

AN EMPIRICAL INVESTIGATION OF THE EFFECTS ON LEARNING  
AND RETENTION OF A MULTIPLE CHANNEL PRESENTATION  
OF AN ADVANCE ORGANIZER

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## CURRICULUM STUDIORUM

The investigator was born in Bathurst, New Brunswick, in 1937. He received the degrees of Bachelor of Arts and Bachelor of Education from Saint Thomas University in 1960 and 1964 respectively. In 1974 he was granted a Master of Education degree in educational administration and supervision from the University of Maine at Orono.

## TABLE OF CONTENTS

Chapter	page
INTRODUCTION . . . . .	viii
I.- REVIEW OF THE LITERATURE . . . . .	1
Ausubel's Theory of Meaningful Reception	
Learning	2
Review of Advance Organizer Studies	8
Identification of the Problem	9
The Effects of Channels of Communication	
upon Advance Organizers	17
Research Problems and Hypotheses	23
Summary	24
II.- EXPERIMENTAL DESIGN . . . . .	26
Sample	26
Materials	27
Measuring Instrument	30
Experimental Procedures	31
Statistical Design and Analysis of the Data	35
Summary	38
III.- PRESENTATION AND DISCUSSION OF RESULTS . . . . .	39
Reiteration of the Research Problem	39
Analysis and Interpretation	41
Implications of the First Hypothesis	48
Implications of the Second Hypothesis	54
Implications for Further Research	60
Summary	61
Conclusion	62
REFERENCES . . . . .	64
 Appendix	
1. VISUAL ADVANCE ORGANIZER (STRUCTURED OVERVIEW) .	79
2. PRINT ADVANCE ORGANIZER . . . . .	81
3. GENERAL INSTRUCTIONS TO ALL TEACHERS . . . . .	84
4. INSTRUCTIONS TO TEACHERS RESPONSIBLE FOR	
TREATMENT ONE SUBJECTS . . . . .	86

TABLE OF CONTENTS

v

Appendix	page
5. INSTRUCTIONS TO TEACHERS RESPONSIBLE FOR TREATMENT TWO SUBJECTS . . . . .	86
6. INSTRUCTIONS TO TEACHERS RESPONSIBLE FOR CONTROL SUBJECTS . . . . .	92
7. ASTRONOMY TEST . . . . .	95
8. LEARNING PASSAGE ENTITLED "STARS" . . . . .	103
9. PERSONAL CORRESPONDENCE BETWEEN DAVID P. AUSUBEL AND RICHARD F. BARRON . . . . .	114
10. PERSONAL CORRESPONDENCE BETWEEN ALBERT C. LAVIGNE AND RICHARD F. BARRON . . . . .	116
11. QUESTION TO DETERMINE THE NAIVETE OF THE SAMPLE WITH RESPECT TO THE LEARNING TASK . . . . .	118
12. ABSTRACT OF <u>An Empirical Investigation of the Effects on Learning and Retention of a Multiple Channel Presentation of an Advance Organizer</u> . .	120

LIST OF TABLES

Table	page
1. Means of Treatment Groups . . . . .	43
2. Summary of Analysis of Variance for Treatments	45
3. Scheffé Simultaneous Confidence Intervals for Simple Contrasts of Means for Main Effects .	46
4. Means and Standard Deviations for Each Group Involved in the Test of $H_{02}$ . . . . .	47
5. Summary of Analysis of Variance for Treatments by Measure (TM) Interaction . . . . .	49
6. Scheffé Simultaneous Confidence Intervals for Simple Contrasts of Means for the Treatment by Measure (TM) Interaction . . . . .	50

LIST OF FIGURES

Figure	page
1. Flow chart showing experimental procedure . . .	36
2. Research design . . . . .	37
3. Superordinate-optimal schema model . . . . .	55
4. TM (Treatment-dependent measure interaction) .	58

## INTRODUCTION

Ausubel (1963) proposes a theory of learning and retention which is a model for information processing and storing. Popularly known as the theory of meaningful reception learning, it addresses itself to the mode of learning which tends to predominate in school, especially in the post elementary grades. The predominant mode is reception learning, where the principal content of what is to be learned is presented to the students by the teacher in its final form.

Ausubel's theory is directed toward explaining the cognitive processes which enable learners to acquire and retain knowledge. Central to the theory is his conception of how cognitive structure functions to acquire knowledge. Ausubel (1963, p. 76) states that the existing cognitive structure is the single most important factor influencing the acquisition of new information. He argues (1968, p. 148) that for meaningful learning to occur, cognitive structure must possess relevant concepts which are at a higher level of abstraction than the material to be learned. The existing concepts interact with the new learning material and serve to anchor it to the existing cognitive structure.

The next step in the learning process involves the subsumption of the new learning material. Ausubel (1963) claims that cognitive structure is hierarchically organized with the

most inclusive concepts subsuming less inclusive concepts and principles as well as specific items of information. It is these subsumptive bonds which link each step in the hierarchy to the next step. Thus, through the anchoring and subsumption processes, the new information is incorporated into the existing conceptual system.

Believing that relevant concepts are not always spontaneously available, or that when they are they may lack particularized relevance and inclusiveness, Ausubel (1963, p. 82) proposes bridging the gap between cognitive structure and the new learning material. This he postulates can be accomplished through the advance introduction of material which is both relevant and inclusive with respect to the material to be learned. Ausubel terms this introductory material an advance organizer. To be maximally effective, advance organizers must be formulated in language and employ analogies already familiar to the learner.

There is a growing body of literature which is divided on the question of whether or not advance organizers are effective in facilitating learning. These clashes are having the result of dividing researchers into two camps. The Barnes and Clawson (1975) review seems representative of those studies which conclude that the effectiveness of the advance organizer as a tool for facilitating learning has not been established. On the other hand, many researchers argue that

advance organizers provide a learning advantage and they find support in such reviews as the one done by Mayer (1979b).

The present study reviews the status of those arguments but the position adopted is consistent with Ausubel's theorizing, namely, that advance organizers are in fact effective learning tools. The present study questions whether or not those studies which purport to show that advance organizers are not effective are in fact a true test of Ausubel's theory, since it may well be that in some cases the advance organizers were not effectively anchored in the learner's cognitive structure. It is a tautology to state that if the advance organizer is not anchored, the benefits to learning and retention postulated by Ausubel do not obtain. The contribution of the current study rests upon the possibility of demonstrating that advance organizers will be effective if measures are taken to ensure that they are successfully anchored in the learner's cognitive structure. It is postulated that a technique designed to ensure an optimal level of anchoring will be likely to demonstrate that advance organizers operate in a manner consistent with Ausubel's theory.

The objectives of the current study are twofold. The first objective is to demonstrate that subjects who are given an advance organizer over combined channels of communication learn more effectively than subjects who either receive the advance organizer at all. The assumption inherent in this

objective is that the multiple channel presentation ensures a more effective anchoring of the advance organizer.

The second objective is to demonstrate that when an advance organizer is successfully anchored, its facilitative effects are more pronounced on delayed rather than on immediate retention measures. Positive results to this second objective would lend credibility to Ausubel's (1963) explanation of the forgetting process in terms of oblitative subsumption. The second objective also assumes that an advance organizer presented in multiple channel fashion offers the best means of slowing down the process of oblitative subsumption.

The thesis is organized into three chapters. In the first chapter, the theory of the advance organizer is explained. This is followed by a review of advance organizer studies. Next the research problem is identified followed by a proposal to ensure the successful anchoring of the advance organizer. Finally, the research problem and hypotheses are stated.

In the second chapter, the sample used in the study is discussed. The materials and testing instrument are described. This is followed by an outline of the procedures used in carrying out the experiment. Finally, a description of the statistical design and analysis procedures is given.

At the end of the thesis a bibliography and appendices

are presented. The appendices contain the visual advance organizer, the print advance organizer, instructions to teachers involved in carrying out the experiment, the astronomy test, the learning passage, personal correspondence, the question used to determine the naïveté of the sample and an abstract of the study.

## CHAPTER I

### REVIEW OF THE LITERATURE

Ausubel (1963) maintains that three conditions are required in order for meaningful reception learning to occur: first, the material to be learned must be meaningful; second, the learner must have a cognitive structure which possesses relevant concepts to which the material to be learned can be related; third, the learner must have a meaningful learning set, that is, he must intend to relate the material to be learned to his cognitive structure in a nonarbitrary and substantive fashion.

The present study investigates how cognitive structure may be optimally manipulated through the use of an advance organizer so that learning and retention are facilitated. Although the present study concerns itself only with how the advance organizer affects the cognitive structure variable, the other two variables are taken into account. For example, the learning passage employed in the present experiment was meaningful in the Ausubelian sense in that it was adapted from a typical school science curriculum. In addition, it is recognized that various learning sets operate during learning, but because in the present study subjects were randomly assigned to both experimental and control groups, it is held that the various learning sets would be equally

distributed across all conditions. Similarly, subjects of various cognitive readiness with respect to the learning task employed in the experiment would also, through random assignment, be evenly distributed among the groups.

In this chapter, Ausubel's (1963, 1968) theory of the advance organizer is outlined followed by a review of advance organizer studies. Next, the problem which is the concern of this study is identified. The next part considers whether three channels of communication used in combination can anchor the advance organizer to cognitive structure more effectively. Finally, the research problem and hypotheses are stated. The chapter concludes with a summary.

#### Ausubel's Theory of Meaningful Reception Learning

Ausubel (1963, 1968) asserts that the existing cognitive structure is the major factor influencing learning. Cognitive structure is the learner's internal representation of the sum total of his life experiences. It is built up through an interaction between the learner's experience and his genetic potential. Anything which is to have meaning for the learner must be interpreted in some form which is recognizable to him through reference to his cognitive structure. In other words, new information is only acquired in terms of what is already known. Ausubel claims that a cognitive structure which contains elements which are relevant

to an understanding of new material to be learned ensures that logically meaningful material will become psychologically meaningful to the learner. Seen in these terms learning is always an idiosyncratic phenomenon (Ausubel, 1963, pp. 41-42).

The importance of the existing cognitive structure in the acquisition of new knowledge through the verbal reception mode is reflected in the importance attached to the individual's readiness for learning. Ausubel (1963, p. 29) defines readiness as the adequacy of the existing cognitive capacity at a given age level for coping with the demands of a specified cognitive task. Readiness is the product of maturation and experience. Ausubel recognizes that the verbal reception mode of learning is not equally effective or suitable for learners of every age since he insists that a state of readiness is required for various types of learning to be achieved effectively and economically.

In those instances where the learner's state of readiness is appropriate to the task at hand, Ausubel (1963, 1968) claims that meaningful learning occurs in the following manner. A learner brings relevant concepts from his cognitive structure to bear upon a learning task. These concepts, which are more inclusive and general than the new information to be acquired, interact with and anchor the new material. The new material is subsequently subsumed and integrated into

the learner's cognitive structure. Ausubel further postulates that this process occurs in a cognitive structure which is hierarchically organized, with the most inclusive and general concepts subsuming less inclusive concepts and principles as well as specific items of information. The major organizational principle is that of the progressive differentiation of a sphere of knowledge from greater to lesser inclusiveness, where each step in the hierarchy is connected to the next higher step through a process of subsumption. It is these subsumptive bonds which provide the anchoring force which enables the existing cognitive structure to subsume the new information. The new information is subsequently assimilated and becomes a part of cognitive structure.

Ausubel's subsumption theory not only explains the learning process. It also accounts for the ultimate forgetting of discrete items of information. He claims that for a time subsumed specifics of information retain their own identity and remain dissociable from the prior existing cognitive structure. However, because it is more economical and less burdensome to retain a single inclusive concept as opposed to a large number of more specific items, the latter learned specifics tend to be replaced and represented by the prior cognitive structure, which has now become expanded and somewhat changed by the inclusion of more information. Ausubel (1963, p. 25) refers to this process as oblitative

subsumption. He conceives of this process as a natural evolution of the original subsumption process.

According to Ausubel (1963, pp. 117-118) learning is influenced by three main cognitive structure variables: (1) the availability of subsuming concepts which are both relevant and inclusive; (2) the stability and clarity of these concepts; and (3) the ability of cognitive structure to discriminate between knowledge that has been acquired and knowledge which is to be learned.

To ensure that these three cognitive structure variables exert their influence in the learning act, Ausubel proposes the use of the advance organizer (AO). The AO is defined by Ausubel (1968, p. 148) as "appropriately relevant and inclusive introductory materials." Ausubel further states that the AO must be introduced in advance of the learning task and must be formulated at a higher level of generality and inclusiveness than the learning task itself (Ausubel and Robinson, 1969, p. 165). Paralleling the hierarchical organization of cognitive structure, the AO bears a superordinate relationship to the subordinate concepts and the more detailed material which are to be learned.

Ausubel theorizes that AO's increase the facilitative action of the three cognitive structure variables. First, with respect to the availability of subsuming concepts, Ausubel argues that the AO mobilizes relevant concepts to

bear upon a learning task. An expository AO is used to serve this mobilizing function when the information to be learned is generally unfamiliar. When cognitive structure is generally devoid of a subsuming concept, the AO itself will act as the subsumer. Once the mobilization of relevant concepts is accomplished, an interaction between the new learning material and the existing concepts occurs. This interaction exploits the relationships between the two sets of learnings and results in the new information being anchored to cognitive structure. The new information is subsequently subsumed and assimilated. Ausubel claims that information acquired in this manner is learned more efficiently and is more resistant to forgetting than when it is arbitrarily related to cognitive structure. Second, discriminability prevents confusion from arising when cognitive structure and the new learning material both contain information which is highly similar. In order to make the information contained in the new learning material more salient, a comparative AO is used to explicitly point out the differences and similarities between the two sets of learnings. Third, to the extent that relevant items in cognitive structure are clear, stable and well organized, learning and retention are facilitated. Conversely, when cognitive structure is unstable and disorganized, learning and retention are inhibited. Ausubel maintains that AO's effect a stabilizing

and organizing influence on the cognitive structure.

While the AO should be more general and inclusive than the material to be learned, it must also be relatable to cognitive structure, otherwise it cannot be expected to form the cognitive bridge between existing concepts and the new material. In order that the AO may provide adequate anchorage for the material to be learned, it must be constructed using language, concepts, and propositions which are already familiar to the learner and it must employ familiar illustrations and analogies (Ausubel, 1963, p. 214).

In summary, the AO is conceived of as a pedagogical device for manipulating the learner's cognitive structure in order to facilitate learning and ensure retention of information for a longer period of time. Ausubel (1963, 1968) contends that AO's facilitate learning either by mobilizing existing relevant concepts or by providing new ones where none exist in order to create a clear and stable conceptual system capable of anchoring and subsuming new ideas. Advance organizers also facilitate learning by discriminating between new material and previously acquired knowledge. Ausubel (1963, 1968) asserts that AO's prolong retention by slowing down the inevitable oblitative subsumption process, a postulate which is tested in the present study.

Review of Advance Organizer Studies

The literature reveals a plethora of studies which test Ausubel's assumption that learning and retention are facilitated by AO's. But the results are mixed. For example, Ausubel (1960) found that an expository AO helped college students do better on a test following a learning passage on metallurgy than a control group who were not given the AO. Ausubel and Fitzgerald (1961) found both an expository and a comparative AO to be significantly better than the reading of an historical passage in facilitating the learning of Buddhism by a group of university undergraduates. Similar results have been reported by Ausubel and Fitzgerald (1962), Ausubel and Youssef (1963), Fitzgerald and Ausubel (1963), Gardner and Schumacher (1977), Karahalios, Tonjes and Towner (1979), Mayer (1979a), Schnell (1973), and West and Fensham (1976). Additionally, Lawton (1977a, 1977b, 1978) demonstrated that the AO not only aided learning and retention but also facilitated a positive transfer of strategies to other problems.

On the other hand, Clawson and Barnes (1973) found no evidence that preorganizers and postorganizers facilitated the learning of structured anthropology materials at either the third-grade or sixth-grade levels. Graber, Means, and Johnsten (1972) found that undergraduates who were given preorganizers and postorganizers did not do better on a test

of chemistry than a control group who did not receive the organizers. Similar results were demonstrated in studies by Jerrolds (1972, pp. 23-29), Koran and Koran (1963), Peterson, Lovett, Thomas, and Bright (1973), and Schumacher, Liebert, and Fass (1975). These investigators found that AO's did not facilitate learning and retention and concluded that they were not effective as learning tools.

Other kinds of mixed results have been reported. Some studies showed that AO's assisted only special groups of learners. Grotelueschen and Sjogren (1968), for example, found that the AO was more effective for high ability subjects while Ausubel and Fitzgerald (1962) and Mayer (1978) found that the AO favored low ability subjects.

Some investigators have attempted to combine organizer modes. In this category of studies, the prose AO was combined with questions by Allen (1970) and Andrews (1972-73); with field experience by Gross and Pizzini (1979) and Pizzini and Gross (1978); and with underlining of key concepts by Proger, Carter, Mann, Taylor, Bayuk, Morris, and Reckless (1973). These investigators have met with varying degrees of success.

#### Identification of the Problem

It is not the purpose of the present study to provide a comprehensive review of AO studies. This has already been

provided by several other researchers (Barnes and Clawson, 1975; Faw and Waller, 1976; Hartley and Davies, 1976; Lawton and Wanska, 1977; Mayer, 1979b; Novak, Ring, and Tamir, 1971). The present study questions the ambiguity of results which characterizes the whole field of investigation about AO's. The concept of the AO is theoretically compelling yet its usefulness as a pedagogical tool does not receive consistent empirical support in the literature. Barnes and Clawson (1975) in their review report that only 12 out of 32 studies showed that AO's facilitate learning. They conclude that the efficiency of AO's has not been established. This contention appears to find support in reviews by Faw and Waller (1976) and Hartley and Davies (1976). Mayer (1979b), on the other hand, points out that the majority of the 44 studies in his review support the pedagogical usefulness of the AO. Support for this conclusion is provided in reviews by Lawton and Wanska (1977) and Novak, Ring, and Tamir (1971).

The inconclusiveness of the results of many AO studies is a perplexing problem, for although Ausubel's subsumption theory of learning is logical and compelling, it still needs to be empirically supported more consistently. The ambiguity in the results must be resolved.

Various explanations have been given for the present state of affairs. One of the more popular arguments used by investigators to explain the ambiguous results found in AO

studies focuses on the construction of the AO. In an uncritical fashion, Lesh (1976a) points out that an ambiguous notion of what an AO is has perhaps contributed significantly to inconsistent results. His observation is not critical of the concept of the AO as such but rather of the investigator who has a poor understanding of it. Indeed Lesh (1976b, 1976c) found that AO's did produce significant positive results. Again, Lesh and Johnson (1976) demonstrated that AO's when combined with models were especially helpful in facilitating learning for fourth grade children.

Other investigators, however, have been openly critical of the potential of the AO to be of any practical use. Cunningham (1972), for example, says the construction of the AO has not been operationalized. Estes (1972, pp. 16-22) says organizers seem definable only on an ex post facto basis, adding that we only know it is one if it works. Hartley and Davies (1976) remark that despite a seemingly strong theoretical base, there is currently no acceptable way of generating or recognizing an AO. Jones (1977, p. 389), however, is of a different mind. He says that the preparations of AO's is not immediately an easy task but becomes so with a minimum of experience. Kahle and Nordland (1975) intimate that the definition of an AO is not clear and hence it would be difficult to construct one.

Ausubel (1978) answers the criticism leveled at AO's.

He reminds his critics that precise operational criteria for an AO and a discussion of how to construct one are contained in his books on meaningful verbal learning and on educational psychology (Ausubel, 1963, 1968). He points out (Ausubel, 1978) that an explicit discussion of the definition, nature, and effects of an AO is contained in various publications (Ausubel, 1960; Ausubel and Fitzgerald, 1961, 1962; Ausubel and Youssef, 1963, Fitzgerald and Ausubel, 1963). There are charges from some quarters that the AO is a vaguely defined concept and that this vagueness is at the root cause of the inconsistent results being reported in AO studies. It can be seen from the foregoing, however, that there is no agreement among investigators on this point.

Ausubel (1978) offers his own reasons to explain the inconsistency. Ausubel (1978) charges that the claim made by Barnes and Clawson (1975) and Hartley and Davies (1976) that most recent studies tend to report negative findings, reflects the highly biased selection of studies reported in their reviews. Lawton and Wanska (1977) agree with this assessment of the Barnes and Clawson review, saying that these investigators appear to have employed no consistent rationale for the inclusion or exclusion of the studies they choose to review. Ausubel further claims that most studies do not properly appraise what concepts are already in the cognitive structure of the learner and what concepts

are to be learned. Such an appraisal is vital if an AO is to be constructed which can bridge the gap between the two sets of learnings. Finally, Ausubel charges that many studies employ tests which require only verbatim retention whereas AO's are designed to favor meaningful learning.

Ausubel's (1978) explanations for the inconsistent results are believable. But are they sufficient to explain away all cases of nonsignificance? Might there not be other reasons for the mixed results being reported? In addressing the problem, it seems important to ask whether or not the AO has been successfully anchored to cognitive structure prior to a learning episode. Ausubel (1963, 1968) states that meaningful learning can only occur when cognitive structure can bring relevant concepts to bear upon a learning task. Ausubel (1963, 1968) further states that the AO mobilizes relevant concepts in cognitive structure or provides them where none exist. If the AO has not been successfully anchored, then the learner in fact has no AO and the postulated benefits of having one cannot be expected. It is a tautology to state that if an AO is not successfully anchored, that is, attached to the learner's cognitive structure, the benefits to learning and retention postulated by Ausubel do not obtain. It serves no useful purpose to argue that an AO which was effective was a true AO while one which did not produce the intended results was not. Such circular reasoning

merely diverts the researcher from looking elsewhere for explanations. When a carefully constructed AO fails to facilitate learning, the investigator may reasonably suspect that it was not effectively anchored.

A general criticism of most AO studies, and in particular of those which do not support the efficiency of using AO's, might be focused on what appears to be an element of carelessness which is common to many AO studies. Almost no one attempts to verify or ensure that the AO is in fact anchored in the learner's cognitive structure. Following this line of reasoning, every effort should be made to ensure that the AO is anchored in the learner's cognitive structure. With this in mind, the present writer explored two lines of thought. The first explored the possibility of devising an instrument capable of testing to determine whether or not the AO was understood by the learner prior to being given the learning task. Positive results to this test would ensure that the organizer was anchored. However, at least two factors vitiate against this approach. First, the construction of such a testing instrument would not be an easy task since the content of an AO is devoid of specific information and contains instead broad generalizations. It is claimed that regurgitation of those generalizations would not necessarily imply that the AO was anchored. At best, such a measuring instrument would have to explore at

length, probably, through personal interview, the learner's understanding of the organizer. Second, the danger exists that in probing to determine whether or not the AO was understood, the AO would become contaminated. This could happen if additional information were betrayed in any of the testing procedures. For example, additional specific information could be provided through the questions asked during the course of the interview. The idea of testing prior to the learning task to determine if the AO is understood is logically compelling but operationally it would be difficult if not impossible to implement.

The second approach to ensuring that the AO would be successfully anchored in the learner's cognitive structure is to consider a way of enhancing the reception and understanding of the AO by the learner. As argued above, if an AO is not successfully anchored, then the learner really does not have an AO. And since the problem of determining whether or not the AO is anchored is difficult if not impossible to solve, the present writer chose to pursue the second approach, namely, of finding a way to facilitate the anchoring of the AO in cognitive structure.

Something which is strikingly obvious when a review of the literature is made is the fact that in virtually every AO study only one channel of communication at a time is used for the presentation of the AO. For example, Mayer (1979a),

Schnell (1973), and West and Fensham (1976) utilized the print channel of communication by employing traditional AO's. The visual channel of communication was used to present the AO's in studies conducted by Bertou, Clasen, and Lambert (1972), Lucas (1973), and Weisberg (1970). An audio presentation mode was employed by Kahle and Rastovac (1976) and Smith and Hesse (1969). None of these investigators attempted to combine channels of communication in presenting the AO.

While some investigators employed various channels of communication in presenting the AO, other investigators used AO's which departed quite radically from the traditional prose type of AO originally described by Ausubel (1963, 1968). Games were used as AO's by Livingston (1970) and Scandura and Wells (1968). Mathematic concepts were used as AO's by Bright (1976), Eastman (1977), and Lawton and Fowell (1978).

Superordinate sentences have been used as AO's by Cashen and Leicht (1970), Gagné and Weingand (1970), and Richards (1975-76). Richards and McCormick (1977) employed topic sentences as AO's. Bayuk, Proger, and Mann (1970), and Smith (1973, pp. 83-85) used topic or underlined sentences combined with questions as AO's.

Special forms of the AO have been used. Among these was one employed by Peeck (1970) consisting of prequestions. Rickards and Di Vesta (1974) gave an AO to one group which consisted of meaningful learning questions. As an AO,

Yawkey and Dashiell (1973) used performance statements describing the behavior learners were to exhibit after completing a lesson. What all of these studies have in common, including the ones reviewed earlier, is the fact that in presenting the AO only one channel of communication at a time is used. Why have they not been used together? It seems important to consider this question since it may provide a clue to a solution of a very perplexing problem, namely, the inconsistency of results being reported in AO studies.

The Effects of Channels of Communication upon  
Advance Organizers

The writer's orientation to the problem of inconsistent results is to look for a way of enhancing the opportunity to anchor the AO. Therefore, the possible effects various single channels of communication and combined channels of communication could have upon anchoring the AO to cognitive structure is explored here.

The three channels of communication chosen to be explored are those most commonly used by learners in a typical school setting, namely the print, audio, and visual channels. Although the tactile channel is used to a limited extent by learners in the primary grades, its use beyond that level is practically nonexistent. Therefore, from the point of view of a typical school environment the print, audio, and visual

channels of communication are the most common transmitters of information and are therefore of prime consideration for the purposes of this study. As remarked earlier, the majority of AO studies use only one channel of communication in their attempt to anchor the AO. The use of a single channel of communication makes no allowances for learners who may be more adept at using another communication channel. It is possible that within a single group of learners some learn best when the learning material is presented in print form while others prefer a visual or verbal (audio) presentation. When dealing with a group of supposedly multi-modal learners, it is possible that a multiple channel presentation respects individual differences within the group.

There is some evidence in the literature to support this position. Gropper (1962) has shown that depending on the I.Q. level of the learner there is a learning advantage to using a verbal or visual mode of presentation. He points out that high I.Q. learners profit more from a verbal program, in terms of being able to later verbalize a concept, than from a visual program, while low I.Q. learners are better able to take advantage of a visual program. Hartman (1961) made an extensive review of the literature dealing with channels of communication. He arrived at generalizations concerning the relative effectiveness of the print, audio, and visual channels of communication for learning meaningful prose. An

examination of 23 studies revealed that the results of 11 studies favored the audio channel, 9 favored the print channel, and 3 showed no differences. Hartman also observed that the audio channel was preferred by young children. It was also preferred when the learning material was relatively simple. Conversely, the print channel offered the best learning advantage when the subjects were older children and adults and when the difficulty of the learning material for the learner increased. A similar analysis comparing the learning effectiveness of the print, audio, and visual channels of communication revealed that the visual channel was more advantageous than either the print or the audio channel.

Kent (1962) observes that some people are more visually oriented than others, and for them a concept which is obscure in its verbal form is often made less so through the use of a model. Moreover, he says the model permits more to be absorbed in less time. Zil'bershtein (1963) points out that a schematic representation enables subjects to get an idea about different objects and phenomena as a whole as well as about their component parts. Interrelationships can be shown visually and graphically. What these studies show is that there are factors residing in the individual learners which make one channel of communication more effective than another. It follows that if one wishes to anchor an AO effectively, these factors must be taken into consideration.

There is also evidence in the literature to suggest that a combination of channels of communication is often superior for the purpose of learning to a single channel. Bransford and Johnson (1972) found that students' recall of passages presented orally was facilitated by the prior presentation of a pictorial illustrating the verbal information. Hartman's (1961) comprehensive review shows a learning advantage when information is presented using multiple channels. For example, when the presentation of information using an audio-print combination was compared to an audio presentation, the results favored the presentation in combined channels. When the same audio-print combination was compared to a print combination, the results in terms of learning and retention were overwhelming in favor of the combination. Hartman (1961) also reported results which show that a combined pictorial-audio presentation is more advantageous than when the information is presented over either the pictorial or audio channel alone. The evidence from the studies reported by Hartman (1961) strongly indicates an advantage for presentations using the combined channels of communication over presentations employing single channels of communication.

Kent (1962) describes a model as diagrammatic representations. He points out that models and words complement each other and that the two together are often more effective in transmitting information than either one alone. Luchins

(1961, p. 14) observes that audiovisual devices (which essentially utilize the print, visual, and audio channels of communication) can be vital instruments to elucidate and clarify ideas and concepts and to bring about a search for insight into structural relationships of the concepts and skills being taught. Using descriptive geometry as content, Rankowski and Galey (1979) found that subjects using a multimedia approach obtained significantly better results than a control group who did not use that approach. The two groups were compared on achievement, problem solving, and attitude toward the subject taught. Rohwer and Harris (1975) found that presentations using combinations of audio, print, and pictorial channels of communication helped low socioeconomic black children more than single media presentations. Rohwer and Matz (1975) showed that fourth grade students achieved better results using an oral presentation accompanied by pictures than using an oral presentation accompanied by print. Zil'bershtein (1963, p. 35) says that there is an inseparable connection between thinking in terms of visual images and thinking in terms of words and concepts. He goes on to say (Zil'bershtein, 1963, p. 41) that combining visual aids with oral explanations can be effective.

From the results reported in these media studies, it seems reasonable to expect that the positive effects upon learning resulting from presentations which use a multiple

channel approach should also apply to the learning of AO's. Several AO studies have given some indication that such is likely to be the case. For example, Jones (1977) combined the audio and visual channels of communication by presenting the AO using an audio tape and slides. Significant differences in favor of the AO group was noted. Kahle and Nordland (1975) used an AO consisting of a 500 word tape recording, a brief film loop and a short experiment which the AO group was obliged to perform. It did not prove effective in facilitating learning. The AO was combined with concrete illustrations and a delayed review in a study conducted by Kalt and Barrett (1973). Learning and retention were significantly facilitated by this combination. Kuhn and Novak (1970, 1971) combined an 800 word expository AO with a diagram and presented it to undergraduate students studying a unit in biology. The results favored the combined AO group over a control group of students who had not been given any AO treatment. In a study of the concepts of equilibrium and ecological systems in science, Pella and Triezenberg (1969) combined a prose AO with models and found that this combination proved more effective than when the prose AO was used alone. However, significance only held at the comprehension level and not at the knowledge and application levels.

Proger, Taylor, Mann, Coulson, and Bayuk (1970, p. 32) conclude from the Pella and Triezenburg (1969) study that

combining two media in an AO treatment can be more effective than a single medium.

Of the studies reviewed here which used combined channels of communication to present the AO, only one failed to demonstrate that learning and retention were facilitated. All of the others demonstrate positive results. Thus, they offer enough encouraging evidence to warrant a further investigation, since they may provide a clue to a way of ensuring that the AO is successfully anchored in the learner's cognitive structure.

#### Research Problems and Hypotheses

On the basis of the foregoing, it seems reasonable to postulate that an AO which is presented through a combination of audio, print, and visual channels of communication will stand a better chance of being successfully anchored than if it were presented using only a single channel of communication. Anchoring the AO to cognitive structure is an essential requirement in Ausubel's theory. Efforts at maximizing the chances of anchoring the AO to cognitive structure are what is generally lacking in previous studies. The present study proposes to show that presenting the AO over multiple channels of communication will provide that added chance. Evidence confirming or abrogating this contention will be found in the performance results of the treated groups.

Accordingly, specific tests of the foregoing postulate will be found in the following hypotheses:

1. Subjects receiving an AO obtain higher scores on tests of retention than control subjects not receiving an AO, with the greatest part of the difference being attributable to subjects receiving the multiple channel presentation of the AO.
2. Of the three tests of retention administered, the third test of retention contributes most to the treatment difference. This is due to the fact that AO's are postulated to slow down the obliterative subsumption process, the result of which is more likely to be evidenced on delayed rather than on immediate tests of retention.

#### Summary

To recapitulate, the advance organizer is predicated on a theory of cognitive organization that presupposes a hierarchically organized structure according to the principle of progressive differentiation. The advance organizer is a pedagogic device for manipulating this cognitive structure to influence learning. It is presented at a higher level of abstractness and generality than the learning task which it precedes, and it seeks to facilitate learning and retention by enhancing discriminability and by clarifying, stabilizing, and organizing the cognitive structure. The first chapter also reviewed AO studies, identified the problem of this report and explored how channels of communication might be utilized to maximize the chances of anchoring the AO to

cognitive structure. Finally, the research problem and hypotheses were stated.

## CHAPTER II

### EXPERIMENTAL DESIGN

This chapter begins with a description of the sample employed in the study. The materials employed in the experiment and testing instrument used to gather the data are reported upon and discussed. The methods and experimental procedures developed for this investigation are described in detail. A description of the statistical design and analysis procedures is given. The chapter concludes with a summary.

#### Sample

The sample was drawn from a population consisting of students enrolled in grade nine classes under the jurisdiction of a New Brunswick urban-rural school district. A total of 325 students were included in the sample.

The decision to conduct the investigation at the grade nine level was made because the materials used in the present study were recognized to be appropriate for this age group. Pilot work established that grade nine students possessed a level of verbal ability which would allow them to respond meaningfully to the verbal nature of the learning task involved in the experiment.

### Materials

Since this study required a visual advance organizer, a decision was made to adopt the one developed by Barron (1970) for his investigation. It is presented in Appendix 1. This decision was based on two reasons. First, Barron (1970) has developed and reported upon a prose (print) advance organizer which is a parallel form of his visual advance organizer. Barron claims that both forms of the advance organizer treat the same ideas at similar levels of abstraction and generality. An advance organizer constructed in both visual and print modes was required for the purposes of the present study since a multiple-channel presentation was being assessed. Second, to this writer's knowledge, only Barron (1969, pp. 29-39) has operationally defined the visual advance organizer. He termed his graphic (visual) advance organizer a "structured overview" and defined it as the hierarchical ordering of principles, concepts, and details within the content of a subject matter area (Barron, 1969, p. 31). The content principles concepts, and details in a learning passage are identified and matched up with their own unique words. The identified vocabulary is next depicted through a diagram which highlights not only the importance of each word but also the relationships between them. When this graphic representation is presented in conjunction with

a verbal discussion, the resultant combination is termed a structured overview (Barron, 1969, p. 32). Because in a structured overview the relationship of the structure of a new unit of work to the course as a whole is shown, and because new information is related to previously acquired relevant subsuming concepts, Barron claims that it takes on the characteristic functions of Ausubel's advance organizer. This position is endorsed by Ausubel (1969).

A structured overview was used by Estes, Mills, and Barron (1969, pp. 40-47). They define the structured overview very succinctly as a visual and verbal representation of the key vocabulary of a learning task in relation to more inclusive or subsuming vocabulary concepts that have previously been learned by the student (Estes, Mills, and Barron, 1969, p. 41).

In addition to the visual advance organizer, Barron's (1970) print advance organizer which is presented in Appendix 2 was also employed. As mentioned above, it is a parallel form of the visual advance organizer in the sense that it utilizes the same key vocabulary from the learning passage and it is claimed to relate to the learning material at the same level of generality and abstraction as does the visual form. The print form also seeks to mobilize the same or related relevant subsuming concepts assumed to exist in the learner's cognitive structure.

A tape recording of the print form of the advance organizer constituted another part of the material utilized in the present study. A tape recording was used in preference to having the advance organizer read to each group by various readers in order to control for different extraneous clues which might be picked up if several readers were employed. The recording was played in conjunction with the print presentation. The fact that the text used in the tape recording was identical to the text used in the print AO respects the research findings. Hartman (1961) states that the supremacy of the audio-print combination over either channel alone is realized when the information in the combined channels is redundant.

A shield designed to allow a tachistoscopic presentation of the print organizer from an overhead projector unto a screen was also used in the present study. The decision to present the print form of the advance organizer in tachistoscopic fashion in conjunction with the audio recording heeds the research findings. Hartman (1961, p. 256) noted that the practice of exposing large amounts of print well ahead of the introduction of the audio channel puts the reader of the print well ahead of the audio voice. The facilitation effect, consequently, is lost. The aperture in the shield was therefore designed to expose only three lines of the print AO at a time, the line being read

from the tape recording and the lines before and after.

The learning passage given to the subjects was adapted from Barron (1970). It consists of approximately 2,300 words dealing with characteristics of the stars. Its readability is approximately at the grade eight level.

### Measuring Instrument

The research design used in the present investigation required that a measure of retention based on a learning passage studied by all subjects be taken at three different times. The first retention measure followed immediately upon the completion of the learning passage (day 3), the second was taken after a 2-day delay (day 5), and the third was taken after a further delay of 12 days (day 17). To obtain the retention measures, it was decided to use a test developed and used by Barron (1970) since it was compatible with the other materials chosen for the present study. This instrument is termed the Astronomy Test (AT) and it consists of 24 multiple choice items of five options each. It is designed to measure information acquired from the learning passage at the "knowledge" and "comprehension" levels as defined in Bloom's (1956) taxonomy. That the AT test is designed to measure at the lower end of the taxonomic scale is in keeping with what Ausubel (1963) maintains is the more proper function of the advance organizer. He argues that

the facilitative influence of the advance organizer is more pronounced when it is required to aid the recall of specifics and less so when it is required to function at the upper levels of the taxonomy. He bases his argument on the premise that the more abstract and general material has its own built-in organizers.

To ensure that answers to all test items could be found in the learning passage, the test and learning passage were closely scrutinized by three grade nine science teachers and the investigator. The four people concluded that both instruments were compatible. This same exercise also yielded an answer key, with all four people in unanimous agreement as to which option in each item constituted the correct response.

#### Experimental Procedures

Prior to the experiment, a pilot study was conducted to reveal, and eliminate if necessary, two potential threats of contamination to the experimental conditions. The first is related to observations made by Ausubel and Youssself (1963) and by Ausubel and Fitzgerald (1961, 1962) who showed that subjects with prior background knowledge in the learning task scored higher on the criterion test than more naïve subjects but that they derived less benefit from the advance organizer. The second potential threat was in the

possibility that the AO in any of its three forms (visual, oral, print) might contain information which could be useful in answering the items on the retention test, thereby providing an advantage to the treatment groups.

To investigate whether either one or both of these two potential situations might be operative during the experiment, the following checks were made. First, an examination of the science curriculum used by the subjects participating in the research experiments was undertaken. This examination revealed that the school curriculum did not contain any content used in the learning passage and it was therefore assumed that prior knowledge would not likely have been transmitted by school instruction.

Second, to investigate if prior knowledge could have been acquired outside of school through independent activity or reading, another check was made. Just prior to receiving the learning passage on day 3 of the experiment, all participating subjects were required to respond to a single question relating to the topic of the learning passage. A review of the responses revealed that only 10 subjects answered the question correctly. Accordingly it was assumed that the sample taken as a group was naïve with respect to the learning passage used in the experiment.

Third, to determine whether or not the AO in any of its three forms (visual, audio, print) would reveal information

that could assist the treatment groups in answering test items, the following procedure was undertaken. Prior to conducting the present experiment, a sample of 56 grade nine students who did not participate in the experiment but who were exposed to the same school curriculum were given the advance organizer treatment in its three forms. They were then required to respond to the astronomy test used to measure retention without the benefit of having read the learning passage upon which the test was based. The results showed a mean score slightly below a chance score. On this basis it was concluded that the AO's did not reveal information which could be used in answering test items.

For the purposes of the present study, the 325 grade nine students were randomly assigned to three groups, two experimental groups and one control group. This was accomplished by assigning a number from 1 to 325 to each subject in the sample. These numbers were then randomly chosen without replacement and alternately assigned to one of the three groups.

The school principal and 11 teachers were involved in executing the experimental procedures. Training sessions were held with them prior to the experiment during which time the purpose of the study was outlined, the experimental materials displayed and the procedures described and demonstrated. In addition to the training sessions, written

instructions were given to each teacher which described in detail how each activity was to be carried out. Details of the procedures are presented in Appendices 3, 4, 5, and 6.

For the purpose of brevity, the three groups of subjects are identified as follows: subjects receiving the multiple-channel presentation of the AO are termed the MCAO group; subjects receiving the print AO only are termed the PAO group; subjects serving as controls are called the C group. For the first three days of the experiment, the subjects were exposed to their respective treatments for 5 minutes each day. The subjects were informed they were participating in an experiment and that they would be informed of the results when it was over.

On day 1 of the experiment, the MCAO group received the "structured overview" in prescribed fashion, the PAO group was exposed to the AO in the print form only, and the C group worked on an unrelated exercise. On day 2, the MCAO group listened to a tape recording of the print organizer while simultaneously reading it from a tachistoscopic presentation projected onto a screen from an overhead projector. The PAO and C groups were exposed to the same treatment as on day 1. On day 3 of the experiment, both the MCAO and PAO groups read the print form of the advance organizer while the C group again engaged in an unrelated activity. At the conclusion of day 3 both experimental groups had received the AO in their

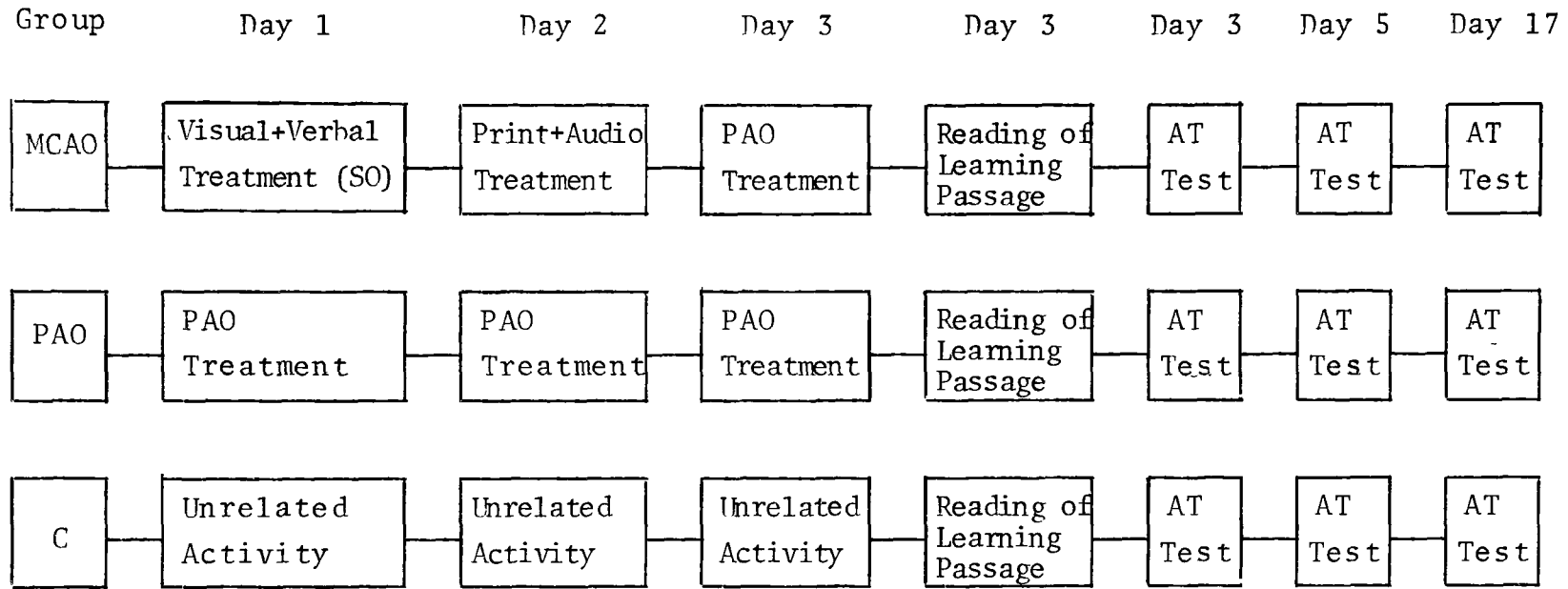
respective forms an equal number of times.

Immediately following this day 3 treatment, all subjects were given 25 minutes to read and review the astronomy learning passage. After 25 minutes had elapsed, all subjects were given 30 minutes to complete the Astronomy Test (AT). Pilot work with grade nine students not employed in the experiment established that the reading time of 25 minutes and the testing time of 30 minutes were appropriate. The same AT test was responded to on two other occasions, once 48 hours after the first administration of the test and again 2 weeks after the first administration. Three retention measures were thus obtained on each subject. Figure 1 presents a flow chart of the experimental procedures. The possibility of transfer effects from one administration of the test to another were minimized by changing the order of presentation of the test items for the second administration and using this new format but changing the position of the correct option in each item for the third administration.

#### Statistical Design and Analysis of the Data

To accommodate the variables investigated in this study and to answer the research questions, a two-way repeated measures design was used. The design is illustrated in Figure 2. The treatment factor is fixed.

The data was analyzed using a program capable of handling



Legend: MCAO = Multiple channel advance organizer group  
 PAO = Print advance organizer group  
 C = Control group  
 SO = Structured overview  
 AT = Astronomy test

Figure 1. Flow chart showing experimental procedure.

	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>
T <sub>1</sub>			
T <sub>2</sub>			
C			

n for all cells = 60

Legend: T<sub>1</sub>, T<sub>2</sub>, C = Treatment and control groups

M<sub>1</sub>, M<sub>2</sub>, M<sub>3</sub> = Retention measures

Figure 2. Research design.

a two-way ANOVA with one factor repeated. A post hoc analysis appropriate to the data and to the questions asked was performed. The actual analysis and reporting of results are presented in the next chapter.

#### Summary

To recapitulate, Chapter II identified the sample used in the study. The materials employed in the study and the testing instrument used to gather the data were also described and discussed. The experimental procedures were outlined in detail. A description of the statistical design and analysis procedures concluded the chapter.

## CHAPTER III

### PRESENTATION AND DISCUSSION OF RESULTS

In Chapter III the research problem and the hypotheses associated with it are reiterated. The data are analyzed and the results interpreted and summarized in a series of tables. This is followed by a discussion which considers the theoretical and practical implications of the results from the testing of the hypotheses. The implications for further research are given in the next section along with the theoretical and practical contributions considered to be made by the present study. The chapter concludes with a summary.

#### Reiteration of the Research Problem

The present study has two main objectives. The first is to demonstrate that subjects who are given an AO over combined channels of communication will learn more effectively and retain information longer than subjects who either receive the AO in the traditional print form or who do not receive any AO at all. Postulating a learning advantage for the AO group is consistent with Ausubel's (1963) claim that AO's stabilize and organize the learner's conceptual system and cause relevant subsuming concepts to bear upon a learning task. The result, according to Ausubel, is more effective

learning which is retained for a longer period of time. This hypothesis is a direct extension of the theory.

In hypothesizing the greatest learning advantage for the multiple channel AO group, as opposed to the print AO group, the postulate goes a step further and is an attempt at answering the concern raised in the literature over the reporting of inconsistent results. Arguing that the failure of some studies to show that AO's facilitate learning was due to the inability of the investigators to successfully anchor the AO in the cognitive structure of the learner, the present writer sought to overcome this shortcoming by maximizing the treatment effects. Supported by evidence from the literature, it was decided that one precaution which could be taken to ensure that the AO was successfully anchored was to present the AO over several channels of communication in combined fashion.

The second objective of the study is to show that where the AO facilitates the retention of knowledge, the results would be more pronounced on delayed than on immediate tests of retention. This hypothesis stems from Ausubel's explanation of forgetting. He describes it as a proactive phenomenon which is viewed as a later temporal phase of the subsumption process called oblitative subsumption. In this process new specific items of information lose their identity and cease to exist as distinguishable entities in themselves.

This occurs as they are assimilated by the existing conceptual system. Having lost their own identity and thus fallen below the threshold of recall, they are now an indistinguishable and undissociable part of the cognitive system which they have modified. Ausubel postulates that the introduction of an advance organizer slows down the oblitative process. If indeed his theory is valid, then subjects exposed to the advance organizer should exhibit a greater retentive power for a longer period of time.

The postulates inherent in these two objectives were examined by testing the following hypotheses in the null form:

1. Subjects receiving an AO obtain higher scores on tests of retention than control subjects not receiving an AO, with the greatest part of the difference being attributable to subjects receiving the multiple channel presentation of the AO.
2. Of the three tests of retention administered, the third test of retention contributes most to the treatment difference. Stated with reference to the sample, there will be an advance organizer-dependent measure interaction; that is, the difference in means between the MCAO subjects and the C subjects on the first retention test will increase on the third retention test.

#### Analysis and Interpretation

The original sample numbered 325 subjects. This number was decimated as a result of subjects being excluded from the sample for several reasons. Subjects were excluded if they missed any of the three retention tests administered or

if they were absent on any of the days during which the treatment was given. In addition, those subjects identified as having prior knowledge of the learning task were dropped from the sample. This resulted in cells with unequal numbers. Accordingly, subjects were dropped randomly from those cells which had greater numbers of subjects than the cell with the least number of subjects. This left the scores of 180 subjects to be analyzed.

The research design is a two-way repeated measures design. The BMDP2V program (1977) was used to analyze the data. This program performs an F test. The F test is a robust one which is unaffected by some departure from variance equality and by moderate deviations of treatment distributions from normality (Keith, 1972, p. 128).

The first hypothesis states that subjects receiving an AO in multiple channel fashion obtain higher mean retention scores than subjects receiving an AO in the print mode only and higher than subjects not receiving any AO at all. The means for the treatment groups show this prediction to be true. The results are presented in Table 1. With the alpha level established at 0.05, an analysis of variance was performed to determine if the mean differences were significant. The results of the analysis of variance show that the differences are significant. The null hypothesis of no difference among treatment groups is therefore rejected. The results

Table 1  
Means of Treatment Groups

Group Classification	N	Mean
Treatment one (MCAO)	60	11.64
Treatment two (PAO)	60	10.74
Control (C)	60	9.09

of the analysis of variance are presented in Table 2.

The analysis of variance tells us that the treatment factor is significant but it does not reveal where this significance occurs. Consequently, a post hoc analysis was made to determine which means differed significantly from each other. The Scheffé test, which is a robust post hoc procedure, was chosen for this purpose. The results of the post hoc analysis are presented in Table 3. They show that both treatment means differ significantly from the control mean but that the treatment one mean (MCAO group) is not significantly different from the treatment two mean (PAO group).

The second hypothesis states that the mean difference between treatment one subjects (MCAO group) and control subjects (C group) on the first retention measure will increase on the third retention measure. This hypothesis was tested because it was postulated that any facilitative action of an AO presented in multiple channel fashion would be more pronounced on the long term rather than immediately. The means and standard deviations of the scores for each group involved in the TM (treatment-dependent measure) interaction are presented in Table 4. The results are in the predicted direction. The significance of the results in Table 4 was tested by subjecting the data to an analysis of variance at the 0.05 level. The analysis of variance shows the TM

Table 2  
Summary of Analysis of Variance for Treatments

Source of Variance	SS	df	MS	F
Treatments	601.604	2	300.802	10.04*
Error	5302.033	177	29.955	

\*p = 0.001

Table 3

Scheffé Simultaneous Confidence Intervals  
for Simple Contrasts of Means for Main Effects

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Contrast of Means	Scheffé Simultaneous 95% Confidence Intervals
$T_1$ (MCAO) - $T_2$ (PAO)	-0.519 to 3.330
$T_1$ (MCAO) - C	1.125 to 3.975
$T_2$ (PAO) - C	0.220 to 3.069

---

Table 4  
Means and Standard Deviations for Each  
Group Involved in the Test of  $H_0$

Group Classification	N	Mean	SD
$T_1M_1$	60	11.92	3.8
$CM_1$	60	9.85	3.7
$T_1M_3$	60	11.30	3.9
$CM_3$	60	8.53	3.4

Legend:  $T_1$  and C = Treatment one (MCAO group) and  
Control (C group)  
 $M_1$  and  $M_3$  = Retention measures one and three.

interaction to be significant. The results are given in Table 5.

A Scheffé post hoc test was used to determine where the significant interaction was occurring. The results of this analysis reveal that the interaction did not occur between the means which were predicted. The null hypothesis of no difference between the mean difference of treatment one subjects and control subjects on measure one and the mean difference of treatment one subjects and control subjects on measure three  $(T_1M_1 - CM_1) - (T_1M_3 - CM_3)$  could not be rejected at the 0.05 level of significance. The second research hypothesis as stated was therefore not supported. This analysis is presented in Table 6.

#### Implications of the First Hypothesis

The hypotheses tested in the present study are derived from Ausubel's (1963) theory of how the human nervous system processes and stores information. Ausubel's theory states that where existing cognitive structure is clear, stable and well organized, learning and retention are facilitated. Cognitive structure is posited to be strengthened by the advance introduction of relevant subsuming concepts termed advance organizers. Advance organizers are mediators which bridge the gap between what is known and what needs to be known. Introduced at a higher level of abstraction, generality,

Table 5  
Summary of Analysis of Variance for Treatments  
by Measure (TM) Interaction

Source of Variance	SS	df	MS	F
TM	71.285	4	17.821	3.97*
Error	1589.733	354	4.491	

\*p < 0.05

Table 6

Scheffé Simultaneous Confidence Intervals for Simple  
 Contrasts of Means for the Treatment by  
 Measure (TM) Interaction

Contrast of Means	Scheffé Simultaneous 95% Confidence Intervals
$(T_1M_1 - CM_1) - (T_1M_3 - CM_3)$	-2.392 to 0.992
$(T_1M_2 - T_2M_2) - (T_1M_3 - T_2M_3)$	-3.242 to 0.142
$(T_1M_1 - T_2M_1) - (T_1M_3 - T_2M_3)$	-3.475 to -0.091

and inclusiveness, they function to mobilize relevant existing concepts which serve as anchoring foci for the incorporation of new ideas. This theory was tested with hypothesis one and it was supported.

The first hypothesis predicted that subjects who are presented the AO in multiple channel fashion would derive the greatest learning advantage. Not only did subjects who received AO's obtain higher scores on the AT test of retention, but the group which was given the AO over three channels of communication obtained the highest mean score of all. The differences of the treatment groups from the control group were shown to be statistically significant. Such a demonstration of the facilitative effects of AO's has not always been shown. Indeed, reviews of AO studies by Barnes and Clawson (1975), Faw and Waller (1976), and Hartley and Davies (1976) point out the ambiguity of many results. Why was the present study successful in demonstrating Ausubel's claims? Why was the multiple channel presentation of the AO superior to the presentation over the print channel alone?

This writer advances the argument that many previous studies were unsuccessful in substantiating Ausubel's claims because the AO was never successfully anchored in the learner's cognitive structure. It is a tautology to state that if the AO is not anchored, the proposed benefits of improved learning and prolonged retention do not obtain. The task, then as the

present writer perceived it, was to increase the opportunity of successfully anchoring the AO in the cognitive structure of the learner. In other words, there was a planned and deliberate attempt to maximize treatment effects. It was postulated that this could be accomplished by presenting the AO over three channels of communication. The three channels chosen were the ones most frequently involved in post elementary learning, namely, the print, audio, and visual channels. This tack was obviously successful, and a theoretical explanation for its success is offered here.

Ausubel states that existing concepts relevant to the learning task must be mobilized and brought to bear upon the learning task. He proposed to do this through the use of a print AO which along with existing concepts, bring particularized relevance to the learning task. Others sought to accomplish the same thing employing audio or visual AO's. A plausible explanation as to why many of these efforts failed is that the AO presented over a single channel of communication often does not exert a sufficient mobilizing influence to cause an optimum number of neural structures to bear upon a learning task. A key term in this explanation is optimum. This writer posits the idea that when less than an optimum number of neural structures are activated, only a weak anchoring effect results. Conversely, when many schemas relevant to a learning task are mobilized, a powerful

anchoring effect results.

A fuller explanation is required to appreciate this reasoning. Whatever is learned through the print channel of communication is in all likelihood accompanied by concomitant and redundant learning over the audio and visual channels of communication. In other words, with respect to a learning task, one channel of communication may serve as the principal transmitter of stimuli to the cortex but the remaining channels of communication serve a secondary role in transmitting redundant information, perhaps from different but complementary perspectives.

Multiple channel learning has implications for the storing of information. Whatever is learned through each channel of communication is stored in overlapping fashion, with the learnings acquired over each channel of communication occupying a definite space in the nervous system in close proximity to each other. With respect to a particular learning task, whatever is learned through the principal channel of communication enjoys a high profile in the cognitive structure but it is flanked on all sides by schemas which are different but complimentary and overlapping and which contain redundant information. All of these schemas, the primary one with its satellite neighbors, form the superordinate schema which is the complete neural representation of a learned item or idea. It is this superordinate schema

with its subordinate parts which contains the optimum number of schemas related to a learning task. It is this superordinate whole which must be mobilized. The AO presented in multiple channel fashion optimizes the chances of bringing the whole schematic composite to bear upon the learning task.

When the superordinate schema is mobilized, the various subordinate schemas within the whole drop "cognitive hooks" which anchor the new idea to the conceptual system. The primary or principal schema within the superordinate schema drops the cognitive hooks with the greatest anchoring power while the related schemas drop secondary hooks having a weaker and peripheral anchoring power. The peripheral schemas, nevertheless, assist in anchoring the new idea to the existing conceptual system. A model of the superordinate-optimal schema explanation is presented in Figure 3. The solid lines indicate primary influences while the broken lines represent secondary influences.

#### Implications of the Second Hypothesis

The second hypothesis states in effect that the beneficial effects of the AO upon retention will be demonstrated more dramatically on the long term rather than on the short term. Specifically, this interaction hypothesis states that the difference between treatment one subjects and control subjects on measure one will increase on measure three. The

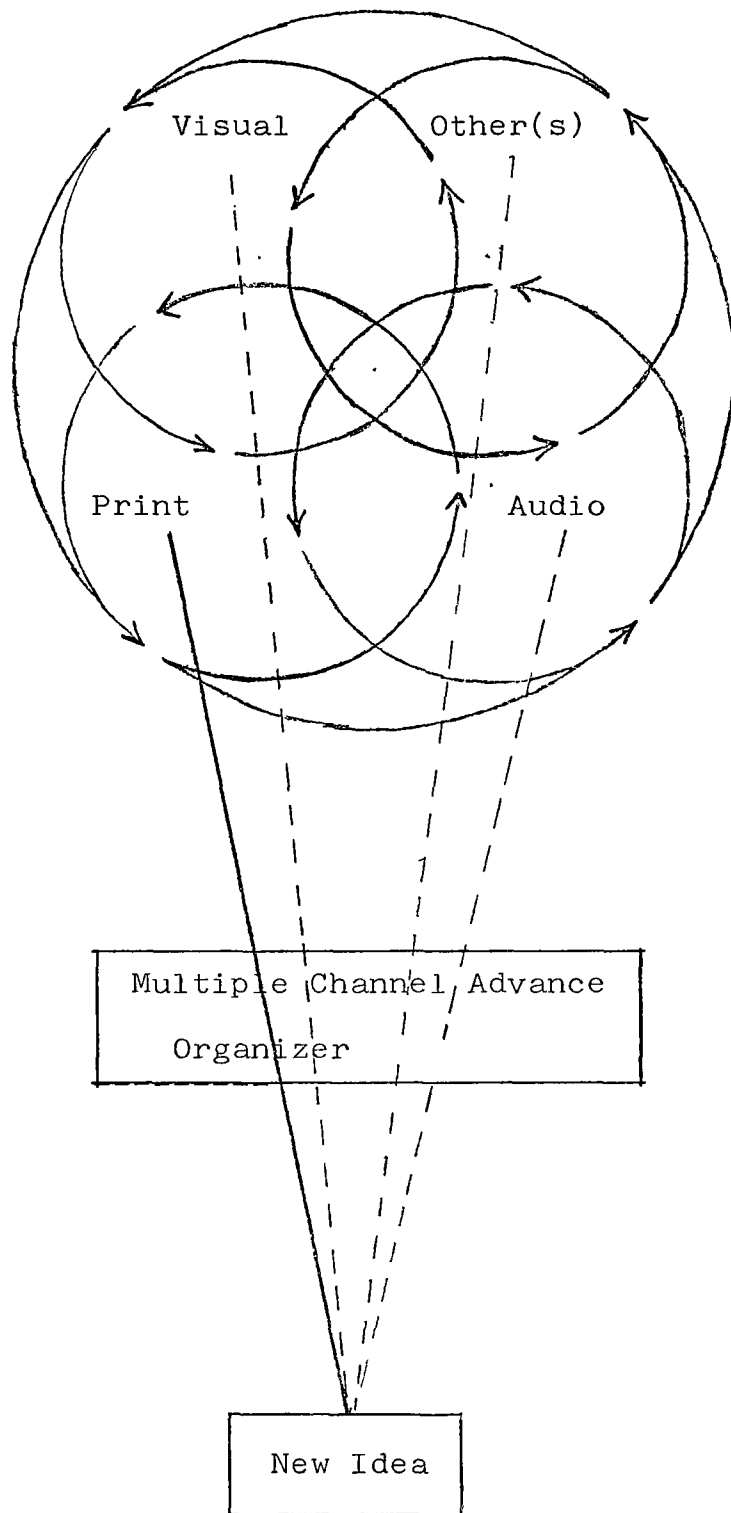


Figure 3. Superordinate-Optimal Schema Model.

hypothesis stems from Ausubel's explanation of forgetting.

Forgetting is explained by some theorists using a retroactive design. By this is meant that subsequent learning experiences, which are similar to but not identical with previously learned material, exert a retroactively inhibitory effect on the retention of the previously learned material by virtue of causing confusion between the two sets of learnings. Ausubel, on the contrary, explains forgetting in a paradigm of proactive inhibition. In this model, all subsequent learning falls prey to the erosive influence of the conceptualizing trend; that is newly learned material gradually loses its distinctive identity as it becomes assimilated into the existing cognitive system. Newly learned items will therefore become indistinguishable and no longer dissociable from the prior existing conceptual system. Ausubel terms this forgetting process oblitative subsumption. He contends that AO's slow down the oblitative process, thereby maintaining newly learned items above the threshold of recall for a longer period of time.

If indeed Ausubel's claims are valid, the facilitative effects of the AO upon retention should be particularly noted on the long term. Immediately following a learning task, the newly learned material, whether aided by AO's or not, is more likely to be recalled with accuracy on immediate recall rather than on delayed recall. But even on immediate recall, subjects

who receive AO's do better on tests of retention because information is better organized in the nervous system with which it interacts. However, it is on delayed tests of retention where one would expect subjects who received the AO to demonstrate their superiority more forcefully. If the erosive influence of the conceptualizing trend is slowed down by the introduction of AO's as Ausubel postulates, then subjects not receiving AO's should be more susceptible to oblitative subsumption and hence have the newly learned items fall below the threshold of recall more rapidly.

Since the second hypothesis as stated was rejected at the 0.05 level, this expectation was not supported. It is interesting to observe, however, two facts which show up in the analysis and which are evident in the interaction between treatments and measures depicted in Figure 4. First, the difference between the means of treatment one and control subjects on the first retention measure increases on the other two retention measures, with the greatest difference noted on the third retention measure. This occurrence is as predicted even though it is not statistically significant at the 0.05 level. Second, and equally interesting is the fact that the difference between treatment one and treatment two subjects on the first retention measure is significantly different from the difference between treatment one and treatment two subjects on the third retention measure at the

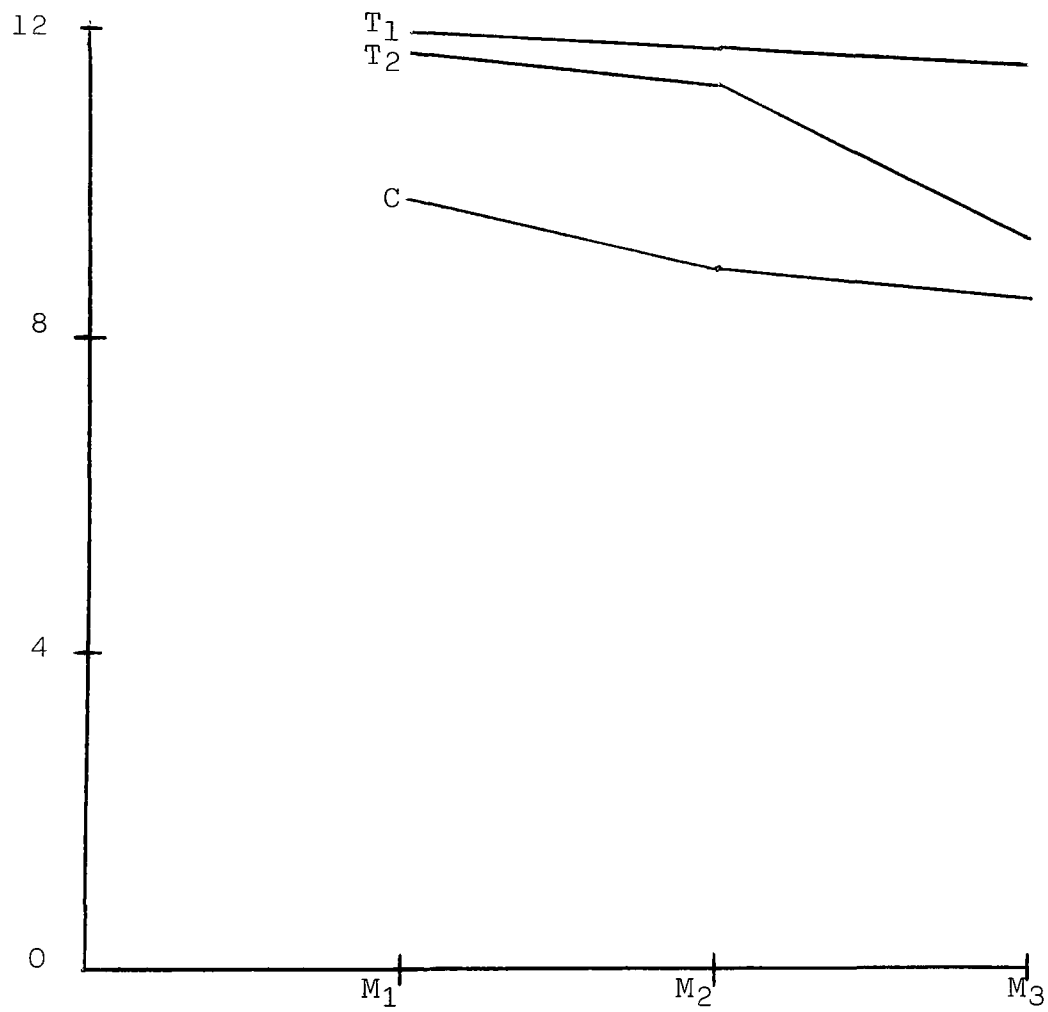


Figure 4. TM (Treatment-Dependent Measure Interaction).

0.05 level. This significant interaction demonstrates the greater effectiveness of treatment one over treatment two. This same conclusion can be drawn from the post hoc analysis given in Table 6. The 95% confidence interval for the  $(T_1M_1 - T_2M_1) - (T_1M_3 - T_2M_3)$  contrast is -3.475 to -0.091. Since zero is not included in this interval, the null hypothesis of no difference is rejected at the 0.05 level. The evidence from the present investigation leads to the conclusion that when an AO is presented in multiple channel fashion, the learning outcomes are greater than when the AO is presented in the print mode only.

Ausubel's explanation of the forgetting process in terms of oblitative subsumption is theoretically compelling, especially for meaningful learning material. Equally compelling is the argument that advance organizers can assist memory by slowing down the oblitative process. A logical conclusion from the theory is that this beneficial effect upon memory should be more evident on the long term. Although evidence from the present investigation supports the conclusion that AO's presented over combined channels of communication cause subjects to retain significantly more information on the long term than subjects who are given the AO in the print channel of communication only, the second hypothesis as stated was not supported. Why was it not supported as stated?

An examination of Figure 4 and of the means given in

Table 4 shows that the control subjects scored very low initially. In fact, their mean score was barely above a chance score. Since there was little room for them to fall lower, only a slight change was recorded for the control group on the third measure. At the same time, the MCAO group also recorded only a slight drop from the first to the third measure. It is hypothesized that this was due to the facilitative action of the AO presented over three channels of communication. The difference between the MCAO subjects and the control subjects therefore remained relatively the same from measure one to measure three. Thus a statistical interaction was not possible. Instead, we see how much more effective with the passage of time treatment one was than treatment two. In demonstrating that the facilitative action of the AO is more dramatically apparent on the long term rather than immediately, the findings of the current study are in agreement with those of Kuhn and Novak (1970) and Romberg and Wilson (1973) who also recorded significance on their long term tests rather than on the immediate tests.

#### Implications for Further Research

The current investigation looked for reasons to explain the present state of ambiguity in AO literature. The investigator postulated that this is due to a failure to successfully anchor the AO to the learner's cognitive structure. The

solution offered to remediate this situation is to maximize the chances of anchoring the AO through the use of a multiple channel presentation of the AO. The solution proved successful in the current study. Since the procedure is new, its authenticity should be determined by replicating the present investigation employing a different learning passage.

The print, audio, and visual channels of communication were the ones combined to present the AO to the learner. It is unknown at this time the extent to which each channel of communication was responsible for successfully anchoring the AO. An experimental design could be devised to determine the relative contribution each channel of communication makes toward this end. Indeed, it may be determined that learners with unique characteristics respond differently to the AO presented in one learning mode or another.

Ausubel and Fitzgerald (1962) and Grotelueschen and Sjogren (1968) found that verbal ability interacted significantly with the AO. Verbal ability was also shown to be a significant variable by Bayuk, Proger, and Mann (1970), Estes (1972), and Lucas (1973). It may be important to know how a multiple channel presentation of an AO functions in subjects of different verbal abilities.

### Summary

Chapter III saw the reiteration of the research problem

and hypotheses. The data were analyzed and reported. An interpretation of the results was followed by a discussion to explain the research findings. Finally, implications for further research were stated.

### Conclusion

The present investigation addressed itself to the problem of inconsistent results reported in AO literature. The present writer perceived the problem to be a failure of some researchers to have the AO anchored to the learner's cognitive structure. A multiple channel presentation of the Ao was proposed as a solution to this dilemma. If through experimentation this solution is found to be consistently effective, it will lend further credence to an already cogent theory.

Learning psychologists and curriculum constructors need direction in order that their efforts remain focused. Lack of a strong theory-based program of studies tends to lead to diffused, ineffective and sometimes conflicting curriculum decisions, much to the detriment of the student. Ausubel's (1963) theory has the potential to compel conviction and provide the guidance and direction needed for constructing learning materials.

In conclusion, two main contributions are perceived as having been made through the present study. First, there is

the contribution to theory. If, as the results from the present investigation appear to indicate, the postulated benefits of AO's are realized with a greater degree of effectiveness through a multiple channel presentation, it may indicate as argued by the present writer that an optimum number of relevant, subsuming concepts need to be mobilized in order for the AO to realize its full potential in facilitating learning. Second, there is the contribution to school learning. If the multiple channel presentation of the AO is found to be consistently effective, it will indicate how curriculum efforts should be orchestrated to enhance school learning. There will be strong implications for the strategy which should be employed in organizing, preparing, and presenting school learning material.

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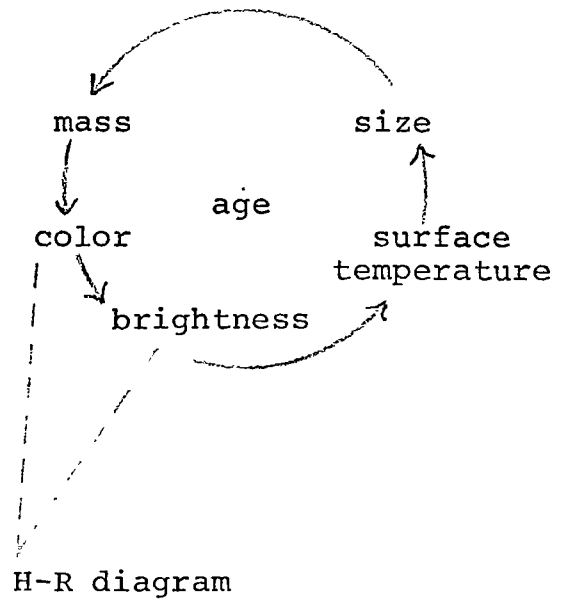
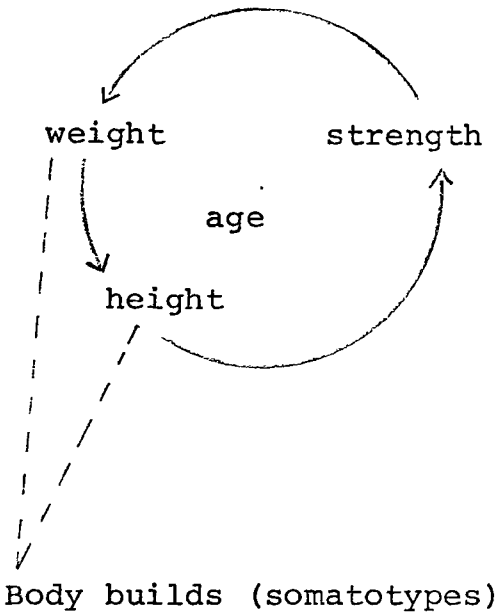
APPENDIX 1  
VISUAL ADVANCE ORGANIZER  
(STRUCTURED OVERVIEW)

SIMILAR - DIFFERENT

COMPARISONS

People

Stars



APPENDIX 2

PRINT ADVANCE ORGANIZER

Two words which scientists find extremely useful are "similar" and "different". These terms assist them in making comparisons. Various characteristics may serve as the basis for a comparison. For example, you might compare people on the basis of similarities or differences in their relative height, weight, or strength. You might also base your comparison on more than one measure. If you considered the height and weight together, you could compare people on the basis of their body build.

In like fashion, astronomers use the terms "similar" and "different" to make comparisons between stars. However, comparisons between stars are made on the basis of color, brightness, surface temperature, size and mass rather than height, weight or strength. Astronomers can also base their comparisons on more than one measure. Stars can be compared on the basis of both color and brightness through the use of something astronomers call an H - R diagram.

Stars, like people, appear to change as they get older. Suppose you were interested in finding out how people's height changes as they get older. You could do this in several ways. One way to do it is to take groups of people of various ages, measure their height, and compare differences in height between the various age groups. In like fashion, astronomers determine how stars change as they get older. Within certain limits, the

astronomers can approximate the ages of various stars. Then they compare older and younger stars in terms of characteristics such as size, color, etc. In this way, astronomers can hypothesize about how stars change with age.

APPENDIX 3

GENERAL INSTRUCTIONS TO ALL TEACHERS

## GENERAL INSTRUCTIONS TO ALL TEACHERS

1. Be certain that none of the materials are kept by the students nor seen by the students outside of the experimental situations.
2. Do not tell the students that there will be a test two and a test three.
3. Do tell the students that they will write a test following the reading of the booklet entitled "Stars". This is outlined to you for the Wednesday, June 1, program.

APPENDIX 4  
INSTRUCTIONS TO TEACHERS  
RESPONSIBLE FOR TREATMENT ONE SUBJECTS

## INSTRUCTIONS TO TEACHERS RESPONSIBLE FOR TREATMENT ONE SUBJECTS

General Instructions: Follow the general instructions.

Monday, May 30: Materials - Transparency entitled "Similar - Different".

Directions - Project the transparency on the screen and in five minutes explain the diagram. The following text will help you make the explanation. You can read it directly from this sheet. After your five-minute explanation, allow a maximum of five minutes for student questions and discussion.

Text To Help you Explain The Diagram

Before starting, say this very important note: "Try to keep in mind what we are talking about this morning because it will help you to understand better what you will be given to read on Wednesday."

1. Display portion of transparency relating to comparisons between people. Say: "I have indicated in this diagram a number of ways in which people can be compared. We can compare people on the basis of their (point to the words) weight, height and strength."

2. Continue to say: "Please notice two things I have tried to show through the diagram. First, the basis for our comparisons

frequently vary according to the age of the individuals being compared. For example, as people get older, (point to the word 'age') the weight, height and strength change. As an example, your height and strength increased from infancy to your teenage years. When you begin to get very old later on, your height will decrease slightly and you will not be as strong. Similarly with your weight. It increases from the time you are born. After a while it stabilizes, but then when you reach middle life, say around forty years of age, you tend to get a bit heavier. The second thing I have tried to show you through this diagram is that we can sometimes base our comparisons on more than one measure. For example, to compare people on the basis of their body builds, we would consider both height and weight together. (Point to the diagram where this is shown.) A person who is short and heavy would be said to have a heavy build. One who is tall and does not weigh very much would be said to have a slender or slight body build. A person whose weight is in the right proportion to his height would be said to have a medium build. Last of all, we can say that two people differ in their strength; that is, one may be stronger than the other. Two people can also differ in their weight. Or again, two people may be similar in their height, one being as tall as the other."

3. Display the whole diagram. Say: "Astronomer use the terms similar and different to make comparisons between stars. (Point to the three underlined words.) However, comparisons between stars are made on the basis of their relative (point to the words) mass, size, surface temperature, brightness and color,

rather than (point to the words) weight, height and strength."

4. Continue saying: "Notice two things about this diagram.

First, as with people, the characteristics of stars change with age. For example, (point to the words) the color, brightness, size and surface temperature are not the same for young stars as they are for older stars. (Point to the word 'age' and continue saying...) We can therefore know something about the age of stars by noting the color, brightness, surface temperature, etc. of the star. The second thing I want you to note about this diagram is that astronomers can also base their comparisons on more than one measure. For example, stars can be compared on the basis of both color and brightness through the use of something astronomers call an H - R diagram. (Point to this on the transparency.) As an example, if a star has a certain brightness and color, (point to these two words) it is placed in one part of the H - R diagram. Stars having a different brightness are placed in another part of the H - R diagram.

5. Lastly, we can say that stars differ from one another in any of their characteristics. One star may be brighter than another or have a different color. (Point to these two underlined words.) Or stars may be similar to one another in that they have the same surface temperature. (Point to the underlined word.)

NOTE: NOW ALLOW A MAXIMUM OF FIVE MINUTES FOR STUDENT INPUT AND QUESTIONS, KEEPING THE DIAGRAM IN VIEW. REMOVE THE DIAGRAM AFTER FIVE MINUTES AND STOP THE DISCUSSION.

Tuesday, May 31: Materials - Transparencies (#1 and #2) of the print organizer.

- Tape recording of what is on the transparency (7.5 speed)

- Shield for tachistoscopic presentation.

Directions - Load the tape on the tape recorder and cue it to the start of the tape. Mount transparency on the overhead projector. VERY IMPORTANT NOTE: Before starting, tell students to try and keep in mind what they will hear and read since it will help them understand what they will be given to read on Wednesday. Start the tape recorder (leave enough lead on the tape so that the machine is running at the proper speed when the audio voice begins) and expose the first frame of the transparency. Be sure that the 3 or 4 lines which are to be exposed are properly showing. Continue exposing the frames as indicated by the beep.

Wednesday, June 1: Materials - Print organizers (on sheets of paper

-Booklets entitled "Stars"

-AT tests (first administration)

Directions - Pass out the print organizer and tell student that they have five minutes to read its contents over several times. VERY IMPORTANT

NOTE: Tell them to try and keep the contents of what they are reading in mind since it will be helpful when they read something else on Wednesday. At the end of five minutes collect all the sheets. Next pass out the booklets entitled "Stars". Tell the students you will allow 25 minutes for reading it and that immediately following the reading they will write a test based on what they read. At the end of 25 minutes collect the booklets and pass out the AT test (first administration) face down. Allow 30 minutes for the test. At the end of 30 minutes tell the students to lay down their pencils. Collect the tests and bring them to the principal's office.

Friday, June 3: Materials - AT test (second administration)  
Directions - Administer the test in the same way you did on Wednesday. Again allow 30 minutes for writing. Return the completed tests to the principal's office.

Wednesday, June 15: Materials - AT test (third administration)  
Directions - Administer the test as you did the previous ones. Allow 30 minutes for writing. Collect the tests and return them to the principal's office.

APPENDIX 5  
INSTRUCTIONS TO TEACHERS  
RESPONSIBLE FOR TREATMENT TWO SUBJECTS

## INSTRUCTIONS TO TEACHERS RESPONSIBLE FOR TREATMENT TWO SUBJECTS

General Instructions: Follow the general instructions.

Monday, May 30: Materials - Print advance organizer (õñ sheets)

Directions - Pass out the print advance organizer and tell the students they have 5 minutes to read its contents over several times. VERY IMPORTANT NOTE: Tell the students to try and keep the contents of what they are reading in mind since it will be helpful when they read something else on Wednesday. At the end of 5 minutes, collect all the sheets.

Tuesday, May 31: Materials - Print advance organizer

Directions - Follow the same directions as for Monday. Be sure to mention the very important note given above.

Wednesday, June 1: Materials - Print advance organizer

- Booklet entitled "Stars"
- AT test (first administration)

Directions- Use the print advance organizer again as on Monday. Be sure to mention the very important note given above. After collecting the print advance organizer at the end of 5 minutes, pass out the booklets entitled "Stars". Tell the students you will allow 25 minutes for reading it and that immediately following that, they will

write a test based on what they read. At the end of 25 minutes collect the booklets and pass out the AT test (first administration) face down. Allow 30 minutes for the test. At the end of 30 minutes tell the students to lay down their pencils. Collect the tests and return them to the principal's office.

Friday, June 3: Materials - AT test (second administration)

Directions - Administer the test in the same way you did on Wednesday. Again allow 30 minutes for writing. Return the completed tests to the principal's office.

Wednesday, June 15: Materials - AT test (third administration)

Directions - Administer the test as you did the previous ones. Allow 30 minutes for writing. Return the completed tests to the principal's office.

APPENDIX 6  
INSTRUCTIONS TO TEACHERS  
RESPONSIBLE FOR CONTROL SUBJECTS

## INSTRUCTIONS TO TEACHERS RESPONSIBLE FOR CONTROL SUBJECTS

General Instructions: Follow the general instructions.

Monday, May 30: Materials - None

Directions - Tell the students that they are taking part in an experiment and that they will be given something to do on Wednesday. In the meantime they may prepare for their next class.

Tuesday, May 31: Materials - None

Directions - Allow students to read, study or do school assignments.

Wednesday, June 1: Materials - Booklets entitled "Stars"

- AT test (first administration)

Directions - Pass out the booklets entitled "Stars". Tell the students you will allow 25 minutes for reading it and that immediately following that, they will write a test based on what they read. At the end of 25 minutes collect the booklets and pass out the test face down. Allow 30 minutes for the test. At the end of 30 minutes tell the students to lay down their pencils. Collect the tests and bring them to the principal's office.

Friday, June 3: Materials - AT test (second administration)

Directions - Administer the test in the same way you did on Wednesday. Again allow 30

minutes to write the test. Return the completed tests to the principal's office.

Wednesday, June 15: Materials - AT test (third administration)

Directions - Administer the test as you did the previous ones. Allow 30 minutes for writing. Collect the tests and return them to the principal's office.

APPENDIX 7  
ASTRONOMY TEST

STUDENT'S NAME (Print): \_\_\_\_\_

**DIRECTIONS:** Print your name in the appropriate space above. For each question circle the letter which represents the best answer for that question. Circle only one letter for each question. If you feel you have circled a wrong answer, erase it or cross it out completely and then circle your new answer.

1. The H-R diagram indicates that
  - a. There are stars with all combinations of brightness, surface temperature, size and mass.
  - b. As one descends the main sequence, the stars become progressively hotter.
  - c. Most stars are in the giant sequence.
  - d. The hottest stars are in the dwarf sequence.
  - e. None of the above.
  
2. On the H-R diagram, our sun is placed
  - a. In the center of the giant sequence.
  - b. Among the white dwarfs.
  - c. At the top of the main sequence.
  - d. At the bottom of the main sequence.
  - e. None of the above.
  
3. Stars differ least in
  - a. Brightness
  - b. Size
  - c. Mass
  - d. Surface Temperature
  - e. Life Span
  
4. The color of the hottest stars is
  - a. Blue
  - b. Red
  - c. Orange
  - d. Yellow
  - e. White
  
5. Stars are placed in the H-R diagram according to their
  - a. Brightness and luminosity
  - b. Luminosity and color
  - c. Temperature and size.
  - d. Color and size.
  - e. None of the above.
  
6. What causes stars to assume the shape of a sphere?
  - a. Heat
  - b. Gravity
  - c. Atomic energy
  - d. Mass
  - e. Particle attraction

7. Which of the following occurs in highly luminous stars?
- Conversion of helium into carbon
  - Conversion of hydrogen into helium
  - Conversion of carbon into heavier elements.
  - All of the above
  - None of the above
8. A star will remain stable until
- It becomes a nova
  - It converts all the hydrogen in its central region into helium
  - Its temperature reaches 100 million degrees
  - It converts all the helium in its outer region into carbon
  - None of the above.
9. If a proto-star is exceedingly large, the star formed will at first be a
- Yellow dwarf star
  - Blue star
  - White star
  - Red dwarf star
  - Either B or C
10. Compression of gas and dust particles in a globule causes a (n)
- Increase in temperature
  - Decrease in mass
  - Loss of color
  - Increase in area
  - All of the above
11. Which of the following statements about the age of stars is false?
- Most stars are 10 to 20 million years old
  - Some stars in our galaxy are in the process of being formed.
  - Highly luminous stars usually have a shorter life span than less luminous stars.
  - Some stars in our galaxy are in the process of dying
  - None of the above (all the statements are true)
12. Which of the following statements about the temperature of stars is false?
- Surface temperatures between stars range from 5000 - 100,000 degrees Fahrenheit
  - The temperature at the center of some stars may reach 10 million degrees Fahrenheit
  - The temperature of a star fluctuates during its life span
  - Surface temperature is unrelated to color
  - None of the above (all statements are true).

13. Which of the following statements about the color of stars is false?
- A star may have several colors during its life span
  - Surface temperature is unrelated to color
  - The colors of stars are more pronounced when viewed through a telescope
  - Blue stars are hotter than yellow stars
  - None of the above (all the statements are true).
14. Which of the following statements about the size of stars is false?
- The largest stars have diameters 3,000 times greater than the sun
  - The size of a star depends upon the size of the gas and dust cloud from which it is originally formed
  - Stars differ more in size than they do in mass
  - The smallest stars have diameters about 400 times less than the sun
  - None of the above (all the statements are true).
15. The brightest stars are
- First magnitude
  - Second magnitude
  - Third magnitude
  - Fourth magnitude
  - Tenth magnitude
16. Which of the following statements about the brightness of stars is false?
- Some stars are 1 million times brighter than the sun
  - Some stars are 1 million times fainter than the sun
  - Stars differ more in brightness than they do in mass
  - Stars differ less in brightness than they do in apparent magnitude.
  - None of the above (all the statements are true).
17. About how many stars are visible to the naked eye from any one point on earth
- 2000
  - 6000
  - 100,000
  - Half a million
  - Many billions
18. The color of the coolest stars is
- Blue
  - Red
  - Orange
  - Yellow
  - White
19. Differences in the colors between stars is directly due to
- Size
  - Mass
  - Age
  - Brightness
  - None of the above

20. Which of the following stars might not be found in the main
- Blue dwarf star
  - White dwarf star
  - Yellow dwarf star
  - Orange dwarf star
  - Red dwarf star
21. A nova is a (n)
- Star that can no longer be placed on the H-R diagram
  - Exploding star
  - Star that is invisible
  - Mature star
  - Newly born star
22. The scale by which stars are ranked according to their brightness is arranged so that there is a difference in brightness of \_\_\_\_\_ times between magnitudes.
- $1/100$
  - $2 \frac{1}{2}$
  - 6
  - 100
  - None of the above
23. The mass of an object is
- It's relative size compared to the sun
  - It's weight
  - The amount of matter it contains
  - Dependent upon gravity
  - None of the above
24. The most luminous stars are \_\_\_\_\_ times as luminous the sun.
- 50
  - 3000
  - 5000
  - 100,000
  - one million

APPENDIX 8

LEARNING PASSAGE

## LEARNING PASSAGE

## STARS

On a clear moonless night the stars seem countless. But this is not really so. Astronomers long ago counted the stars that can be seen without instruments and discovered that about 2,000 can be seen from any one place at a given time. All told, there are about 6,000 stars visible to the unaided eye in both the Northern and Southern Hemispheres of the earth. With a telescope you can see many more stars and each time a larger telescope is developed, still more stars come into view. Galileo's little telescope revealed half a million stars, but today, with the 200-inch telescope on Polomar Mountain, many billions of stars can be seen. All stars are so far away that they appear only as points of light in the most powerful telescopes. In fact, the nearest star is 25 trillion miles away, while many stars are more than a thousand times farther away still.

Stars differ from one another in a number of ways. One of the ways in which they differ is in their luminosity, that is, in their actual brightness. When we look at the night sky, we note at once that some stars are brighter than others. The brightest stars are called first-magnitude stars. The next brightest are the second-magnitude, and so on. Classified in the sixth magnitude are those stars which are just visible to the unaided eye. The scale is so arranged that-

Page Two

there is a difference in brightness of  $2^6$  times between magnitudes, thus making the first-magnitude stars 100 times as bright as those of the sixth magnitude. These magnitudes are called apparent magnitudes because they represent the appearance of the stars. A star may appear brighter than other stars for one of two reasons: first, it may actually be brighter than most stars or secondly, it may be closer to us than most stars and so appear brighter. Astronomers call the actual brightness of a star its luminosity. The luminosity range of stars is extremely great, with the most luminous stars being a million times brighter than the sun and the least luminous stars being a million times fainter than the sun.

A careful look at the night sky reveals that the stars differ in color as well as apparent magnitude. Some stars shine with a beautiful and intense white light while others have a ruddy hue. These colors are more pronounced in the telescope, which shows that stars range in color from red, through orange, yellow and white, to a brilliant blue. This difference in color is due to a difference in surface temperature. The red stars, with surface temperatures of about 5,000 degrees Fahrenheit, are the coolest and are only red hot. The blue stars, whose surface temperatures soar to 100,000 degrees or more, are the hottest stars and are blue-hot.

Stars differ not only in luminosity but also in size. The largest stars have diameters 2,000 times the diameter of the sun-

Page Three

while the smallest stars, whose diameters measure only  $1/100$  that of the sun, are no larger than our own moon. However stars differ less in mass than in size because the larger stars are less dense than the smaller ones. (The mass of any object is the amount of matter it contains.) The most massive stars have about 50 times the mass of the sun, the least massive ones about  $1/25$ .

Are there stars with all combinations of luminosity, surface temperature, size and mass? The answer is no. Only certain combinations are found and this fact was noted by two famous astronomers, one named Ejnar Hertzsprung and an American at Princeton University by the name of Henry Norris Russell. It can be shown most easily on a chart which astronomers call the Hertzsprung-Russell diagram or H-R diagram for short. (This diagram is shown on the last page of this passage.) You will notice that the color is marked along the bottom of the diagram. Luminosity, in terms of the sun, is marked along the side.

Most of the stars fall inside a track that begins with highly luminous blue stars and runs diagonally down the diagram ending with faint red stars. This track is called the main sequence. Luminosity, temperature, size and mass all grow steadily smaller from the top to the bottom of the main sequence. At the top of the main sequence are blue stars which are 100,000 times as luminous as the sun. They have surface temperatures of about 100,000 degrees Fahrenheit, diameter approximately 20 times that of the sun and they are 32 times as massive.

Page Four

As we descend the main sequence, we encounter stars that are progressively cooler. Consequently, the colors of the stars change from blue to white, yellow, orange and finally red. At the same time the stars grow less luminous, smaller and less massive. At the bottom of the main sequence, we find red stars that range from 1/100 down to 1/10,000 as luminous as the sun. They have surface temperatures of about 5,000 degrees Fahrenheit, diameters about one-fourth or less than that of the sun and they are about one-fifth or less as massive. The stars of all the main sequence are all relatively small stars, especially the stars in the lower part which are called dwarf stars. Our own sun fits into the yellow portion of the main sequence and is consequently called a yellow dwarf star. The red stars at the bottom of the main sequence are called red dwarfs.

However, not all the stars fit into the main sequence. There is another band to the right which begins at the upper end and slopes upward to the right to the right hand end. These stars, which are at least 10,000 times as bright as the stars of corresponding color in the main sequence, are consequently said to be very large. The diameter of a giant star is about 100 times the diameter of a main-sequence star of corresponding color. The largest stars in this sequence are red and are known as the red giants.

You will notice another band along the top of the H-R diagram consisting of very rare stars of exceptional luminosity. These stars, called supergiants, are the very largest known stars and range

Page Five

in color from red to blue. Two of the supergiant stars are Betelgeuse, the bright red star in the familiar constellation of Orion, and Antares, also a bright red star, in the constellation of Scorpio. Betelgeuse, with its diameter of 800 million miles, is so large that if put in place of the sun at the center of the solar system, it would extend beyond Mercury, Venus, the earth and Mars to the orbit of the planet Jupiter.

Finally you will notice other stars in the lower left part of the diagram. These very small stars are known as white dwarfs, although some are yellow in color, and some blue.

The stars form a gigantic system which we call the galaxy. Some time we speak of it as our galaxy because there are others at vast distances from our own.

The stars in our part of the galaxy are moving in all directions, much like a swarm of bees, but because distances are so vast, they do not seem to us to be moving very fast. In fact, however, the majority of the stars are moving at a speed of 5 to 50 miles per second, with some moving even faster. Arcturus, for example, the bright orange star in the constellation of Bootes, has a velocity of 5 miles per second. Our sun is moving in the direction of the constellation of Hercules with a speed of 10 miles per second.

Page Six

Stars differ not only in brightness, color, surface temperature, size and mass, but also in age. Some of the stars we see in the heavens are very young while others are very old. Although stars are being born in our galaxy today, other stars are dying. Moreover, stars have different life spans. While some burn themselves out in 10 or 20 million years, others, regardless of the fact that they are already billions of years old, will continue shining for additional billions of years.

A star, astronomers now believe, begins its life as a great cloud of gas and dust which gravity causes to contract and assume the shape of a sphere. It is not yet a star, but only a gigantic dark globe referred to by astronomers as a proto-star or globule. As gravity causes the sphere to shrink more and more, it begins to grow hot. If you have ever pumped up a bicycle tire, you may have noticed that the pump gets hot. This occurred because the temperature of the air increased as it was compressed into the tire. Similarly, the temperature of the gas at the center of the globule rises as the outer layers of gas squeeze more and more and cause the globule to contract. Ultimately, the gas becomes red hot. The globule has now become a star. It is a red star of giant size, shining dimly with irregular fluctuations in its brightness.

Contraction continues, causing the center of the star to grow even hotter. In time, the center may reach a temperature of 10 million degrees Fahrenheit or more causing a very important change to take place. This temperature is high enough to make possible the atomic reaction by which hydrogen is transformed into helium.

Four hydrogen atoms combine to form one helium atom. A loss of mass occurs in this transformation, with the loss in mass being converted into energy. This process, incidentally, also takes place in our sun. The star now possesses a source of energy at its center. The outward push of the heated gas and the radiation from it balance the inward pull of gravity resulting in the star settling into the steady state which it will maintain for most of its life.

The size of the original cloud determines how long it takes the star to settle down and what it will be like. If the cloud is exceedingly big, it contracts more rapidly because the force of gravity is greater. In this case it may take 100,000 years for the star to settle down; when it does, it is a highly luminous blue or white star. A smaller cloud takes longer, becoming a less luminous yellow dwarf or red dwarf star.

When a star has settled down, it has taken its place in the main sequence. You will recall from previous pages that the great majority of stars form an array that begins with the highly luminous blue stars and ends with the small cool stars, referred to as red dwarfs. With the help of the H-R diagram, as shown on the last page, we can chart the evolution of a typical star. How long a star stays in its place in the main sequence depends upon how rapidly it uses up its supply of hydrogen. As the hydrogen is converted into helium at the center of the star a core of helium is formed. A star remains stable until it has converted all the hydrogen in its central region into helium. You might think this would happen more quickly in a dwarf star than in a more massive blue star. But just the opposite is true because the conversion of hydrogen into helium occurs so-

much more rapidly in the more massive star.

A highly luminous star may remain on the main sequence for only 10 million years, using up its hydrogen at a tremendous rate in spendthrift fashion. A less luminous star may take from 10 billion to 20 billion years to exhaust its hydrogen supply. Once a star has exhausted all the hydrogen in its central region, an important change takes place. The star now begins to consume the hydrogen in the layer or shell around the helium core resulting in the interior of the star becoming sufficiently hot to cause the outer regions of the star to swell up and grow larger. As the star expands, the surface is not only larger but also farther from the central source of heat. As a result, it grows cooler and the star no longer belongs to the main sequence.

The star is now on its way to becoming a red giant. For a time, it is unstable and becomes a variable star, but eventually it becomes a red giant with a diameter a hundred times greater than the star's original diameter. When the helium core has grown to the extent that it accounts for about 40 percent of the star's mass, it begins to contract, causing its temperature to rise to about 250 million degrees Fahrenheit. At this temperature another atomic reaction begins. Three helium atoms unite to form one carbon atom. The star now has two sources of energy: first, the conversion of hydrogen into helium in the shell around the core and, second, the conversion of helium into carbon in the core. What -

Page Nine

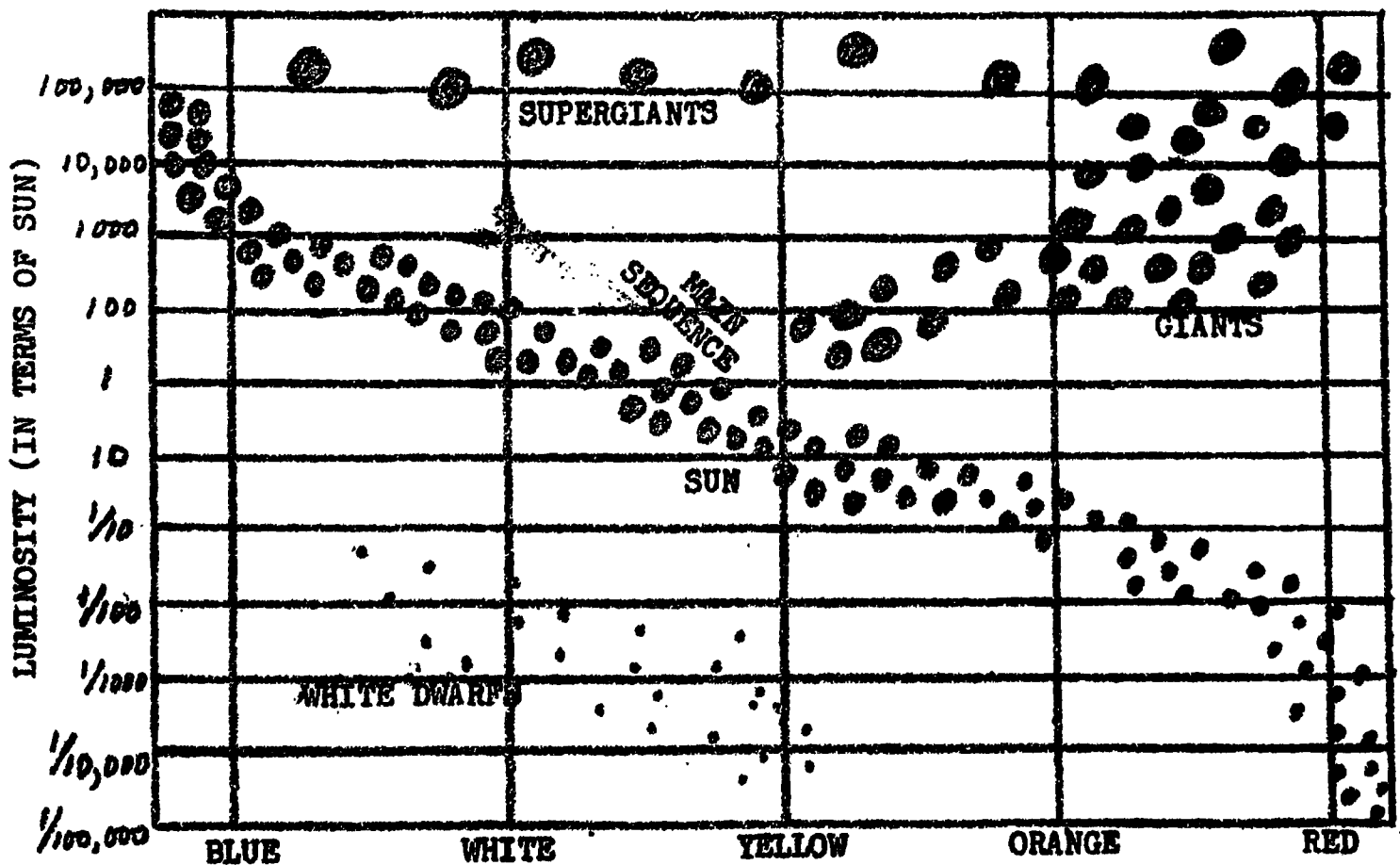
happens from this point on is not known with certainty. According to one theory, the star begins to grow hotter, and its color goes through a series of changes, with the red giant becoming in turn an orange giant, a yellow giant, a white giant, and a blue giant.

The final chapters in a star's history depend upon how massive it was to begin with. If it was only a little more massive than the sun, it is now near the end of its career because it has just about exhausted all of its atomic fuel. Soon it can generate heat and light only by further contraction. The star is now shrinking rapidly and on its way to becoming a white dwarf. Although the star is now dying, it apparently does not always give up easily. It may become a nova, perhaps a repeating nova, blowing off shells of gas in one or more terrific explosions. Finally, it becomes a white dwarf, perhaps no larger than the moon, and is so tightly compressed that a spoonful of its material weighs several tons. It no longer has any source of heat and light and is cooling off so that one day it will be just a cold, dead sphere.

Highly luminous stars, which are comparatively rare, have a different life history. One of these stars continues to produce energy even after it has converted much of the helium in its core into carbon because it develops three zones of energy production. In addition to producing helium from hydrogen and carbon from helium, it begins to convert the carbon at the center of the core into heavier elements. In this way, scientists now believe, the heavier-

Page Ten

chemical elements are created in the interior of stars. But because of the tremendous temperatures involved, the giant star may become extremely unstable during the closing chapters of its life. If it explodes, it becomes a supernova, a million times more luminous than it was originally. But after the explosion, it is only a dwarf white star surrounded by a complex tangle of gaseous clouds and filaments. It, too, will grow dimmer with the passage of time and finally go out.



THE HERTZSPRUNG-RUSSELL (H-R) DIAGRAM

APPENDIX 9  
PERSONAL CORRESPONDENCE BETWEEN  
DAVID P. AUSUBEL AND RICHARD F. BARRON

The City University of New York  
 Graduate Center: 33 West 42 Street, New York, N. Y. 10036



212/947-4549

September 30, 1969

Richard F. Barron  
 Research Intern  
 Syracuse University  
 Reading Research Center  
 732 Ostrom Avenue  
 Syracuse, New York 13210

Dear Mr. Barron:

Thank you very much for your letter of September 17 and for the accompanying materials.

Your notion of "structured overviews" is quite compatible with my view of meaningful reception learning. I would regard them as a special form of organizer the aim of which is to relate new concepts to be learned to the relevant body of related concepts already existing in cognitive structure. In contrast to traditional organizers they deal only with conceptual relationships as opposed to both conceptual and propositional (principles) relationships. Thus they serve a more limited function. However I would see no incompatibility between using both types simultaneously. "The structured overview" is a short-hand, telegraphic, and graphic way of indicating relationships between new and existing concepts that can supplement a more general type of organizer that presents the relationship (in prose form) of a body of organizing concepts and principles both to established knowledge and to the learning task. Insofar as it is at a higher level of generality, inclusiveness and abstraction than the learning task, I would think that "organizer" would be a better term than "overview" (perhaps one might call it a graphic conceptual organizer). In my opinion the technique definitely has merit, and promise and should undoubtedly be pursued further.

With best wishes,

Sincerely,

David P. Ausubel  
 Professor and Program Head

DPA:sp

APPENDIX 10  
PERSONAL CORRESPONDENCE BETWEEN  
ALBERT C. LAVIGNE AND RICHARD F. BARRON

OAKLAND UNIVERSITY

Rochester, Michigan 48063

Area 313/377-3050

SCHOOL OF EDUCATION

② 02 313/377-3091  
\*① 02 313/377-3065

June 22, 1976

Albert Lavigne  
68 Hebert Street  
Gatineau, Quebec  
CANADA

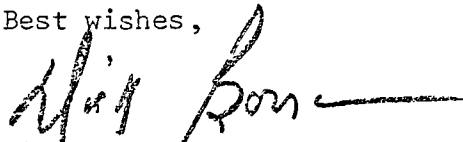
Dear Albert:

Realizing that time is an important factor for you at this point, I am sending you some of the materials you requested (and a few things you did not ask for). This package should contain:

1. Correspondence to Ausubel (dated Sept. 1969) inquiring whether or not he felt the structured overview assumed the properties of an advance organizer. I believe that you will find his reply interesting,
2. Copies of the studies undertaken with Stone and with McCann. These were taken from the NRC yearbooks. I shall try to find copies of the complete (unedited) manuscripts and mail these to you in the near future,
3. Materials (i.e., overview, organizer, and criterion measure) from the Cooper, Stone, and McCann studies. I have been unable to locate a copy of the passage used in the astronomy study. I will continue to search for this in stored materials at home.

If I can provide any additional assistance to you, please feel free to call upon me. As I recall money was tight when I was a doctoral student -- If need be call me (collect) at 313-377-3065.

Best wishes,



Richard Barron  
Associate Professor

RB/jy

Enclosures

APPENDIX 11

QUESTION TO DETERMINE THE NAIVETE OF THE  
SAMPLE WITH RESPECT TO THE LEARNING TASK

QUESTION TO DETERMINE THE NAIVETE OF THE SAMPLE WITH  
RESPECT TO THE LEARNING TASK

Print the name of one First-Magnitude star. If you know the name of one but cannot spell it, simply print it the way it sounds. If you cannot name a First-Magnitude star, do not be surprised. Many students can't. Pass in your blank sheet anyway.

The name of a First-Magnitude star is \_\_\_\_\_.

APPENDIX 12

APPENDIX 12

ABSTRACT OF

An Empirical Investigation Of The Effects On Learning  
And Retention Of A Multiple Channel Presentation  
Of An Advance Organizer

## ABSTRACT OF

An Empirical Investigation of the Effects on Learning  
and Retention of a Multiple Channel Presentation  
of an Advance Organizer<sup>1</sup>

Ausubel (1963) claims that new information is acquired in terms of what is already known. Existing concepts which are more inclusive and general than the new information to be acquired and which are relevant to the learning task at hand interact in a meaningful way with the new information and anchor it to the existing cognitive structure. He further postulates that cognitive structure is hierarchically organized, with the most inclusive concepts subsuming less inclusive concepts and principles as well as specific items of information. He says that learning occurs in this way when cognitive structure is clear, stable, and well organized.

Ausubel postulates that learning can be facilitated through pedagogical intervention. This he claims can be done through the use of advance organizers. Advance organizers are relevant statements formulated at a higher level of generality and inclusiveness than the learning task itself. Introduced in advance of a learning task, they serve to organize and clarify the cognitive structure. Since the advance organizers are written using language and analogies

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<sup>1</sup> J. Albert C. Lavigne, doctoral thesis presented to the School of Graduate Studies of the University of Ottawa, Ontario, 1980, xiii-123 p.

already familiar to the learner, they either mobilize existing relevant concepts or provide them where none exist.

There is some question in the literature about the effectiveness of advance organizers as learning tools. The investigator reasons that where advance organizers fail to facilitate learning, they have not been successfully anchored in the cognitive structure of the learner. The purpose of the present study, therefore, is to maximize the chances of successfully anchoring the advance organizer. The investigator postulated that this could be done through a multiple channel presentation of the advance organizer.

The subjects were 325 grade nine students in an urban-rural New Brunswick school district. These subjects were randomly assigned to two experimental groups and one control group. The experimental groups were exposed to three five-minute treatments on three consecutive days while the control subjects worked on unrelated activities.

Immediately following the treatment on the third day, all subjects, including control subjects, were given a learning passage of approximately 2300 words to read. This was followed immediately by a retention test. The same retention test was given twice again, once after a two-day delay and again after a further delay of twelve days.

Analysis of the retention scores revealed that subjects who were presented the advance organizer in multiple channel

fashion did significantly better ( $p=0.05$ ) than control subjects who did not receive any advance organizer. They also did better than the treatment two subjects who received the advance organizer in the print form only, although the difference was not statistically significant. Furthermore, it was found that subjects who were presented the advance organizer in multiple channel fashion retained significantly more information on the third administration of the test than treatment two subjects who only received the advance organizer in print form.