
27	9	27	9
28	9	28	9
29	9	29	9
30	9	30	9
31	9	31	9
32	9	32	9
33	8	33	8
34	8	34	8
35	8	35	8
36	8	36	8
37	8	37	8
38	7	38	8
39	7	39	7
40	7	40	7
		41	7

RAW SCORES

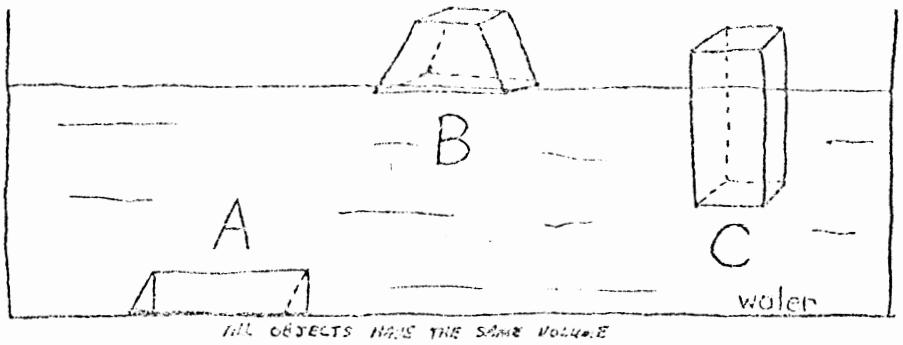
Test Scores of Students Classified as Low Prerequisite Skills and Knowledge

Students

Advance Organizer		Non Organizer	
Subject	PRSKT	Subject	PRSKT
1	7	1	7
2	7	2	7
3	6	3	7
4	6	4	6
5	6	5	6
6	6	6	6
7	6	7	6
8	6	8	6
9	5	9	6
10	5	10	5
11	5	11	5
12	5	12	5
13	4	13	5
14	4	14	4
15	4	15	4
16	4	16	4
17	3	17	4
18	3	18	3
19	3	19	3
20	2		

APPENDIX D

CRITERION TEST



ALL OBJECTS HAVE THE SAME VOLUME

Use figure above to answer questions 1-9.

1. The greatest amount of water is displaced by object(s):
a. A b. B and C c. B d. C e. none of these

2. The least dense object is:
a. B b. C c. A d. B and C e. none of these

3. The order of density of the three objects from least to most is:
a. A-B-C b. B-C-A c. C-B-A d. C-A-B e. A-C-B

If the water is replaced by a fluid whose specific gravity is 0.6, answer the following questions-

4. Object A will:
a. float on surface b. sink to bottom c. be one-half or more below surface
d. remain where placed e. can't predict

5. Object B will:
a. float on surface b. sink to bottom c. be one-half or more below surface
d. remain where placed e. can't predict

6. Object C will:
a. float on surface b. sink to bottom c. be one-half or more below surface
d. remain where placed e. can't predict

If the fluid is replaced by a fluid with specific gravity of 6., answer the following questions:

7. Object A will:
a. float on surface b. sink to bottom c. be one-half or more below surface
d. remain where placed e. can't predict

8. Object B will:
a. float on surface b. sink to bottom c. be one-half or more below surface
d. remain where placed e. can't predict

9. Object C will:
a. float on surface b. sink to bottom c. be one-half or more below surface
d. remain where placed e. can't predict

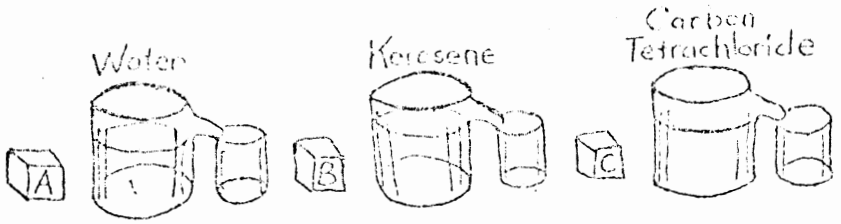
10. The specific gravity of tungsten is 18.6. If 25 grams of tungsten is submerged in water, how much mass will it appear to lose?
a. 0.74g b. 18.6 g c. 6.4 g d. 1.34 g e. none of these

11. The densities for cork, coconut oil, and sulfur are as follows: cork, 0.2; coconut oil, 0.93; sulfur, 2.0. You can reasonably predict that
a. cork floats in coconut oil b. sulfur floats in coconut oil
c. coconut oil sinks in water d. water floats in coconut oil

12. Consider the four different solid objects listed below:

OBJECT	DENSITY
Object A	3.6 g/cm^3
Object B	1.5 g/cm^3
Object C	7.5 g/cm^3
Object D	0.111 g/cm^3

Which of these objects float in water?
a. Object A b. Object B c. Object C d. Object D e. none of these



Kerosene is lighter than water, and carbon tetrachloride (CCl_4) is heavier than water. Blocks A, B, and C are of equal size and each weighs 500 grams. Block A is placed in water, B in kerosene, and C in carbon tetrachloride.

13. The liquid(s) in which the block of wood sinks deepest is:
a. kerosene b. carbon tetrachloride c. water d. kerosene and water e. carbon tetrachloride and water

14. The liquid(s) in which the block of wood sinks the least is:
a. kerosene b. carbon tetrachloride c. water d. kerosene and water e. carbon tetrachloride and water

15. A piece of stone has a mass of 200 grams in air, an apparent mass of 120 grams in water, and an apparent mass of 136 grams in alcohol. What is the specific gravity of alcohol?
a. 1.25 b. 0.8 c. 0.6 d. 1.13 e. none of these

16. The specific gravity of aluminum is 2.7. If a block of aluminum weighs 1404 grams, what weight of water would it displace when submerged?
a. 270 g b. 3790.8 g c. 135 g d. 1040 g e. none of these

17. A piece of metal weighs 190 grams when completely submerged in water. If its volume is 80 cm^3, how much does the metal weigh in air?
a. 2.3 g b. 270 g c. 110 g d. 190 g e. none of these

18. A block of iron weighs 1064 grams and will displace 140 grams of water when submerged. Find the specific gravity of iron.
a. 6.6 b. 7.6 c. 0.1 d. 4.6 e. none of these

19. A bottle weighs 54 grams when filled with kerosene and 60 grams when filled with the same volume of water. The empty bottle weighs 30 grams. What is the specific gravity of the kerosene?
a. 0.8 b. 0.9 c. 1.8 d. 2 e. none of these

20. A barge is 10 meters long, 4 meters wide, and 2 meters deep. It weighs 2000 kilograms. What is the maximum load that can be placed in the barge before it is submerged?
a. 6000 kg b. 78,000 kg c. 80,000 kg d. 18,000 kg e. none of these

21. If 1000 cubic centimeters of a liquid weigh 800 grams, its specific gravity is:
a. 800 b. 80 c. 8 d. 0.8 e. none of these

22. If an object having a volume of 48 cm^3 and weighing 96 grams is placed in a tank of water, it will:
a. sink b. float c. be partially submerged d. none of these

23. A stone has a specific gravity of 3.0. It weighs 600 grams in air. What is its volume?
a. 1800 cm^3 b. 500 cm^3 c. 3 cm^3 d. 200 cm^3 e. none of these

24. What is the weight of the stone in air in water?
a. 400 g b. 200 g c. 600 g d. 800 g e. none of these

25. A piece of metal weighs 20 grams in air and 18 grams in water. What is its specific gravity?
a. 10 b. 9 c. 1.1 d. 0.1 e. none of these

APPENDIX E

CRITERION TEST SCORES

RAW SCORES

Split-Half Reliability Scores for Criterion Test

Subjects	Odd	Even
1	4	0
2	4	3
3	3	2
4	7	5
5	4	3
6	3	0
7	4	2
8	7	4
9	3	2
10	3	1
11	2	1
12	5	2
13	6	3
14	4	2
15	4	3
16	2	2
17	5	0
18	2	1
19	4	3
20	1	0
21	4	4
22	3	2
23	5	4
24	3	1
25	3	1
26	4	1

RAW SCORES

High Prerequisite Skills and Knowledge

Students' Criterion Test Scores

Advance Organizer		Non Organizer	
Subject	CTS	Subject	CTS
1	12	1	17
2	12	2	17
3	13	3	9
4	20	4	12
5	11	5	10
6	10	6	8
7	11	7	8
8	8	8	13
9	10	9	10
10	8	10	17
11	11	11	9
12	16	12	13
13	10	13	13
14	12	14	14
15	11	15	10
16	9	16	13
17	10	17	8
18	9	18	8
19	10	19	8
20	6	20	13

RAW SCORES

Middle Prerequisite Skills and Knowledge

Students' Criterion Test Scores

Advance Organizer		Non Organizer	
Subject	CTS	Subject	CTS
1	10	1	8
2	9	2	8
3	7	3	4
4	7	4	10
5	4	5	x
6	8	6	8
7	7	7	14
8	5	8	4
9	7	9	11
10	9	10	10
11	4	11	7
12	9	12	12
13	14	13	7
14	6	14	13
15	5	15	11
16	x	16	6
17	7	17	7
18	8	18	13
19	9	19	3
20	9	20	4
21	6	21	7
22	10	22	8
23	7	23	9
24	5	24	11
25	8	25	9
26	6	26	5
27	5	27	6
28	11	28	8
29	7	29	9
30	8	30	8
31	3	31	7
32	8	32	7
33	2	33	5
34	9	34	4
35	x	35	8
36	7	36	10
37	5	37	9
38	7	38	6
39	10	39	9
40	x	40	11
		41	3

RAW SCORES

Low Prerequisite Skills and Knowledge

Students' Criterion Test Scores

Advance Organizer		Non Organizer	
Subject	CTS	Subject	CTS
1	9	1	8
2	7	2	4
3	9	3	6
4	7	4	6
5	3	5	13
6	7	6	9
7	5	7	9
8	6	8	12
9	6	9	x
10	9	10	4
11	8	11	7
12	4	12	9
13	5	13	6
14	2	14	7
15	7	15	8
16	4	16	5
17	5	17	x
18	8	18	6
19	7	19	5
20	8		

APPENDIX F

LEARNING MATERIALS (POST HOC) ANALYSIS

RAW SCORES

Post Hoc Test Scores of Learning Materials

Subject	Pretest	Posttest	Subject	Pretest	Posttest
1	12	9	45	11	14
2	13	10	46	10	13
3	9	9	47	9	5
4	11	10	48	8	14
5	8	10	49	6	9
6	9	12	50	5	12
7	9	8	51	5	12
8	12	7	52	4	7
9	6	11	53	4	9
10	9	7	54	5	4
11	14	9	55	8	4
12	8	9	56	9	4
13	11	10	57	8	8
14	8	4	58	5	1
15	10	6	59	5	4
16	8	5	60	9	6
17	10	10	61	8	4
18	11	7	62	13	6
19	8	10	63	2	6
20	10	12	64	4	6
21	7	10	65	4	5
22	14	14	66	4	6
23	4	12	67	9	10
24	6	5	68	7	8
25	8	13	69	7	10
26	4	9	70	8	8
27	9	11	71	4	7
28	9	10	72	10	12
29	8	10	73	7	5
30	8	7	74	9	11
31	10	9	75	5	9
32	9	9	76	4	7
33	8	8	77	6	8
34	8	8	78	9	4
35	8	6	79	11	10
36	7	8	80	9	13
37	4	9	81	5	8
38	9	7	82	4	7
39	11	5	83	6	12
40	8	10	84	10	9
41	9	13	85	5	9
42	8	9	86	8	10
43	8	11	87	7	5
44	8	9			

APPENDIX G

ADDITIONAL NULL HYPOTHESES

ADDITIONAL NULL HYPOTHESES

The following null hypotheses were stated at the beginning of this research project but not directly related to the focus of this study and therefore are included here in the Appendix for reference. These hypotheses were tested at the .01 level of significance (2-tailed) using t-test techniques. This was an appropriate procedure since the hypotheses were stated before data collection and not post hoc.

H1: For students who receive the advance organizer there will be no significant difference between the criterion test scores of those who are low prerequisite skills and knowledge students and those who are high prerequisite skills and knowledge students.

The computed t-value was 5.74 (df = 1/38). The critical value was 2.75 (df = 1/30). This hypothesis was rejected.

H2: There will be no significant difference between the criterion test scores of the high prerequisite skills and knowledge, advance organizer students and the low prerequisite skills and knowledge, non organizer students.

The computed t-value was 4.30 (df = 1/35). The critical value was 2.75 (df = 1/30). This hypothesis was rejected.

H3: For students who receive the advance organizer there will be no significant difference between the criterion test scores of those who are middle prerequisite skills and knowledge students and those who are high prerequisite skills and knowledge students.

The computed t-value was 5.23 (df = 1/56). The critical value was 2.704 (df = 1/40). This hypothesis was rejected.

H4: There will be no significant difference between the criterion test scores of the high prerequisite skills and knowledge, advance

organizer students and the middle prerequisite skills and knowledge, non organizer students.

The computed t-value was 3.80 (df = 1/58). The critical value was 2.704 (df = 1/40). This hypothesis was rejected.

H5: There will be no significant difference between the criterion test scores of the low prerequisite skills and knowledge, advance organizer students and the high prerequisite skills and knowledge, non organizer students.

The compute t-value was 6.19 (df = 1/38). The critical value was 2.75 (df = 1/30). This hypothesis was rejected.

H6: For students who receive the non organizer there will be no significant difference between the criterion test scores of those who are low prerequisite skills and knowledge students and those who are high prerequisite skills and knowledge students.

The computed t-value was 4.43 (df = 1/35). The critical value was 2.75 (df = 1/30). This hypothesis was rejected.

H7: There will be no significant difference between the criterion test scores of the middle prerequisite skills and knowledge, advance organizer students and the high prerequisite skills and knowledge, non organizer students.

The computed t-value was 5.76 (df = 1/56). The critical value was 2.704 (df = 1/40). This hypothesis was rejected.

H8: For students who receive the non organizer there will be no significant difference between the criterion test scores of those who are middle prerequisite skills and knowledge students and those who are high prerequisite skills and knowledge students.

The computed t-value was 4.41 (df = 1/58). The critical value was

2.704 (df = 1/40). This hypothesis was rejected.

H9: For students who receive the advance organizer there will be no significant difference between the criterion test scores of those who are middle prerequisite skills and knowledge students and those who are low prerequisite skills and knowledge students.

The computed t-value was 1.63 (df = 1/56). The critical value was 2.704 (df = 1/40). This hypothesis was not rejected.

H10: There will be no significant difference between the criterion test scores of the low prerequisite skills and knowledge, advance organizer students and the middle prerequisite skills and knowledge, non organizer students.

The computed t-value was 2.50 (df = 1/58). The critical value was 2.704 (df = 1/40). The hypothesis was not rejected.

H11: There will be no significant difference between the criterion test scores of the middle prerequisite skills and knowledge, advance organzier students and the low prerequisite skills and knowledge, non organizer students.

The computed t-value was .08 (df = 1/53). The critical value was 2.704 (df = 1/40). This hypothesis was not rejected.

H12: For students who receive the non organizer there will be no significant difference between the criterion test scores of those who are low prerequisite skills and knowledge students and those who are middle prerequisite skills and knowledge students.

The computed t-value was .86 (df = 1/55). The critical value was 2.704 (df = 1/40). This hypothesis was not rejected.

VITA

George Robert Moore

Candidate for the Degree of

Doctor of Education

Thesis: THE EFFECTS OF AN ADVANCE ORGANIZER ON STUDENTS DIFFERING IN PREREQUISITE SKILLS AND KNOWLEDGE

Major Field: Curriculum and Instruction

Biographical:

Personal Data: Born in Altus, Oklahoma, November 17, 1940, the son of Mr. and Mrs. Hoyle Moore.

Education: Graduated from City View High School, Mangum, Oklahoma, in May, 1959; received Bachelor of Science in Education degree from Southwestern Oklahoma State University in 1964; received Master of Teaching degree in Education from Southwestern Oklahoma State University in 1966; completed requirements for the Doctor of Education degree at Oklahoma State University in December, 1981.

Professional Experience: Junior high and high school science teacher, Leedey Public Schools, Leedey, Oklahoma, 1964-1970; biology and chemistry teacher, Kingfisher Public Schools, Kingfisher, Oklahoma, 1970-1973; graduate assistant, Department of Curriculum and Instruction, Oklahoma State University, 1973-1975; junior high science teacher, Lindsey Public Schools, Lindsey, Oklahoma, 1975-1976; K-8 science coordinator and middle school science teacher, Kingfisher Public Schools, Kingfisher, Oklahoma, 1976-1981.

Professional Memberships: Oklahoma Science Teachers Association.