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Title: THE EFFECTS OF ADVANCE AND POST ORGANIZATION ON THE LEARNING AND RETENTION OF PROSE MATERIAL

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Purpose of the Study

The main purpose of this study was to determine the influence of the use of written advance organization, post organization or both advance/post organization on learners as compared to the use of non organization for the learning and retention of verbal, academic material. An additional interest was to determine the effect of the type of student using the various organizers at two different times of recall; immediate and retention three weeks following the initial learning experience.

Procedure

Eighty (80) subjects from each of three areas of study at Oregon State University participated in a learning experiment which utilized four levels of a written conceptual organizer. The four

levels of organizer (i.e., advance, post, advance/post, and non organizer) established the four treatment groups used for each type of student.

Students (116 female, 124 male) from teacher education, industrial education, and science majors in chemistry were presented appropriate verbal organizers prior to and/or following the learning of meaningful verbal material to determine whether learning and retention were enhanced.

The post and non organizer groups received a non organizing, historical passage to study for eight minutes prior to reading a longer learning passage on the metallurgical properties of carbon steel. The advance and advance/post organizer groups received a concept building, background passage prior to reading the same learning passage.

Following a twenty minute period allowed for reading the learning passage, the advance and non organizer groups received the historical, non organizing passage to study for an eight minute period. The post and advance/post organizer groups received the concept building, background passage for the same period of time.

All subjects took the same criterion test consisting of thirty-two (32) multiple choice questions immediately following the last stage of the experiment. No time limit was imposed and the subjects completed the test at their own speed. All subjects repeated the same test three weeks following the learning exercise for a measure of retention. The learner's score on the criterion test was determined by the number of correct responses. The materials used in the study were developed by and used with the permission of Dr. David P. Ausubel.

The collected data were analyzed using the F statistic to determine if differences existed among the mean scores. Both the three-way analysis of variance and a multiple comparisons analysis were conducted. The Least Significant Difference test was utilized when comparisons showing significant differences contained more than two means.

Conclusions

The following conclusions were supported as a result of the study and are based upon the findings:

1. A written advance organizer effectively facilitated the learning and retention of meaningful verbal material.
2. Neither post nor advance/post organization significantly facilitated the learning and retention of meaningful verbal material for the sample as a whole.
3. Both advance and advance/post organization facilitated learning and retention significantly more than did non organization for industrial education subjects only.

4. The performance of different types of students using the same types of organizers as an aid to facilitate learning differed significantly.
5. The performance level of the different types of students did not persist for all four types of organizer.

The Effects of Advance and Post Organization on the Learning and Retention of Prose Material

by

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THE EFFECTS OF ADVANCE AND POST ORGANIZATION ON THE LEARNING AND RETENTION OF PROSE MATERIAL

I. INTRODUCTION

Students in formal education encounter a large amount of written verbal material almost every day. Improving the student's effectiveness to conceptually learn verbal material, distinguish between major and minor ideas and retain and apply the new material, has been of major concern to educators.

Organizing aids have been used extensively to reduce difficulties encountered by students in the above areas. Teachers often give a written or verbal overview of the material to be covered prior to beginning a new unit of instruction. The unit of instruction is often concluded with a summary of the main terms and concepts. Many textbooks provide an introduction at the beginning or a summary at the end of each chapter or both. Abstracts, underlining, and the use of boldface type or italics are often examples of organizing aids employed to facilitate student learning.

Research conducted during the last fifteen years evaluating the effectiveness of these aids, the type of organizer used, the position of the organizer relative to the learning experience and the type of learning material they should be used with, have produced contradictory results. The learning influenced by various organizers has been specific in nature and application and retention of the new learning have generally been poor.

There appears to have been very little if any research that has studied the effects on the performance level of verbal learning as a result of using both an advance and post organizer for the same learning material. Likewise, studies are scarce which examine whether a verbal organizer will differentially effect the performance level of different types of students having different levels of familiarity with the learning material.

This study examined those areas of concern, in addition to looking at the effects of advance and post organizers as reported in other contradictory studies.

Statement of the Problem

The main purpose of this study was to determine whether a written advance or post organizer, or both, facilitated the learning and retention of meaningful verbal material. Appropriate organizers were introduced prior to and/or following the learning of academic material to determine whether learning and retention were enhanced. A multiple choice criterion test given immediately following the learning, and administered again three weeks later, provided a measure of the learning and retention performance of the subjects.

The study also examined whether a verbal organizer differentially influenced the performance level of three different types of students having different levels of familiarity with the learning material. The need for clarification of previous contradictory findings and the need for additional information in related areas containing very little research stimulated initiation of this study. Some questions that were examined are:

1. Does the use of verbal organizers facilitate the level of performance in learning and retaining verbal material?
2. Does the use of advance or post or both organizers facilitate the performance levels of learning and retention?
3. Does the performance level vary for the three types of students having different levels of familiarity with the learning material?
4. Does any significant interaction effect exist between the various organizer and student type levels?
5. Does any significant interaction effect exist between the various organizer and time levels?
6. Does any significant interaction effect exist between the various student and time levels?
7. Does any significant interaction effect exist among the various organizer, student, or time levels?

Definition of Terms

In order to clarify the meaning and use of certain terms used throughout this study, the following definitions have been offered. Other terms are considered to be self explanatory.

Advance Organizer. An introductory paragraph or passage preceding and containing background information for the learning passage. The organizer should be more general, inclusive and concept-building than the material to be learned. The passage should not provide direct answers either in a declarative way or by making the reader aware of specific answers for which to look. A copy of the advance organizer used in this study is included in Appendix A.

Non Organizer. A paragraph or passage of identical length and appearance to the organizer passage, but consisting of the type of historical information commonly included in most textbooks to enhance student interest. It contained historical background information such as the evolution of the methods of processing iron and steel. The passage contained no framework for organizing the more detailed facts and relationships included in the learning passage nor did it supply any pertinent information that would help on the criterion test. See Appendix B for the passage.

Learning Passage. A 2500-word passage dealing with the metallurgical properties of plain carbon steel. The passage was developed by Ausubel (1960) and used with his permission for this research. The passage is reproduced in Appendix C.

Post Organizer. A summary paragraph or passage that contains background information for and is presented following the learning passage. The post organizer consists of the exact same information as the advance organizer and the only difference is the time of presentation relative to the learning experience.

Advance/Post Organizer. A paragraph or passage containing background information for and presented both preceding and following the learning passage.

Criterion Test. The instrument used to measure the level of assimilation and retention of the learning passage information by the subjects. The test consisted of 32 multiple choice questions constructed by Ausubel (1960). The test and key are reproduced in Appendix D.

Immediate Achievement. Immediate achievement refers to the criterion test score achieved by each subject immediately following the learning experience.

Retention. Retention refers to the criterion test score achieved by each subject three weeks following the learning experience.

Rationale

Most, if not all, students in education are introduced to new materials that are variants of previously learned concepts. Ausubel (1960) postulated the idea that learning and retention of unfamiliar but meaningful material can be facilitated by the advance introduction of relevant subsuming concepts (organizers). "New, meaningful material becomes incorporated into the learner's cognitive structure in-so-far as it is subsumable under relevant, existing concepts" (Ausubel, 1961). The notion is that the learning of a second prose passage should be facilitated by exposure to an initial passage which establishes a cognitive structure. The new material of the second passage can be subsumed into the structure developed by the organizer.

The results of Ausubel's study clearly supports a facilitating influence of advance organizers on both the incorporability and longevity of learning (1960). A more recent study by Kuhn and Novak (1970) fully supported Ausubel's findings. Related studies by Rothkopf (1966), Pyper (1969), Proger *et al.* (1970), and Weisberg (1970) also support a facilitating influence of an organizer.

The preceding research, with the exception of Rothkopf (1966), only studied the effects of an organizer which preceded the learning material. Rothkopf found that test-like questions presented after reading the relevant text passage had both specific and general facilitative effects. Test-like questions presented before reading the text passage had only specific facilitation. Two points relevant to the present study are indicated by Rothkopf's findings: (1) Maximum facilitation of learning as a result of the position of the organizer and (2) specific versus general facilitative effects.

The few studies that have examined the effects as a result of the position of the organizer have reported varied results. Rothkopf's finding indicated that the effects of the post organizer were more desirable. Bauman and Glass (1969) reported post organizers significantly more effective than advance organizers, but that organizers were not significantly different than non organizers. Bayuk, Proger and Mann (1970) reported no significant differences between advance and post organizers. Most investigators indicated a need for additional research, with attention given to the position of the organizer.

In regard to the second point to be considered, a general facilitating effect is more desirable in verbal learning than a specific effect unless little more than content learning and rote memorization is required. The lower levels of retention, comprehension and general applicative value obtained with rote learning in comparison to concept learning have been shown and it is generally accepted as being less desirable.

A criticism of the studies showing only specific facilitation, which Bayuk, Proger and Mann (1970) make, is that the organizers the studies employed gave answers or became "flags" telling the learner what to remember from the learning task. The subjects tended to learn only the specific materials outlined by the organizer and the inability to generalize and poor retention on the part of the subjects indicated rote learning.

Paraphrasing Ausubel's discussion (1960) points out his assertion that the overviews and outlines used by many lecturers and textbooks have the same faults. Students learn new and unfamiliar disciplines relying on the outlines which detail specific terms of facts before having available a sufficient number of key concepts. As a result, he maintains that students are trapped into rote memorizing the learning material for examination purposes. Learning and retention of the unfamiliar material could have been facilitated by an advance organizer that was more general, inclusive and abstract (concepts rather than facts reported) than the material to be learned.

Research by Royer (1974) provides the first substantial evidence supporting the non-specific facilitation of verbal learning. His results showed that non-specific learning occurred when (1) the information presented in the learning passage was unfamiliar or difficult to comprehend and (2) when the organizer passage contained concrete referents which increased the comprehensibility of the learning passage. Neither finding disagrees with Ausubel's assertions.

A study by Graber et al. (1972), however, does conflict and contradicts Ausubel's findings. Graber obtained from Ausubel the materials that he used in his original study (1960) and conducted a similar study. Graber added post organization to the organization variable and also added a second variable of organizational ability. The results showed no significant differences among advance, post or non organizers nor any significant interaction effect between organizational ability and type of organizer.

A notable difference between the two conflicting studies is the type of subjects used for each. Graber used students enrolled in general chemistry courses as subjects. Ausubel used students enrolled in teacher education courses and eliminated subjects with an industrial education major because of probable familiarity with the learning material (qualities of plain carbon steel). Ausubel (1961) and Royer (1974) have indicated that the organizer will have more facilitative effect when the learning material is unfamiliar to the subject. However, Bayuk, Proger and Mann (1970) found no significant interaction effect while examining the same variable. Differences in level of familiarity on the part of the subjects could have been a factor in the conflicting results obtained in Ausubel's and Graber's studies; however, at this point, the effects are equivocal.

Proger, *et al.* (1970), Bayuk, Proger and Mann (1970) and Graber *et al.* (1972) are several of the investigators who stated that more study is needed in the following areas:

1. The extent and effect of organizers on learning.
2. The position effect of the organizer (advance or post).
3. The extent and effect of interaction variables.

The purpose of the present study was to fill the information gap existing in the above areas. Since this study included materials used by both Ausubel and Graber in contradictory studies, this research tended to confirm one of the two findings and perhaps helped establish a trend towards a degree of consistency. The present study extended the previous areas of research by including both an advance and post organizer in addition to one or the other for the same subjects. It also extended previous research by examining interaction effects between types of students and types of organizer. The types of students suggested for this study were chosen for that purpose and also to relate the research to areas of vocational education.

II. REVIEW OF RELATED LITERATURE

In addition to the rationale already presented, this chapter presents research important for enhancing understanding and interpretation of the results of the present study. The areas reviewed are: storage and retrieval; retroactive inhibition; and the effects of intelligence on organization.

Storage and Retrieval

An important aspect of organization is the order in which people recall material with which they are presented to learn. Studies have shown that free recall is not characterized by a haphazard, random retrieval of items, but rather by a sequential grouping of items into clusters showing identifiable relationships. Bousfield (1953) presented subjects with a list of 60 words with 15 in each of four categories; animals, vegetables, first names, and professions. Although the items were presented randomly and free recall was used, subjects tended to recall them organized into their distinct categories; animals in one, names in another, etc.

Various studies are supportive of Bousfield's and also establish that clustering is a phenomenon occurring along many dimensions besides well-defined categories (Jenkins, Mink, and Russel, 1958) (Tulving, 1962) (Jenkins and Russel, 1952) (Cohen, 1966) (Bousfield and Wickland, 1969). Grouping items that rhyme, that begin with the same letter, that have similar uses, that are made of the same materials, are some examples of associative and subjective clustering.

Furthermore, Tulving (1965) found that subjects grouped seemingly unrelated words and that the order of grouping was relatively consistent from one subject to another. The experiment consisted of subjects learning a list of 16 words that were unrelated in meaning. The order of presentation was varied so that subjects could not learn them serially. During testing, certain words were recalled together even though there seemed to be no reason for the order and many subjects were unfamiliar with the meaning of some of the words; for example, DRUMLIN, POMADE, QUILLET, and HOYDEN were frequently clustered in that order.

Tulving went one step farther and presented ths list of words to a new group of subjects in the organized order established by his previous subjects' free recall. Another group was given the same words in an order that occurred infrequently in the previous recalls. If organization was an important variable, the high organization list should have been recalled more effectively than the low. The results clearly supported his hypothesis. Studies by Cofer (1965) Cohen (1966) and Tulving and Pearlstone (1966) also show that superior recall occurred for items which were organized compared to the same items which were randomly presented.

As the importance of organization in recall became apparent, the question arose as to whether information is arranged into cohesive groups previous to/or during storage or whether organization comes into being at the time of retrieval. If organization of newly learned materials is most important at the time of intake or storage, retention would be enhanced by having appropriate organizing schemes prior to the learning. If bits of information are stored separately and an efficient organizing scheme is used to search the available information for appropriate retrieval, then organization just prior to recall would be most effective. Resolving the problem has been of special interest to education where a great deal of focus has been placed on organization of textbooks as well as instructional strategies.

Deese (1957) supports the idea that organization occurs prior to storage and that items in storage are dependent or clustered. He attempted to separate storage and retrieval processes by introducing serial recall instructions before or after the presentation of items to be recalled in order to contrast the effects. Serial recall instructions preceding the first presentation of items resulted in better performance than did the same instructions following the first presentation. The implication was that it is easier to remember items which have been stored according to the retrieval plan used than to reorganize and recall the same items once they have already been stored in a different arrangement.

Tulving (1967) demonstrated that the two phases are separate processes. Subjects were presented 36 nouns at the rate of one per second and then allowed a 36 second interval for free recall of the nouns. Tulving then had the subjects recall the words a second, third and fourth time during 36 second intervals without the subjects ever seeing the original list again. His logic was that the pattern of recall for a single word would be either RRRR (recalled correctly each time) or NNNN (not recalled), if storage and retrieval were the same process. If they were different processes, a NNNR would indicate a retrieval problem since an item had been stored and not retrieved in the initial responses. If a storage problem existed, there could never be an N followed by an R since one can not retrieve something that does not exist.

The results indicated that more information is stored than can be retrieved. Although the same number of words were recalled for each interval, words not recalled in initial trials were recalled later (e.g., NNNR) at a significant level.

Slameka (1968) favors the idea that storage of items is independent and that organization of recall is due to a retrieval plan. His experiment involved providing one group of subjects with some of the items just learned at the time of recall so that he could compare their recall of the remainder of the list with that of a group which had no items provided. Slameka's assumption was that if items are stored independently, the fate of one does not influence the fate of any other. If some items are made accessible at recall, it should not change the probability of retrieving the rest. On the other hand, if items were stored dependently (e.g., grouped in storage), providing some of the items at recall should increase the probability of retrieving the rest.

No benefit was found for providing part of the items at the time of recall. The results led Slameka (1968) to argue that traces are stored independently of each other and a systematic retrieval strategy is adopted for maximum recall. He holds that categories of names, attributes and other organizational cues, used in various studies to facilitate recall, may suggest a plan for retrieval rather than serving to arrange traces into similar categories for storage, as the authors held. Slameka also indicated an laternative explanation for Tulving's (1966) study which showed that adding to the length of an already learned list retarded learning of the enlarged list as compared to a control group. Tulving felt retardation was due to a necessity of reorganizing stored items when the list was expanded; Slameka felt that it was due to a necessity of devising a new retrieval plan. A later study (Slameka, Moore and Carey, 1972) showed that part-list learning can facilitate later learning of the entire list, but only if the subject was told to be free and non-discriminating in his recall of the expanded list (e.g., take a guess at any word he remotely suspected of being on the list).

In a series of experiments, Earhard (1968) explored the matter of independence vs. organized storage of unrelated items by requiring subjects to recall in alphabetical order, words they had been memorizing under free, serial or cued recall conditions. Half of the subjects were told about the change in recall conditions before the items were presented and half were told after the items had been presented for various numbers of trials. The reasoning was that if organization during retrieval determines the number of words recalled, then it should make no difference whether the retrieval strategy is changed before or after the items have been presented or stored. Also, if items are stored independently, then subjects should have no more trouble changing their recall organization to that of alphabet after much preliminary practice than after few preliminary learning trials.

Earhard found that in every experiment, and for every level of previous practice, recall was superior when the alphabetic instructions were provided before presentation of the stimulus items. Also the recall performance varied inversely with increasing amounts of practice trials prior to the alphabetic test. Her results support

Deese's (1957) findings which leads one to argue that some aspect of the organization important to efficient recall occurred during the storage process.

Perlmutter and Royer (1973) included Earhard's manipulation in their study to attempt to extend her findings from list learning to a prose situation. In addition, a goal was to offer additional clarification as to the relative efficiency of attribute, name, and random organizations for learning prose. Frase (1969), Schultz and DiVesta (1970), and Myers, et al. (1972) had all found superior recall for organized prose (i.e., attribute and name categories to aid retention), which is consistent with the list learning literature. However, divergent results had been obtained by the studies concerning the relative merits of name and attribute organizations.

The attribute organization group received various paragraphs with all sentences within a specific paragraph having a common attribute. The name organization group received all sentences with a common country name to a paragraph; random organization group received five sentences including both types of sentences which were randomly assigned to each paragraph. Part of the subjects of all groups read instructions describing the type of order in which they were to recall the materials prior to receiving the paragraphs (e.g., attribute, name or free recall). The other part received their recall instructions after reading the paragraphs.

The procedure allowed comparison of performance using the same type of organization for recall as was used to learn the material (attribute - attribute) with the performance using a different type of organization for recall than was used during learning (attribute - name). Also, the time of instructions for recall (before of after) could be compared.

The results showed that the organized paragraphs led to significantly more recall than unorganized material. The comparison of attribute with name organization showed no significant differences between the two types, however, the results suggested that subjects tend to store materials according to the input organization. Manipulation of the time when subjects were told how to recall the material, either before or after the learning, resulted in better recall for the group receiving instructions following the learning. The effect was consistent even for the free recall groups. The authors stated they could think of no reason why telling a subject after he has read a passage that he can recall the material in any order he chooses should be more beneficial than giving him the same instructions prior to reading the passages (Perlmutter, Royer, 1973).

Other studies using prose materials to investigate the effects of organization at the time of storage and retrieval have been conducted recently. Dooling and Lachman (1971) presented highly metaphorical passages to subjects who were informed or not informed of the theme previous to reading the passage. Subjects informed of the theme prior to reading the passage recalled significantly more words than the control group.

Bransford and Johnson (1972) presented subjects with a line drawing picture which helped the subject make sense out of a conglomerate of unrelated sentences. Some subjects saw the picture before hearing the sentences, some after hearing and some listened to the passage without being exposed to the picture. Subjects who saw the appropriate picture prior to listening to the passage recorded significantly higher comprehension and recalled more idea units than the other groups.

The survey of literature tends to indicate that the problem concerning the importance of storage vs. retrieval organization does not have an "either - or" solution. It would appear that retrieving information from memory is not entirely independent of the storage process and that items are stored according to retrieval information. Most researchers have taken the position that organization occurs during both storage and retrieval phases of learning (Earhard, 1969). However, having an organizational strategy prior to or during storage that is to be used for recall has generally been superior to devising a strategy or changing strategies at the time of retrieval.

Retroactive Inhibition

A second area of research related to organizational enhancement of learning has centered around the effects of retroactive inhibition as a result of the characteristics of the learning material and its sequence. One of the purposes of education is to learn skills that will later be useful in our everyday life. When a stimulus is encountered that is similar or identical to an already learned stimulus and the response required for each situation is similar or identical, positive transfer often occurs (i. e., the second task is easier to learn than the first). However the learning of one bit of information may also interfere with the retention of another bit of information. For example, when the learning of task B interferes with the retention of previously learned task A, the interference depicted by the decrement in performance is called retroactive inhibition.

Significant retroactive inhibition (RI) has been demonstrated many times in nonmeaningful (nonsense syllables) and nonconnected (paired word association) studies (cf., Osgood, 1949; Keppel, 1968; Postman and Stark, 1969). However, the results of studies using meaningful connected material (prose, poetry, or segments thereof) have been equivocal. Ausubel (1968) has argued that RI should be a relatively rate phenomenon in prose learning and in many cases facilitation rather than inhibition should occur.

Studies with connected material that found no RI (Ausubel, Robbins, and Blake, 1957; Hall, 1955; Wong, 1971; and Ausubel, Stager, and Gaite, 1968) have tended to support Ausubel's contention. Other studies using connected material have shown at least some RI; (King and Cofer, 1960; Slameka, 1960, 1962; Entwistle and Huggins, 1964; Mehler and Miller, 1964; Crouse, 1970, 1971) and have tended to contradict Ausubel's contention.

Anderson and Myrow (1971) and Ausubel (1968) have suggested that the cited studies, with the exception of Crouse, found significant RI because the procedures used forced rote learning and demanded verbatim recall. Although Slameka (1960) used connected prose, learning and recall of the passages was based on the serial anticipation method. The presentation of one phrase serves as a cue for the subject to anticipate and recall the phrase immediately following since they are always presented in the same order. The procedure encourages memorization in order of presentation and could help conceal relationships and meanings of the short passages.

Slameka was attempting to show that RI occurred with prose material when using rote memorization. King and Cofer (1960) Mehler and Miller (1964) and Entwistle and Huggins (1964) used different procedures and did not consider the basis of learning for their studies to be rote memorization. In any event, because of the nature of the material learned and the fact that all required verbatim recall, it appears probable that rote memorization did occur.

Entwistle and Huggins (1964) tested subjects on the principles of electrical circuit theory. Half the subjects studied voltage principles for 15 minutes and the next 15 minutes studied similar current principles. The control group studied voltage principles and then studied irrelevant material on computer programming during the two intervals. Since the material was principally mathematical in nature (formula) rather than verbal, Ausubel, Stager, and Gaite (1968) argue that the inhibition shown was for rote, rather than meaningful learning and proposed a study of their own to demonstrate the effect.

The study conducted by those authors had two main purposes: (1) to test whether RI occurred with meaningful learning requiring substantive rather than verbatim recall and (2) to test whether or not reading two passages having similar stimuli but requiring different responses resulted in RI for retention of the first passage. They proposed that the effect of successive learning on retention of already learned information is not necessarily a function of the similarity of the original and interpolated materials. Instead, they hold that it depends on whether the interpolated material increases or decreases the subject's discriminability of the concepts he learned from the original passage. The results showed that a passage judged to be "similar but conflicting" facilitated memory for a passage studied earlier instead of inhibiting it.

Subjects in the study received passage on Zen Buddhism and then either a passage on Buddhism or an irrelevant passage on drug addiction. After an interval of seven days, a multiple choice Zen Buddhism test was administered. Subjects who received the Buddhism passage, which was similar but conflicting with the Zen Buddhism passage read earlier, did significantly better than those who read the drug addiction passage. The authors suggest that the second passage may have served as a review and clarification of the previous passage by allowing the subject to better discriminate between the two religious beliefs.

A later study focused on the problem again, since conflicting evidence existed. Crouse (1971) noted that RI generally increases as the similarity of the materials learned in successive tasks increases for paired associate and serial learning. To test that effect with prose material, he developed short passages and generated a set of questions which each passage answered. The passages were presented so that in successive passages, the questions were different, similar, or identical, but always had different answers, than the questions for the initial passage. It was expected that RI would increase for the three methods of presentation as the similarity of the material increased; from the different condition, to the similar condition to the identical condition. Crouse found that no significant RI occurred for the different condition, but that significant RI occurred for both the similar and identical conditions.

Anderson and Myrow (1971) also conducted a study to determine the effects of stimulus and response similarity on retroactive inhibition. They suggested that one can predict facilitative, inhibitory or neutral transfer effects for different aspects of successively learned passages. These predictions would be based on an analysis of similarity and difference relationships between the original and interpolated material. An example of some of the material used by Hall (1955) illustrates the point. Assume that a first passage (passage A) and a second passage (passage B) are concerned with two ficticious African tribes. A sentence from passage A indicates that the first tribe was located in southern Africa and a sentence from passage B indicates the second tribe was located in northern Africa. A question concerned with the location of tribe A would be expected to show RI for a group exposed to both passages relative to a group receiving only passage A. The reason for this expectation is that the stimulus event for both passages is similar (i. e., "the tribe is located . . . . ") whereas the responses are different. This can be contrasted to the situation where both the stimulus events and the responses are similar, in which case, facilitation rather than inhibition would be predicted. The final situation described by

Anderson and Myrow is one in which neither facilitation nor inhibition would be expected. This would occur in the situation where both the stimulus events and the responses were different in the two passages.

After applying the above analysis to two different sets of passages, Anderson and Myrow (1971) demonstrated that actual performance corresponded well with predicted performance. The subjects showed depressed performance on test items predicted to be interfering, facilitated performance on items predicted to be facilitory and neutral performance on items in which there was no similarity for the two passages.

This review of pertinent literature did not resolve why or how, or even if, retroactive inhibition occurs with retention of meaningful prose material. However, some areas of general agreement are found for the majority of the researchers: (1) Retroactive inhibition does occur for rote learning and verbatim recall of prose material; (2) No retroactive inhibition has appeared when only a multiple choice test was used (Anderson and Myrow, 1971). (3) Retroactive inhibition occurs when the subject's understanding of the initial passage decreases as a result of conflicting responses for similar or identical stimuli; disagreement exists for the reasons.

Intelligence Effects

Many aspects of the effects of intelligence on learning have been studied, and one could not include a review of all aspects in one paper. For the purposes of the present study, only the effects of intelligence on conceptual learning involving verbal materials are included in this review.

It is frequently assumed that intelligence is related to the use of conceptual processes and often suggested that (1) individuals of high intelligence learn concepts more readily than individuals of lower intelligence and (2) individuals of high intelligence use mediation and other cognitive processes more effectively than individuals of lower intelligence (Jacobson et al., 1969). However, a close look at the available literature indicates there are few experimental studies which support those suggestions. The relationship of intelligence to conceptual learning has demonstrated that learning performance is influenced by complex interactions of subject variables, organization, and learning tasks (Osler and Fivel, 1961; Osler and Trautman, 1961; Osler and Weiss, 1962; Jensen, 1966; Jacobson, Millham, and Berger, 1969; Jacobson, et al., 1968, 1969).

Osler and Fivel (1961) studied the effects of superior and normal intelligence on concept attainment. The subjects were divided into gradual and sudden learners on the basis of a learning curve established by their learning performance. It was found that the group of sudden learners contained more subjects of superior intelligence than it contained subjects of normal intelligence. The group of gradual learners contained significantly more subjects of normal intelligence. The authors made the assumption that gradual learners build up stimulus-response (S-R) associations and that sudden learners test successive hypotheses; a mediated learning process.

Their suggestion was also based on a previous study by Kendler and Kendler (1959) which found that fast learners achieved a reversal shift more readily than a non-reversal shift. For example, subjects are presented a number of stimuli varying on two dimensions. They must learn a concept based on a dimension of the items presented that identifies only certain stimuli as belonging to a mutual group. The fact that choosing only red stimuli results in a correct response, is one example of a concept to be learned. Color is the common dimension.

A non-reversal shift occurs when, unknown to the subject, the dimension representing a correct response is changed to the other dimension; size for example. Choosing items of a particular size results in a correct response. Reversal shift occurs when the characteristic resulting in a correct response is changed to a different level of the same dimension. The important dimension is still color, but the color required for a correct response is changed; (i. e., from red to green).

Because of the difference in performance observed for the two types of learners, Kendler and Kendler (1959) inferred that fast learners utilized mediators in original discrimination. The less effecient problem solving potential of developing an S-R association would account for the lower performance of the slow learners.

Osler and Trautman (1961) developed an experiment to test the inferred relationship between intelligence and the mechanism involved in concept learning. They reasoned that increasing the number of irrelevant dimensions on which hypotheses could be based would decrease the speed of problem solution for subjects using hypothesis testing. If subjects achieve solution by a gradual buildup of an S-R association, no relation between the number of dimensions and speed of solution would be anticipated.

The results demonstrated that increasing the number of irrelevant dimensions slowed down subjects of superior intelligence but did not affect those of normal intelligence. High intelligence subjects achieved higher concept attainment on tasks which provided information useful for mediated learning.

Osler and Weiss (1962), in a third related experiment, studied the effects of non-specific and specific directions for tasks to be solved by subjects of superior or normal intelligence. Tasks with non-specific directions would entail problem finding as well as problem solution; tasks with specific directions would require only problem solution. Comparisons of the two intelligence groups would determine whether superior performance associated with high intelligence was a result of greater competency in problem finding, solution or both.

Under non-specific instructions, superior intelligence was associated with higher concept achievement for three different measures of performance. With specific instructions, subjects of average intelligence improved while the performance of superior intelligence subjects remained essentially the same. The results favored an advantage for superior intelligence for problem definition, but not solution.

Jacobson, _et al._ (1969) found that subjects of high intelligence learned concepts more rapidly and made fewer errors than subjects of lower intelligence for _both_ mediated and non-mediated concepts. The School and College Abilities Test was used to determine the intelligence grouping of the subjects. The results for non-mediated concept learning did not support the previous mentioned Osler, _et al._ results. Also, both high and low-intelligence subjects improved from their original performance to the same extent for mediated learning. Although high-intelligence subjects scored significantly higher, they did not display an advantage over low-intelligence subjects for the use of mediated concept learning.

Another study by Jacobson, Millham, and Berger (1969) used similar materials as the preceding study but used the scores on the vocabulary test of the Wechsler Adult Intelligence Scale as a measure of intelligence. It was found that subjects of higher intelligence learned mediated concepts significantly better than low intelligence subjects, but did not achieve greater performance for non mediated concepts. The two different measures of intelligence used for the two studies interacted differently for similar experimental conditions.

In spite of inconsistent results in some areas, the majority of studies have been consistent in indicating that the effects of both intelligence and mediation occur during the response generation stage of conceptualization (Osler and Weiss, 1962; Jacobson *et al.*, 1969; Jacobson, Millham, and Berger, 1969). This is the period beginning with the presentation of stimuli when the subject must process information in order to generate the first correct response. The period from the first correct response until concept attainment has been termed the recognition stage of conceptualization (cf. Jacobson, Elenewski, Lordahl, and Lairoff, 1968). Little if any, evidence supports significant effects of intelligence or mediation during the recognition stage. Also, most studies agree that performance tends to be higher for mediated than for non-mediated conceptual learning for all levels of intelligence; although, high intelligence subjects perform significantly better than below average intelligence subjects.

Millham, Jacobson, and Berger (1971); Osler and Weiss (1962); and Jacobson et al. (1969) indicate that subjects of superior intelligence most likely use other processes besides mediation in concept learning. Experimental studies can not control for the subject's utilizing personal problem solving strategies beyond those provided by or restricted by the experimenter; thus, inconsistent results occur. Besides that variable, the following factors have been shown to influence the subjects performance:

1. The measure of intelligence used to distinguish subject groups.
2. The stage of the conceptualization process studied.
3. The type of learning task employed.
4. The type of performance indicator employed.

Two additional studies are worth mentioning at this point because they included advance organizers in their study of intelligence effects. The first, a study by Allen (1970) tested the effects of advance organization, intelligence, and the level of cognitive processing on the learning and retention of written academic material. Students at or above the 60th I.Q. percentile were compared with those between the 20th and 59th percentiles. Questions testing the learning of biology concepts, consisted of both specific memory level questions and higher order cognitive processing level questions. Advance organizers were also used with both types of questions preceding the learning material.

The results for the memory level and the higher order processing questions indicated specific learning effects which diminished over time. Neither type of question showed significant advantages over the other. However, the effect (specific facilitation) was more resistant to forgetting for average and below average students than for above average students when combined with advance organizers.

No difference due to the advance organizers was observed on the immediate recall test. On the retention test, the advance organizer had specific facilitation effect for low ability subjects, while high ability subjects appeared to show general facilitation effect in their performances. The retention test was administered three weeks following the initial learning. The low ability subjects did not show any general facilitated effect of any significance as tested by the higher order questions. High ability subjects did not show facilitated effect for the specific, memory level questions.

Lucas (1972) studied the effects of advance organization on the learning of conceptual material and also the effects of the student variables intelligence, abstract reasoning and sex. He used audio, visual and written advance organizers as the treatment groups for students of high, medium and low intelligence and abstract reasoning ability. A control group received a historical passage instead of an advance organizer. The treatment period consisted of one hour a day for a total of four weeks at which time an achievement test was administered.

The results showed no significant advantage for the use of the three advance organizers over use of the control passage. Also, it was found that none of the student variables of intelligence, abstract reasoning or sex had a significant effect upon treatment; nor was significant interaction found for the four variables. Lucas reported that subjective data obtained from autobiographical sketches indicated advance organizers helped in the attainment of the biological concept.

Summary

The review of literature indicates that the various aspects of verbal conceptual learning tend to interact in a complex way with many variables and the numerous studies are somewhat inconsistent as a result. The areas where general agreement has been found are helpful when planning learning strategies.

Most researchers reviewed agree that organization of learning material facilitates learning and recall of that material. Also, most agree that organization by the subject of the newly learned material takes place during both storage and retrieval phases of learning. Having an organizational strategy to be used during recall prior to or during storage has shown superior learning results to devising a strategy at the time of retrieval or changing the organizational strategy at the time of recall.

Studies on the effects of retroactive inhibition have shown evidence that retroactive inhibition occurs when verbal material is learned rotely and verbatim recall is required. It is also evident when the learner's understanding of the concepts learned in an initial passage decreases as a result of conflicting responses for similar stimuli contained in successive learning. Little or no retroactive inhibition has occurred when performance was measured with multiple choice tests.

Studies on the effects of intelligence on conceptual learning indicate that superior intelligence is associated with higher performance during response generation stage of conceptual learning. Performance is also better for mediated than for unmediated concept learning for all levels of intelligence studied. Other variables such as the measure of intelligence used, the type of learning task involved, the type of performance variable employed and the stage of the conceptual process studied, influence the results obtained.

III. DESIGN OF THE STUDY

The main purpose of this study was to determine the effects of advance and post organization on the learning and retention of verbal material. The study employed a three-way analysis of variance design which consisted of a fixed model with four levels of the type of organizer, three levels of the type of student and two levels of time period (immediate recall and retention). The F statistic was used in the analysis and the level of significance was set at $\alpha = .05$ for the determination of significant differences.

The Dependent Variable

The dependent variable was the learner's score on a 32-item multiple choice criterion test given first at the conclusion of the learning experience (immediate achievement) and a second time three weeks later (retention). The learner's score on the criterion test was determined by the number of correct responses.

The instrument was developed by Ausubel for his 1960 study by using an item analysis procedure to select the questions from a larger population of items. Scores on the test showed a satisfactory range of variability and were normally distributed. The test had a corrected split-half reliability of .79 (Ausubel, 1960).

The test was later used by Graber in a 1972 study which reported results that were in direct contradiction of Ausubel's findings. Since both men had used the test questions previously and it was desirable to compare the results of this research with their contradictory findings, no changes were made in the instrument for this study. The instrument was considered to produce reliable results for the purposes the present research. The criterion test is reproduced in Appendix D for examination.

The Sample

The sample population consisted of 240 undergraduate students (116 female, 124 male) enrolled in three different areas of study at Oregon State University. Eighty subjects from each of the areas of teacher education, industrial education and science majors in chemistry were randomly selected and randomly assigned to four treatment groups.

The names and the major and minor areas of study for all students enrolled in the three subject matter areas were obtained from the instructors of the courses involved. Students having overlap with one of the other two subject areas were eliminated before random selection of the study sample was made (e.g., none of the student teacher subjects had majors in industrial education or science related areas).

The study sample was identified by selecting every fifth name from the alphabetized list of the remaining students for each subject area. Each subject selected was assigned to a treatment group by drawing a number (one through four) from a pool of numbers equal to the total sample size. Eight alternates were chosen for each treatment group using the same procedure to insure that the desired number of responses would be obtained. This was necessary to offset subject mortality since there was a three-week interval between the administrations of the test for immediate recall and retention.

All students enrolled in the courses providing subjects participated in the learning experiment regardless of whether or not their responses were used in the study. Also, none of the subjects were aware of the specific treatment that their group received as opposed to the other groups. This procedure was used to control for Hawthorne effect which often occurs when some individuals are singled out of a group to participate in an experiment. All students in the present study participated in the same experiment, received the same instructions and took the same tests. Possible Hawthorne effect should have been distributed among all four treatment groups.

In addition to the control of random sampling of subjects from a much larger population, the three types of subjects did not differ significantly in mean age or mean grade point average at Oregon State University. There was less than one year difference between the mean ages of the three groups and the F-ratio of 2.02 was not significant at the α = .05 level. Likewise, the computed F-value of .119 for differences among mean G.P.A.'s was not significant. The sampling design matrix for this study is shown in Table 1.

Since type of student was one of the major factors considered for the study, it was determined to use those types of students most comparable to the subjects used in the two studies already mentioned. Ausubel (1960) used students enrolled in teacher education courses and omitted students enrolled in industrial education because of their possible familiarity with the learning material. The general chemistry students used by Graber (1972) had little familiarity with the learning material, but had a science background. The present research included those two types of subjects and added industrial education subjects in order to provide three diverse levels of the type of student. The possibility that the previous two studies obtained contradictory results because the subjects differed in their level of familiarity with the learning material was investigated by this study.

Statistical Design

A 4 X 3 X 2 factorial analysis of variance (ANOVA) design was used for this study. The design consisted of a fixed model with four levels of the type of organizer, three levels of the type of student and

Table 1. Sample design matrix - time periods.

	1. Achievement immediately following learning				2. Achievement 3 weeks following learning				
	Adv. Org.	Post Org.	Both Adv. Post	Non Org.	Adv. Org.	Post Org.	Both Adv. Post	Non Org	Total
Teacher Educ.	N=20	N=20	N=20	N=20	N=20	N=20	N=20	N=20	160
Science Majors	N=20	N=20	N=20	N=20	N=20	N=20	N=20	N=20	160
Indust. Educ.	N=20	N=20	N=20	N=20	N=20	N=20	N=20	N=20	160
Total	60	60	60	60	60	60	60	60	480

two levels of the time period. The ANOVA arrangement is depicted in Table 2.

The F-statistic was selected as the appropriate analysis tool for this research study. The F-statistic is an acceptable and respected research procedure that has been used extensively in a wide variety of situations for comparisons of variance and to test for differences among means. The major application of the F-statistic presents itself in the analysis of variance where several means are being considered (Courtney and Sedgwick, 1973).

The critical F-ratio was set with the appropriate degrees of freedom as specified in the ANOVA table arrangement with $\alpha = .05$ for the determination of significant differences. The critical region values are shown in Table 3.

Hypotheses to be Tested

The design of the study allowed for the testing of three main effects and four subsidiary hypotheses. These hypotheses are enumerated below:

1. There is no significant organizer effect.
2. There is no significant student type effect.
3. There is no significant time effect.
4. There is no significant interaction effect between type of organizer and type of student.

Table 2. ANOVA arrangement (Fixed Model).

Source of Variation	Degrees of Freedom	SS	MS	F
Organizer Type	3	A	A/3	MS_o/MS_{error}
Student Type	2	B	B/2	MS_s/MS_{error}
Time	1	C	C/1	MS_t/MS_{error}
Organizer X Student	6	D	D/6	MS_{oxs}/MS_{error}
Organizer X Time	3	E	E/3	MS_{oxt}/MS_{error}
Organizer X Student X Time	6	G	G/6	MS_{oxsxt}/MS_{error}
Error	456	H	H/456	
Total	479	I		

Table 3. Critical region table.

Source of Variation	Degrees of Freedom	α-Level	Critical F (tabular)
Organizer Type	3, 450*	.05	2.62
Student Type	2, 450	.05	3.02
Time	1, 450	.05	3.84
Organizer X Student	6, 450	.05	2.12
Organizer X Time	3, 450	.05	2.62
Student X Time	2, 450	.05	3.02
Organizer X Student X Time	6, 450	.05	2.12

*Degrees of freedom equal to 479 is not available in the existing F-table; hence, 450 degree of freedom was chosen as the table value for determining the critical F-values.

5. There is no significant interaction effect between type of organizer and time period.

6. There is no significant interaction effect between type of student and time period.

7. There is no significant interaction effect among type of student, type of organizer, and time period.

The focus of hypothesis one was to determine whether the use of a specific type of organizer facilitated learning significantly more than did the use of a non organizer for the study's sample as a whole. Groups one, two and three all received a different type of written conceptual organizer, while group four received a written non organizer.

A priori hypotheses were generated to insure that the desired comparisons could be made in the event that hypothesis one was rejected. The test of Least Significant Difference (L. S. D.) was utilized to determine where differences existed among the mean scores obtained for the four types of organizers. The following *a priori* hypotheses were tested.

1. $\mu_1 = \mu_4$
2. $\mu_2 = \mu_4$
3. $\mu_3 = \mu_4$

The next analysis was a one-way analysis of the student type data. The immediate recall score and retention score for each subject were combined to compare overall performance of each student type for the four kinds of organizers. The three types of subjects, each in four types of treatment, made a total of 12 groups, of which any two could be compared for significant differences using this analysis. See Table 4 for the ANOVA arrangement.

The hypothesis tested by the analysis is as follows:

There is no significant differences among the mean scores for the 12 groups included in the study.

The purpose for these comparisons was to determine whether a specific type of organizer facilitated learning significantly more than did the use of a non organizer for a specific type of student. *A priori* hypotheses were again generated to insure that the desired comparisons could be made in the event the hypothesis was rejected. The L. S. D. test was applied to identify the areas of significant difference.

Groups one through four represented teacher education subjects, groups five through eight represented science major subjects and groups nine through twelve represented industrial education subjects. For each student type, the first three groups received the written conceptual organizer (e.g., Means 1-3, 5-7, 9-11). The fourth group for each student type received the non organizer (e.g., Means 4, 8, 12). The following *a priori* hypotheses were tested:

1. $\mu_1 = \mu_4$

Table 4. ANOVA arrangement (one-way).

Source of Variation	Degrees of Freedom	SS	MS	F
Treatment	11	A	A/11	MS_t/MS_{error}
Error	468	B	B/468	
Total	479	C	C/479	

Note: The Critical F-value at the .05 level of significance is 1.75.

2. $\mu_2 = \mu_4$

3. $\mu_3 = \mu_4$

4. $\mu_5 = \mu_8$

5. $\mu_6 = \mu_8$

6. $\mu_7 = \mu_8$

7. $\mu_9 = \mu_{12}$

8. $\mu_{10} = \mu_{12}$

9. $\mu_{11} = \mu_{12}$

Data Collection

The data for this study were obtained by presenting a 32-item multiple choice test to 240 undergraduate students from three different areas of study at Oregon State University. The same criterion test was presented on two different occasions: (1) immediately following the learning experience; and (2) three weeks following the learning experience. A total of 480 responses were used for the study.

Procedure

All materials for this study were presented to the subjects in their regular classroom. The investigator personally presented the materials and administered the directions to all groups of subjects.

A cover sheet for all materials prevented the subjects(Ss) from viewing the enclosed materials while the remainder of the Ss were still receiving their copies. The cover sheet was color coded which enabled the investigator to easily distinguish the materials and avoid errors in distribution. To further avoid the possibility of confusion, the materials for each treatment group had a small number printed on the upper right hand corner of the cover sheet. The numbers "1-4" designated the four treatment groups and the materials for each group were stacked separately for distribution.

Each sample of 80 subjects from the three chosen areas of study had been randomly assigned to the four treatment groups as described previously. The materials were administered with the students seated in their usual places. The following directions were read to all subjects prior to the distribution of any materials:

> The activity for today will consist of a reading exercise that will require about one hour of your time. You will need a pencil or pen, but are asked to use no scratch paper of any kind. The material you will be given will have your name on it and a set of directions. Check to make sure you have the material intended for you. Read the directions on your materials as they are read aloud to you and ask questions if it is not clear what you are to do.
>
> When told to begin, turn the page and procede to read and study the passage. It is important that you do as well as you can and that you do your own work. There will be no talking with other subjects until this exercise is completed. Are there any questions?

After answering any questions, the materials for the first stage of the experiment were distributed by the experimentor calling each student's name and placing the appropriate materials on his desk. Treatment groups one and three received the written conceptual organizer passage (blue coversheet) and groups two and four received the historical non organizer passage (green coversheet). The subjects followed the written instructions while the experimentor read them aloud. The instructions for both the organizer and non organizer passages were exactly the same. All instructions are included in the Appendix accompanying the appropriate passage.

After asking for questions, the subjects were instructed to begin and timing was started. At the conclusion of the eight minute interval, the subjects were asked to bring the concluded passage to a table where the materials for each group were stacked separately. Subjects in group one returned the original passage and picked up a copy of the next passage which had a number "1" on the top right-hand corner. Only the appropriate materials for the next stage of the experiment were placed on the table at one time so that no subject could pick up the wrong materials. The same procedure was followed for the other three groups.

All subjects received the learning passage material for this stage of the experiment. The directions printed on the coversheet were read aloud by the experimentor while the subjects followed their own copy. After answering any questions, the subjects were instructed to begin and timing was started.

At the end of the 20 minute learning period, the subjects returned the learning passage and picked up the appropriate organizer passage for their group using the same procedure as was used following the first stage of the experiment. The experimentor made sure that each subject picked up materials bearing the same number as that which was on the material just returned.

This time, groups two and three received the written organizer passage (blue coversheet) and groups one and four received the historical non organizer passage (green coversheet). The subjects followed the written instructions while the experimentor read them aloud. Timing was begun after answering any questions and the subjects had been told to begin reading.

At the conclusion of that eight minute period, all subjects picked up a copy of the criterion test after returning the reading material. The directions for the test were read aloud by the experimentor while the subjects followed their copy. There was no time limit set for taking the criterion test and subjects were allowed to finish at their own speed. Figure 1 indicates the method of presentation for each treatment group and the time intervals for each stage of the experiment.

Treatment Group	8 Minutes	20 Minutes	8 Minutes	No Time Limit	Type of Treatment
One	Advance Organizer	Learning Passage	Non Organizer	Criterion Test	Advance Organization
Two	Non Organizer	Learning Passage	Post Organizer	Criterion Test	Post Organization
Three	Advance Organizer	Learning Passage	Post Organizer	Criterion Test	Both Advance and Post
Four	Non Organizer	Learning Passage	Non Organizer	Criterion Test	Non Organization

Figure 1. Presentation procedure.

The same criterion test was administered a second time to all subjects three weeks following the initial learning experience for a measure of retention. No other materials preceded the administration of that test with the exception that the directions for the test were again read aloud by the experimentor before the subjects began. There was no time limit for the retention test.

The above procedure insured that all groups had the same amount of study time for each stage of the experiment and that all subjects had for inspection only the one appropriate passage during any one stage of the experiment. The subject's attention was less inclined to wander to other materials instead of reviewing the learning material for the total study time.

The time intervals used for this experiment were chosen because Graber (1972) indicated that many of the subjects ceased to review the materials when longer study periods were used. Some of the subjects continued studying the full time period and introduced an unwanted variable to the study; namely, length of study time effect on performance. The time allowed was sufficient for all subjects to complete the reading but not so long that they became bored.

IV. ANALYSIS OF DATA

This chapter presents the data obtained from the learning and retention performances of 240 undergraduate students at Oregon State University. The data were analysed by testing the hypotheses cited in Chapter III, which contains the detailed procedure and statistical technique for the study.

The data for this study were provided by eighty subjects from each of three areas of study; namely, teacher education, science major and industrial education. The subjects participated in a learning experiment which utilized four levels of a written conceptual organizer. The purpose was to determine the influence of the various organizers on the learning of verbal, academic material as well as to determine the effect of the type of students using the various organizers. Performance scores were obtained for the subject's immediate recall as well as their performance scores for retention three weeks following the initial learning experience. The data from which tests were made are provided in Appendix E.

Results of Analysis of Variance

The design of the study was a 4 X 3 X 2 factorial which enabled the researcher to study the three main effects of organizer type, student type and time on the learning of verbal material. In addition, the design allowed for the investigation of the interaction effects of the three main factors with each other. Table 5 presents the results of the three-way analysis of variance used to test for significant differences. The .05 level of significance was chosen as the critical region for all tests of significance included in this study.

Based on the results of the analysis, the three hypotheses for main effects were rejected at the specified level of significance. In addition, significance was found for two of the four interaction effects; namely, hypotheses four and six. The results of the main effect hypotheses are discussed below.

Results of Tests of the Main Hypotheses

The mean achieved scores for immediate recall were significantly higher than the mean achieved scores for retention three weeks following the learning. Also, science majors and industrial education subjects scored significantly better than teacher education subjects and advance organization facilitated learning significantly.

Hypothesis Three. The hypothesis stated that there was no significant difference between the mean scores achieved for immediate recall and retention. The critical F-value at the .05 level of significance with degrees of freedom (df) = 1, 450 is 2.62. The

Table 5. ANOVA arrangement (three-way).

Source of Variation	Degrees of Freedom	SS	MS	F
Organizer Types	3	240.683	80.228	4.31*
Student Types	2	1185.279	592.639	31.82*
Time	1	1184.408	1184.408	63.60*
Organizer X Student	6	327.304	54.551	2.93*
Organizer X Time	3	3.375	1.125	.06
Student X Time	2	115.829	57.915	3.11*
Organizer X Student X Time	6	55.687	9.281	.50
Error	456	8492.070	18.623	

* Significant at the .05 level.

computed F-value of 63.60 is well within the critical region; thus, the hypothesis was rejected.

Hypothesis Two. The hypothesis stated that there was no significant difference among the mean scores achieved by the three types of student studied. The critical F-value at the .05 level of significance with df = 2, 450 is 3.02. The computed F-value of 31.82 was within the critical region and Hypothesis Two was rejected. The Least Significant Difference (L. S. D.) test was used to analyze the various levels of the student factor. No *a priori* hypotheses were generated for the L. S. D. testing of Hypothesis Two. Table 6 presents the findings.

Table 6. L. S. D. test (student factor).

Subjects	$\bar{X}$ Score	$\bar{X}$ - $\bar{X}$	Decision
Science Majors	15.30		
		.57	retain
Industrial Education	14.73		
		3.02*	reject
Teacher Education	11.71		

The critical L. S. D.-value at α = .05 is .89.
*Significant at the .05 level.

The science major subjects' mean score did not differ significantly from the mean score of the industrial education subjects. However, the mean score of the industrial education subjects was significantly higher than the score achieved by the teacher education subjects at the .05 level of significance. Since the science major students had the highest mean score of any group, their performance was also considered to be superior to that of the student teachers.

Hypothesis One. The hypothesis stated that there was no significant difference among the mean scores achieved for the four types of organizers. The critical F-value at the .05 level of significance with df = 3, 450 is 2.62. The computed F-value of 4.31 is within the critical region and Hypothesis One was rejected. The L. S. D. test was used to analyze the various organizer means and to test the *a priori* hypotheses cited in Chapter III. Table 7. illustrates the results.

Table 7. L. S. D. test (organizer effect).

Organizer Type	$\bar{X}$ Score	Non Organizer $\bar{X}$ Score	$\bar{X}$ - $\bar{X}$	Decision
Advance (μ_1)	14.95	13.20	1.75*	reject
Post (μ_2)	13.33	13.20	.13	retain
Both (μ_3)	14.17	13.20	.97	retain

The critical L. S. D. value at α = .05 is 1.09.
*Significant at the .05 level.

The results show that only the mean score for the subjects using the advance conceptual organizer was significantly higher than the non organizer (control) mean score. Although the mean score of those receiving both the advance and Post organizer approached significance, the critical F was not within the rejection region. The post organizer group were not significantly different from the non organizer group.

Results of the Tests of Subsidiary Hypotheses

Hypothesis Four. The hypothesis stated that there was no significant interaction effect between the type of organizer and the types of students studied. The critical F-value at the .05 level of significance with df = 6, 450 is 2.12. The computed F-value of 2.93 is larger than the tabular; hence, there was significant interaction between organizer and student mean scores. The organizer level scores did not persist for all levels of students. The interaction pattern is plotted in Appendix F.

The mean score for the advance/post organizer level is the point at which the three types of students varied most radically. Industrial education subjects achieved a higher mean score for that method than for any of the other levels of treatment. On the other hand, teacher education subjects received a mean score even lower than that of the non organizer group which received no aid to facilitate learning. Science majors followed the general pattern of the industrial education students, whose lowest mean score was for the post organizer level; each was lower than the mean score of the non organizer group.

The plotted means of the science major and industrial education students cross between the post organizer and advance/post organizer levels, indicating disordinal interaction. Disordinal interaction is also evidenced between the advance/post level and the non organizer level where the plotted means again cross. Science majors scored higher than industrial education students for advance and post organizer levels, lower on the advance/post level and higher again for the non organizer level.

The plotted mean scores for the teacher education subjects indicate ordinal interaction when compared with either science major or industrial education mean scores for all four levels of organizer. The effect is slightly more pronounced in the comparison with the industrial education subjects. Since the interaction effect is essentially the same for both comparisons, only one description is given here.

The plotted mean scores converge between advance and post organizer levels, mainly as a result of the poor performances of both science majors and industrial education subjects for that method. The means diverge sharply between the post organizer and advance/post organizer levels where teacher education subjects received their lowest mean score and industrial education and science majors achieved high mean scores. The means converge again between advance/post organizer and non organizer levels with the teacher education score increasing and both other groups' mean score decreasing.

Hypothesis Five. The hypothesis stated that there was no significant interaction effect between the type of organizer used and the time of recall (immediate or retention). The critical F-value at the .05 level of significance with df = 3, 450 is 2.62. The computed F-value of .06 is smaller; hence, the null hypothesis was retained. There was no significant interaction effect between the various levels of organizer and the time mean scores.

Hypothesis Six. The hypothesis stated that there was no significant interaction effect between type of student and the time of recall (immediate or retention). The critical F-value at the .05 level of significance with df = 2, 450 is 3.02. The computed F-value is 3.11 was within the critical region; therefore, Hypothesis Six was rejected. There was a significant interaction between the various levels of student and time. See Appendix F for a plot of the interaction pattern.

Interaction did not occur between teacher education and industrial education subjects for immediate recall and retention mean scores. However, a large decrease in the mean retention score for science major subjects resulted in ordinal interaction between their group and the teacher education subjects. The plotted means converge sharply towards the retention scores.

The interaction was even more pronounced between the science major and the industrial education students where the plotted means crossed, resulting in disordinal interaction. The mean scores for science majors was higher for immediate recall, but lower for retention than the mean score of the industrial education subjects.

Hypothesis Seven. The hypothesis stated that there was no significant interaction effect among type of student, type of organizer and the time of recall. The critical F-value at the .05 level of significance with df = 6, 450 is 2.12. The computed F-value of .50 was smaller than the tabular F-value; therefore, Hypothesis Seven was retained. There was no significant interaction among the various levels of organizer type, student type and time.

Results of the Multiple Comparison Analysis

Previously, it was indicated that a multiple comparison analysis was conducted to enable a more direct comparison between the various levels of organizer for each specific type of student. Nine *a priori* hypotheses were generated to insure the desired comparisons. The details of the analysis of variance hypothesis, and the *a priori* hypotheses for L. S. D. testing are cited in Chapter III. Table 8 shows the results of the one-way analysis of variance for the treatment data: Table 9 reports the L. S. D. test results.

Table 8. ANOVA arrangement (one-way).

Source of Variation	df	SS	MS	F
Treatments	11	1753.26	159.38	7.57*
Error	468	9851.40	21.05	
Total	479	11604.66		

* Significant at the .05 level.

The hypothesis stated that there was no significant differences among the mean scores for the 12 groups included in the study. The tabular F-value at the .05 level of significance with df = 11, 450 is 1.75. The computed F-value of 7.57 falls within the critical region; hence, a significant difference was found to exist among the mean scores. The L. S. D. test resulted in the rejection of two of the nine a priori hypotheses. See Table 9 for a summary of the L. S. D. test results.

Both of the rejected hypotheses indicated that differences existed among the means of the various industrial education groups. The advance organizer group scored significantly higher than the non organizer group. The group receiving both the advance and post organizer treatment also scored significantly higher than the non organizer group.

Table 9. Least Significant Difference (L. S. D.) test results.

a priori Hypotheses	$\overline{X}$ Score	Comparison $\overline{X}$ Score	Difference	Decision
$\mu_1 = \mu_4$	12.87	11.37	1.50	retain
$\mu_2 = \mu_4$	12.32	11.37	.95	retain
$\mu_3 = \mu_4$	10.30	11.37	1.07	retain
$\mu_5 = \mu_8$	16.22	14.90	1.32	retain
$\mu_6 = \mu_8$	14.37	14.90	.53	retain
$\mu_7 = \mu_8$	15.70	14.90	.80	retain
$\mu_9 = \mu_{12}$	15.77	13.32	2.45*	reject
$\mu_{10} = \mu_{12}$	13.30	13.32	-.02	retain
$\mu_{11} = \mu_{12}$	16.52	13.32	3.20*	reject

The critical L. S. D. value at $\alpha = .05$ is 2.01

*Significant at the .05 level.

The post organizer group for industrial education did not differ significantly from the comparison group, not did any of the science major or teacher education organizer groups differ significantly from their respective non organizer group. All hypotheses testing those means were retained as indicated by Table 9.

V. SUMMARY AND CONCLUSIONS

Restatement of the Purpose

The main purpose of this study was to determine the influence of the use of written advance organization, post organization or both advance/post organization on learners as compared to the use of non organization for the learning and retention of verbal, academic material. An additional interest was to determine the effect of the type of student using the various organizers at two different times of recall. Performance scores were obtained for the subjects' immediate recall as well as for their retention three weeks following the initial learning experience.

The Dependent Variable

The dependent variable was the learner's score on a 32-item multiple choice criterion test given first at the conclusion of the learning experience (immediate recall) and a second time three weeks later (retention). The learner's score on the criterion test was determined by the number of correct responses.

Restatement of Procedures

Eighty subjects from each of three areas of study at Oregon State University participated in a learning experiment which utilized four levels of a written conceptual organizer. The four levels of organizer (i.e., advance, post, advance/post and non organizer) established the four treatment groups used for each type of student.

Students from teacher education, industrial education and science majors were presented appropriate verbal organizers prior to and/or following the learning of meaningful verbal material to determine whether learning and retention were enhanced.

The post and non organizer groups received a non organizing, historical passage prior to reading a longer learning passage on the metallurgical properties of carbon steel. The advance and advance/post organizer groups received a concept building, background passage prior to reading the same learning passage.

Following the learning passage, the advance and non organizer groups received the historical, non organizing passage and the post and advance/post organizer groups received the concept building, background passage. All subjects took the same criterion test immediately following that stage and repeated the test three weeks following the learning exercise.

The collected data were analyzed using the F statistic to determine if differences existed among the mean scores. Both the three-way analysis of variance and a multiple comparisons analysis were conducted. The test of Least Significant Difference was utilized when comparisons showing significant differences contained more than two means.

Conclusions

The following conclusions are drawn as a result of the study and are based upon the findings:

1. A written advance organizer effectively facilitated the learning and retention of meaningful verbal material.
2. Neither post nor advance/post organization significantly facilitated the learning and retention of meaningful verbal material for the sample as a whole.
3. Both advance and advance/post organization facilitated learning and retention significantly more than did non organization for industrial education subjects only.
4. The performance of different types of students using the same types of organizers as an aid to facilitate learning differed significantly.
5. Immediate recall of learning was significantly higher than retention of learning three weeks following the learning exercise.
6. The performance level of the different types of students did not persist for all four types of organizer.

Discussion of the Results

The results of this study support Ausubel's argument (1960) that facilitated learning of a second prose passage is possible as a function of being exposed to material in an initial passage which establishes subsuming concepts. The findings conflict with Graber's (1972) study, which showed no significant facilitating effect for advance or post organizers while using the same materials employed by both Ausubel and the present study. The present research and other studies completed recently (cf. Allen, 1970; Kuhn and Novak, 1970; Bransford and Johnson, 1972; and Royer, 1973) indicate that an advance verbal organizer is an effective means of facilitating the learning of academic material.

The fact that interaction effects were found to exist between student type and organizer type and between student type and time indicate that other variables confound the facilitating effect of the organizer. Since an organizer is an effective organizer only if it facilitates learning, it appears probable that an organizer for one person may be a non organizer for another person. Considering the wide range of backgrounds and previous learning experiences that students bring to the college classroom, it seems quite possible that the facilitated performance of some students for one type of organizer could be obliterated by the low performance of other students for the same organizer. The heterogeneous structure of the subjects used may be a reason several studies have reported no facilitating influence of advance organization.

The results obtained in this study for the subjects receiving both advance and post organization are a case in point. Both science majors and industrial education subjects achieved high mean scores for advance/post organization; in fact, the science major score was almost identical and the industrial education score was higher than their respective performances for advance organization. On the other hand, the teacher education mean score for advance/post organization was their lowest performance, including the non organizer group, and was significantly lower than their score for advance organization. The low performance on the part of the teacher education subjects tended to obliterate much of the facilitated performance of the other two groups for advance/post organization.

Royer (1973) and Graber (1972) are in agreement that facilitated learning is more likely to occur when (1) the learning passage material is difficult to comprehend, but does not exceed the subject's capabilities, and (2) the initial passage contains referents that are relatable to the subjects' past experience so as to increase the comprehensibility of the learning passage. Nothing in the present study contradicts those conditions for facilitation and the study adds support to the idea that matching the type of organizer with the students' level of comprehension for the specific learning task is the most effective use.

Implications

Since no single method of learning is effective for all students of varying backgrounds and capabilities, it is difficult, if not impossible, to provide optimum conditions for each learner. However, some methods facilitate learning to a larger degree and for a wider range of students than do others. The following implications are supported as a result of this study:

1. Proper organization of academic materials should be used to aid students to learn and retain the information more effectively and efficiently. Demands of society for educational accountability also support a need for more efficient and effective learning.
2. The development and content of learning modules and teaching strategies should allow for schemes that are flexible for both teaching and student learning strategies.
3. When one method of instruction is used for all students, the learning material should be preceded by information that provides referents relatable to the students' past experience or background. Developing the basic concepts

needed before the new learning is presented increases the comprehensibility of the material to be learned for the widest range of student familiarity.

4. As the difficulty level of the learning material increases, consideration should be given to varying the type of organizing aid so as to meet the needs of students having varying levels of familiarity. Preassessment of students is used frequently and provides a good basis for determining what directions the learning will proceed.

Suggestions for Additional Study

In light of the preceding observations, future research is suggested in the following areas:

1. Research should be directed towards identifying the subject characteristics or variables that respond favorably or unfavorably to the various organizers.
2. More efforts need to be directed towards combining the various types of organizers in order to increase overall effectiveness.
3. More research is needed in the area of developing subsuming organizer material which encourages general rather than specific facilitation.

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APPENDICES

APPENDIX A

ADVANCE/POST ORGANIZER

DIRECTIONS

This is some introductory background material pertaining to a longer and more detailed selection in the same general subject-matter area that you will be studying shortly. You will have eight minutes in which to study this introductory material.

When you are told to begin, turn this page and read the entire selection at your customary reading speed. During the first reading, concentrate on grasping the general features of the material and becoming generally familiar with it. During the remainder of the available time, use whatever method you prefer to fix the substance of the material and the details in your memory. Do not take any notes or make any marks on the reading material.

You may ask any questions that you have now.

DIRECTIONS

This is some summary material pertaining to the longer and more detailed selection that you have just studied. You will have eight minutes in which to study this summary material.

When told to begin, turn this page and read the entire selection at your customary reading speed. During the first reading, concentrate on grasping the general features of the material and becoming generally familiar with it. During the remainder of the available time, use whatever method you prefer to fix the substance and the details of the selection in your memory. Do not take any notes or make any marks on the reading material.

Metals and Alloys

Metal has certain unique advantages over other substances as a material for tools and implements. It is hard, strong, durable, and can be molded to any desired shape. When no longer required for a particular use it can be melted and made into a new product. But even more important, perhaps, is the fact that it has a wide diversity of properties under the control of man.

Many important physical properties of metal depend upon its internal grain structure. We can, therefore, alter the properties of a given metal by changing its internal structure. Both heat and various mechanical processes modify the internal structure and hence the properties of metals. Heat, for example, changes the grain structure of metals in such a way as to soften them, and hammering at room temperature changes their grain structure in such a way as to harden them.

Nevertheless, despite the possibility of modifying the internal structure of metals by heat and mechanical means, the range of properties available among pure metals is obviously limited by the existence of only a small number of pure metals. Hence, if man restricted himself to the use of pure metals he would only have a limited variety of grain structures and a correspondingly limited range of physical properties at his disposal.

It is true, of course, that pure metals do have certain unique functions that alloys cannot perform, especially in laboratory instruments. For most practical purposes, however, it is expedient to alloy a metal with other metals or non-metals, and thus take advantage of the much wider selection of grain structures and physical properties which thereby becomes available. Generally speaking, other elements are alloyed with metals to confer such properties as increased hardness, strength, toughness, and flexibility. Almost any desired combination of physical properties can be developed to meet the specific requirements of a metal part by selecting an appropriate metal, by choosing suitable kinds and percentages of alloying elements, and by subjecting the resulting alloy to appropriate mechanical and/or other procedures.

It is clear from the foregoing, therefore, that the properties of a given alloy, like those of a pure metal, are (within certain limits) determined by its distinctive grain structure. This structure in turn depends upon the particular metal and the specific type and amount of alloying substance used. Alloys also resemble pure metals in the fact that their internal structure also varies with temperature. Unlike pure metals, however, the grain structure (and hence the properties) of some alloys are modified by the rate at which they are cooled.

Hence, before we could predict the grain structure and properties of an alloy belonging to the latter category of alloys, we would not only have to know (a) its temperature, and (b) its principal metal component, and the type and amount of alloying substance used, but also (c) the rate at which it was cooled.

APPENDIX B

NON ORGANIZER

DIRECTIONS

This is some summary material pertaining to the longer and more detailed selection that you have just studied. You will have eight minutes in which to study this summary material.

When told to begin, turn this page and read the entire selection at your customary reading speed. During the first reading, concentrate on grasping the general features of the material and becoming generally familiar with it. During the remainder of the available time, use whatever method you prefer to fix the substance and the details of the selection in your memory. Do not take any notes or make any marks on the reading material.

DIRECTIONS

This is some introductory background material pertaining to a longer and more detailed selection in the same general subject-matter area that you will be studying shortly. You will have eight minutes in which to study this introductory material.

When you are told to begin, turn this page and read the entire selection at your customary reading speed. During the first reading, concentrate on grasping the general features of the material and becoming generally familiar with it. During the remainder of the available time, use whatever method you prefer to fix the substance of the material and the details in your memory. Do not take any notes or make any marks on the reading material.

You may ask any questions that you have now.

Iron and Iron Alloys

Iron and iron alloys have a long and interesting history. The wide range of iron derivatives available today occupies an intermediate position in both time and complexity between the ancient art of the metalsmiths and our modern science of metallurgy. Although modern methods of mass-producing iron and iron alloys are only about one-hundred years old, iron products have been used for about 4000 years, and many of the basic processes employed today are several hundred years old.

Meteoric iron was probably the first iron alloy used by man in most parts of the world. This type of iron accounts for the existence of many iron tools in areas where iron smelting was unknown. It has a high nickel content peculiar to meteoric iron; no known iron ore shares this characteristic. Although this alloy could not be melted with charcoal fires, it could be softened and formed into tools far superior to those of bronze or copper.

Wrought iron was in use before the first written records and was the primary iron product made by man until about 100 years ago. It is almost pure iron that contains strips and pieces of slag throughout, and is fairly strong and easy to work.

Wrought iron was produced in a crude charcoal-burning furnace similar to that used in the refining of copper and tin. Wood charcoal and ore were placed in the tube-like furnace, and the charcoal was ignited from the bottom. The natural draft of air in such a furnace, however, was insufficient for the charcoal to burn fast enough to produce the necessary heat and temperature. To overcome this difficulty, the furnace was made higher and hand-operated bellows were used to increase the available air flow.

Although this type of furnace was hot enough to melt tin and copper ores, it was not hot enough to reduce iron ore to a molten (liquid) state. In the case of iron ore it only yielded a black, spongy material with no obvious use and hardly resembling a metal. Before this spongy mass could be converted into a usable metal, it had to be alternately heated and hammered to force the particles of iron together and to squeeze out the slag. This was a long, arduous process that yielded only very small quantities of wrought iron. This process, however produced practically all of the known iron products from about 1350 to 1850 A. D.

The mass production of iron, therefore, was delayed until about 1850 A. D., when a furnace was invented that produced a temperature sufficiently high to reduce large quantities of ore to molten metal. This was the blast furnace utilizing coke as a fuel, as well as a vastly augmented air blast from a steam engine. The produce of this blast furnace is pig iron. It contains many impurities, cannot be worked, and must be refined further before it becomes a useful product.

Prior to about 1830, all good steel had to be fabricated from laboriously made wrought iron. The introduction of the blast furnace and the mass production of pig iron from iron ore, however, soon led to large-scale methods in the manufacture of steel. Steel is made today by refining molten pig iron in either a Bessemer Converter or an open hearth furnace.

APPENDIX C

LEARNING PASSAGE

DIRECTIONS

This is a test of how well you can learn the substance and details of typical scientific material at the college level. You will have twenty minutes in which to study this material.

When you are told to begin, turn this page and read the entire selection at your customary reading speed. During the first reading, concentrate on grasping the general features of the material and becoming generally familiar with it. During the remainder of the available time, use whatever method you prefer to fix the substance and details of the selection in your memory. Do not take any notes or make any marks on the reading material.

You will be examined on this material by means of a multiple choice test. The ability to provide correct answers to these questions will presuppose adequate comprehension of the material as well as precise knowledge of the details. In three weeks you will be examined on this material again in order to determine how much of the material you have retained.

You may ask any questions that you have now.

THE PROPERTIES OF PLAIN CARBON STEEL

Steel as an Alloy

An alloy is a metallic substance obtained by combining two or more elements at least one of which is a metal. Depending on its temperature it may be either a solution of its constituent elements or a homogeneous mixture resulting from the cooling of such a solution. When examined under a powerful microscope it is found to have a uniform internal structure from one portion to another.

If a metal merely contains other elements, for example, impurities, embedded within it non-homogeneously in scattered pockets or inclusions, it is not considered an alloy. Most alloys, however, do contain small residual percentages of impurities, usually derived from the metal ore, which are not completely removed by the refining process. In these instances the amount of impurities in the alloy is so small that it does not materially impair the usefulness of the metal. Complete removal of all impurities is not feasible because of the prohibitive expense of such a procedure.

A relatively simple metallic grain structure is predictable as long as the constituent elements of an alloy do not interact chemically. The grains resulting from the cooling of a solution of bronze (an alloy of copper and tin), for example, are metallic grains comparable to grains of pure metal except for having two metallic constituents instead of one. All of the grains are alike: each grain is a grain of bronze. And although the copper and tin components of the grain are not chemically united they are no longer distinguishable as separate metals

A somewhat different situation prevails when the constituent elements of an alloy enter into chemical combination. In the case of steel (an alloy of iron and carbon), for example, carbon and small amounts of iron interact chemically forming a compound of the two elements (iron carbide), and particles of this compound are then uniformly dispersed among the grains of metal. Thus we do not have a solution or homogeneous mixture of a simple type of metallic grain such as bronze, the components of which are indistinguishable from each other. We have instead a solution or homogeneous mixture of two structurally distinct and identifiable components, namely, metallic grains (iron) and particles of an iron-carbon compound (iron carbide) distributed within and around the grains of iron. This opens up a whole new variety of more complex grain structures that cannot be achieved in the case of simple metallic grain alloys and/or pure metals, thereby making possible such procedures as hardening by "heat treatment". Of all the thousands of alloys, only iron alloys containing small amounts of carbon, and certain alloys of magnesium and aluminum may be "heat treated".

For our purposes, steel may be defined as an alloy of iron with a small percentage of carbon, usually from 0.10% to 1.5%, but never more than two per cent. It may also contain one or more other alloying elements (in addition to carbon) to confer such properties as increased hardness, strength, toughness, flexibility, and resistance to corrosion. But most steel made today, as well as most steel in use, is plain carbon steel.

Relation of Internal Structure of Steel to Temperature

The properties of steel vary with its temperature. The most obvious property change related to a change in temperature is the transition from a solid to a liquid state as steel is heated above its melting point. The reverse transition occurs when molten (liquid) steel is cooled below its melting point and solidifies into grains (crystals), much like water freezing into ice.

At normal atmospheric temperatures, the grains of iron and the iron carbide particles in solid steel are fixed in position, that is, immobilized in a definite structural arrangement. As heat is applied to this steel, however, many changes in internal structure take place while it is still in the solid state and below the melting temperature. Generally such changes take place at definite temperatures known as "critical temperatures." Solid steel at high temperatures (i.e., above its upper critical temperature) is actually a solid solution.

It may seem odd to think of a solid material as being a solution. Yet steel, while in the solid state below the melting point but above its upper critical temperature, has a uniform internal structure that varies within wide limits. This is the definition of a solution. Glass is probably the best known solid solution.

Characteristic of steel as a solution (liquid or solid), therefore, is its variability of internal structure. The iron carbide breaks up into tiny, hard and brittle particles which more or less float throughout the grains of iron. The particles have a great amount of freedom to form and reform, change size and relationship to each other, and otherwise rearrange themselves; at any given temperature they assume the size, shape and relationship most normal at that temperature. As steel cools through its lower critical temperature and ceases to be a solid solution, this freedom is lost and its internal structure becomes fixed or invariable.

The lower critical temperature of steel is that temperature at which the carbide starts going into solution when steel is heated. As the temperature is raised, more and more carbide goes into solution. The upper critical temperature represents the point at which all carbide present in the steel is in solution. The lower critical temperature is always the same for all carbon steels, namely, 1350°F. The upper critical temperature, however, decreases as the carbon content increases. It decreases from 1600°F. for 0.10% carbon to 1350°F.

for 0.80% carbon. Thus for 0.80% carbon steel (and above), the upper and lower critical temperatures are the same, and all of the carbide goes into solution at 1350°F. When less than 0.80% carbon is present, the carbide in steel is only partially in solution between the upper and lower critical temperatures. Beyond 0.80% carbon, greater carbon content in steel does not lower the upper critical temperature below 1350°F.

Relation of Internal Structure of Steel to its Carbon Content

The second important factor that determines the internal structure of steel is the amount of carbon (in the form of carbide) it contains. At 0.80% carbon (and below), all of the carbide is located within the grains of iron. If steel contains 0.80% carbon, sufficient carbide is available to saturate all of the iron grains. In 0.40% carbon steel, one half of the grains are saturated with carbide; the remaining half are grains of pure iron. In 0.20% carbon steel, one-quarter of the grains are saturated with iron carbide and three-quarters of the grains are pure iron. Intermediate amounts of carbon are distributed proportionately. Any amount of carbon over 0.80% also saturates all of the iron grains with iron carbide particles; the excess carbide forms a shell-like layer around the grains.

Since the tiny carbide particles are extremely hard, the higher the carbon content of the steel is, the harder the steel will be. This statement is unequivocably true up to 0.80% carbon steel. Above this figure, the relationship between the carbon content of steel and its hardness depends on the rate at which it is cooled (this will be discussed further below).

Relation of Internal Structure of Steel to Rate of Cooling

The precise type of fixed internal structure that steel assumes as it changes from a solid solution, while passing through its upper and lower critical temperatures, depends on the rate at which it is cooled through these temperatures.

In the solid solution condition, as already pointed out, the carbide particles in steel are mobile, almost floating, and are free to rearrange themselves in a manner most normal for a particular temperature. When the metal is cooled through its upper and lower critical temperatures, however, the carbide assumes a fixed size and position in and around the iron grains. If a solid solution of steel is cooled slowly through its two critical temperatures, the carbide particles have sufficient time to rearrange themselves and thus become fixed in an orderly structure natural for lower temperatures. If cooled rapidly, on the other hand, sufficient time is not available for this orderly and normal rearrangement to take place, and the resulting fixed structure is strained and unnatural.

Slow Cooling

It is clear, therefore, that when a piece of steel is cooled very slowly through its critical temperatures, it assumes a natural and unstrained internal structure. The carbide particles have time to collect into spheres within all of some grains and into layers around the grains depending on whether the percentage of carbon in the steel is 0.80%, or below or above this figure. (How the internal structure varies with the amount of carbon in steel, has already been described in a previous section.)

When plain carbon steel is heated above its critical temperatures and then cooled slowly, the natural internal structure it assumes makes it relatively soft and tough. Hence steel treated in this fashion is quite easily formed, but by the same token is also easily bent or stretched without cracking or breaking. The carbide spheres do have some influence, however, since higher carbon steels emerge slightly harder than lower carbon steels from the same slow-cooling procedure. This relationship between carbon content and hardness holds true even beyond 0.80% carbon in the case of slow-cooled steels. When 1.2% carbon steel is cooled slowly, for example, it becomes slightly harder than when 0.90% carbon steel is cooled slowly.

Rapid Cooling

Rapid cooling of steel for a solid solution traps the tiny carbide particles in a fixed structure before they have time to reform and collect in spheres within, and in layers around the grains of iron. Faster and faster cooling results in the carbide being trapped in a fixed condition in ever finer particles more completely dispersed within the iron grains. This particular unnatural structure makes for greater and greater hardness and brittleness, which properties also increase proportionately with the amount of carbon present, up to 0.80% carbon. At this point maximum hardness is achieved. Rapidly cooled 1.0% carbon steel, for example, is not harder than rapidly cooled 0.80% carbon steel.

If a piece of steel is cooled through its critical temperatures in less than one second, the carbide particles are trapped in a completely dispersed structure. This is a spiny, needle-like network resembling pine leaves. The spines act as interlocking reinforcing rods to in concrete, locking the iron grains in a very hard, rigid arrangement. The higher the carbon content (up to 0.80%), the more spines, and consequently the greater hardness. High carbon steel treated in this way is very hard and brittle--even more brittle than glass. It will break before bending.

This process of hardening steel by first heating it above its critical temperatures, and then taking advantage of the particular unnatural internal structure that develops as it is cooled rapidly through these temperatures, is known as "heat treatment". It should be borne in mind, however, that heat treatment accomplishes nothing in the way of hardening unless the carbide is first in solution. This only begins to occur above the lower critical temperature. Hence even very rapid cooling from any temperature less than 1350°F. will not increase hardness.

Although excess carbon beyond 0.80% does not increase the hardness of "hardened" steel, it does serve a useful purpose by increasing the wear resistance of such a piece. In wearing away this piece of steel, one would have to wear down both the hard grains of steel as well as the much harder layers of carbide particles around each grain. A major disadvantage of high carbon steels, however, is the fact that the brittle shell of iron carbide around the iron grains increases brittleness. Hence these steels are more likely to fracture on impact or bending than tougher low carbon steels.

An important complicating factor in heat treatment arises from the fact that steel is chemically more active at high temperatures. If it is heated in an ordinary air, oxygen actually burns carbon out of the surface of the steel, thereby lowering its carbon content. Atmospheric oxygen also oxidizes (i.e., rusts) the iron itself at a very rapid rate when steel is hot. If heated in an atmosphere of carbon gases, on the other hand, steel absorbs carbon into its surface. Special precautions, therefore, must be taken to prevent oxidation, burning out of carbon, or the absorption of carbon while finished parts are heat treated. In some instances, however, a finished part (made of low carbon steel) may be deliberately heated in an atmosphere of carbon gases so that it may absorb carbon and thus acquire a hard outer case.

Tempering

Hardness alone is seldom desired in a piece of steel. Any given piece must have the most desirable combination of properties possible for its particular use--whether hard and brittle, soft and tough, flexible, etc. Theoretically it should seem possible to control the degree of hardness that results from heat treating steel, be regulating the rate of cooling through its critical temperatures. If, for example, we wanted a relatively soft and tough piece of steel we should simply have to cool it less rapidly than if we wanted a harder and stronger piece. Actually, however, it is very difficult to regulate the rate of cooling with sufficient precision so as to achieve the desired degree of hardness. In practice, therefore, steel is cooled at the fastest possible rate during hardening or heat treatment, and any undesired amount of hardness and brittleness is then removed later from the fully hardened piece by tempering, a process of reheating steel to a temperature below the lower critical temperature. The hardness of steel is so closely related to its other properties, that if we achieve the correct degree of hardness in a piece after heat treatment and tempering, we can rely on its having the desired other properties.

The unnatural needle-like formations of trapped carbide particles in hardened steel generate structural stresses, thereby exerting an internal force toward reforming into a more natural structure. At ordinary room temperature, however, modification of this unnatural structure is impossible. But as the fully hardened piece of steel is reheated, some of the trapped carbide spines do reform into spheres. This reforming starts as low as 212°F. As each higher temperature below the critical is reached, additional spines break down and reform into spheres, thus making the metal softer and tougher (less brittle). The highest temperature to which the hardened piece of steel is subjected during the reheating operation determines its final degree of hardness and brittleness (or softness and toughness), and is the important factor in tempering.

A tool such as a file, for example, is reheated to 212°F. This modifies some needles, thereby removing some of the brittleness but retaining practically all of the hardness. Cutting tools and wearing parts are tempered at about 400°F. This removes most brittleness and, of necessity, a little hardness. Battering tools are reheated to about 500°F.; still more needles are removed resulting in a loss of hardness, but more important, the tools are tougher and less apt to break under a blow. Springs are tempered at about 750°F. to obtain the best balance between hardness, toughness and flexibility. Parts reheated to 900° - 1000°F. lose additional hardness but gain in toughness (or the ability to withstand a blow by bending before breaking). Each higher tempering temperature modifies an additional portion of the spiny structure. If a part should be over-heated for any reason (thereby becoming too soft), it must be rehardened (i.e., heated above its critical temperatures and then cooled rapidly) and then tempered to the proper temperature.

APPENDIX D

CRITERION TEST

DIRECTIONS

The questions on the following pages test your knowledge of the material that you have just studied. You will have all the time you need to answer the questions.

These questions are all of the multiple-choice type. For each question choose the lettered alternative that is most appropriate. If two or more answers seem appropriate, choose the one that seems most correct to you. Only one answer may be chosen for each question. Answer all questions even if you are not completely certain of your answer in a particular case.

When you have decided which of the five lettered answers is correct for each question, blacken the corresponding space on the answer sheet with pencil or pen. Make sure that the number of each question you answer on the answer sheet corresponds to the same number as the question. You can avoid errors by answering each question as you come to it. Do not skip around from one question to another.

You will have an opportunity before the end of the quarter to learn your own score, the mean score for your class and the mean scores of the other classes in the study.

PLEASE MAKE NO MARKS ON THE QUESTION BOOKLET

The Properties of Plain Carbon Steel

Question Booklet

1. The primary purpose of tempering steel is to reduce:
   (a) hardness;
   (b) brittleness;
   (c) wear-resistance;
   (d) toughness;
   (e) softness.

2. An alloy is a substance composed of two or more elements:
   (a) which has metallic properties;
   (b) which has at least one metal constituent;
   (c) which do not interact chemically;
   (d) "a" and "b";
   (e) "b" and "c".

3. The most reliable method of making the first of two identical pieces of steel harder than the second is to:
   (a) cool the first piece more slowly during heat treatment;
   (b) cool the first piece more rapidly during heat treatment;
   (c) heat the first piece to a higher temperature during heat treatment;
   (d) temper the first piece at a higher temperature;
   (e) temper the first piece at a lower temperature.

4. In 0.60% carbon steel:
   (a) all of the iron grains are saturated with carbide;
   (b) one-quarter of the iron grains are saturated with carbide;
   (c) one-half of the iron grains are saturated with carbide;
   (d) three-quarters of the iron grains are saturated with carbide;
   (e) carbide forms in a shell-like layer around the grains of iron.

5. A kitchen knife made of which of the following would remain sharp the longest?
   (a) .20% carbon steel;
   (b) .40% carbon steel;
   (c) .80% carbon steel;
   (d) .95% carbon steel;
   (e) 1.5% carbon steel.

6. To be able to get maximum hardness in steel, it must contain:
   (a) at least 0.10% carbon;
   (b) at least 0.40% carbon;
   (c) at least 0.80% carbon;
   (d) not over 1.5% carbon;
   (e) not over 2.0% carbon.

7. Which of the following events do not occur as steel is transformed from a mixture to a solution?
   (a) the carbide particles become more highly dispersed;
   (b) the metal becomes a liquid;
   (c) the carbide particles become smaller;
   (d) the grain structure varies with changes in temperature;
   (e) the carbide particles acquire greater freedom to reform.

8. By knowing the hardness of a piece of steel we do not know:
   (a) its toughness;
   (b) its tensile strength;
   (c) its corrosion resistance;
   (d) its ability to withstand impact;
   (e) its ability to withstand bending without breaking.

9. When an alloy is examined under a powerful microscope, it can be demonstrated that:
   (a) it has a uniform internal structure throughout the piece;
   (b) all grains have the same general appearance;
   (c) all grains have the same size and general appearance;
   (d) its internal components are not distinguishable from each other;
   (e) "b" and "d".

10. Cooling a piece of steel rapidly from the tempering temperature will:
   (a) completely reharden the piece;
   (b) partially reharden the piece depending on the tempering temperature;
   (c) partially reharden the piece depending on the carbon content;
   (d) partially reharden the piece depending on both tempering temperature and carbon content;
   (e) have no effect whatsoever.

11. A steel part with a tough center and a hard, wear-resistant surface (such as an axle) could be produced by:
    (a) hardening a high carbon steel part and then reheating only the surface;
    (b) hardening a low carbon steel part and then reheating only the surface;
    (c) hardening and tempering a low carbon steel in a carbon atmosphere;
    (d) hardening and tempering a high carbon steel in an ordinary air atmosphere;
    (e) hardening and tempering a low carbon steel in an ordinary air atmosphere.

12. Which of the following statements is <u>not</u> true?
    (a) the carbide in 0.60% carbon steel starts to go into solution at the same temperature as the carbide in 0.40% carbon steel;
    (b) the carbide in 0.60% carbon steel is all in solution at a lower temperature than the carbide in 0.40% carbon steel;
    (c) the carbide in 1.5% carbon steel is all in solution at a lower temperature than the carbide in 0.80% carbon steel;
    (d) the carbide in 1.5% carbon steel begins to go into solution at the same temperature as the carbide in 0.80% carbon steel;
    (e) the carbide in 0.60% carbon steel begins to go into solution at the same temperature as the carbide in 0.80% carbon steel.

13. Which tempering temperature is best for battering tools?
    (a) 300^{o}F.;
    (b) 400^{o}F.;
    (c) 500^{o}F.;
    (d) 750^{o}F.;
    (e) 950^{o}F.

14. If a broken spring has been repaired by welding (joining the two pieces by remelting the metal at the break):
    (a) the heated section must be cooled slowly;
    (b) the heated section must be cooled rapidly;
    (c) the entire piece must re retempered;
    (d) the entire piece must be rehardened and retempered;
    (e) the entire piece must be retempered and cooled rapidly.

15. Steel is an alloy of iron:
   (a) which contains less than 2% carbon;
   (b) which always contains one or more alloying elements in addition to carbon;
   (c) which may contain one or more alloying elements in addition to carbon;
   (d) "a" and "b";
   (e) "a" and "c".

16. To make a steel maximally hard its temperature at the time of cooling must be:
   (a) above the upper critical;
   (b) below the upper critical;
   (c) at the melting point;
   (d) below the lower critical;
   (e) between the upper and lower critical.

17. Springs are tempered at:
   (a) 300^{o}F.;
   (b) 400^{o}F.;
   (c) 550^{o}F.;
   (d) 750^{o}F.;
   (e) 920^{o}F.

18. The carbide in steel begins to go into solution:
   (a) at 212^{o}F.;
   (b) at 500^{o}F.;
   (c) at 1000^{o}F.;
   (d) at 1350^{o}F.;
   (e) at none of the above.

19. Steel with a carbon content over 0.80% is used where it is important to have:
   (a) extra hardness;
   (b) increased flexibility;
   (c) high corrosion resistance;
   (d) great toughness;
   (e) high wear resistance.

20. The upper critical temperature of steel:
   (a) is the temperature above which steel melts;
   (b) is the temperature at which all of the carbide in steel is in solution;
   (c) is the temperature at which the carbide in steel begins to go into solution;

(d) is the temperature above which steel must be heated for tempering to take place;
(e) is the temperature below which steel solidifies.

21. When a piece of high carbon steel is cooled rapidly for a solid solution, the piece will be:
(a) soft;
(b) hard;
(c) soft and tough;
(d) hard and brittle;
(e) brittle.

22. The most important consideration in choosing the tempering temperature of a finished steel part is:
(a) its desired mechanical properties;
(b) the rate at which it was cooled;
(c) the maximum temperature during heat treatment;
(d) the carbon content of the part;
(e) the internal grain structure of the part.

23. Which of the following alloys may be heat treated?
(a) iron-chromium;
(b) iron-carbon-tungsten;
(c) copper-zinc;
(d) iron-nickel-chromium;
(e) copper-tin.

24. Which of the following statements is <u>not</u> true?
(a) Slowly cooled 1.5% carbon steel is harder than slowly cooled 1.0% carbon steel;
(b) Slowly cooled 0.75% carbon steel is harder than slowly cooled 0.60% carbon steel;
(c) Rapidly cooled 0.70% carbon steel is harder than rapidly cooled 0.50% cargon steel;
(d) Rapidly cooled 0.80% carbon steel is harder than slowly cooled 0.80% carbon steel.
(e) Rapidly cooled 1.5% carbon steel is harder than rapidly cooled 1.0% carbon steel.

25. When tempering a cutting tool that is to be driven with a hammer (e.g., a chisel), the following tempering temperatures should be used:
(a) $212^{o}F.$;
(b) $400^{o}F.$;
(c) $550^{o}F.$;

(d) 700°F.;
(e) 900°F.

26. The effect of tempering steel first becomes noticeable at:
(a) its upper critical temperature;
(b) its lower critical temperature;
(c) 212°F.;
(d) 900°F.;
(e) 1200°F.

27. As the tempering temperature increases steel becomes:
(a) tougher;
(b) harder;
(c) softer;
(d) tougher and harder;
(e) tougher and softer.

28. The higher the carbon content of steel:
(a) the lower the temperature at which all of the carbide is in solution;
(b) the higher the temperature at which all of the carbide is in solution;
(c) the higher the temperature at which the carbide starts going into solution;
(d) the lower the temperature at which the carbide starts goint into solution;
(e) the higher its melting point.

29. The most reliable way of having a piece of low carbon steel acquire a hard outer case during heat treatment is to:
(a) use a particularly high maximum temperature during heat treatment;
(b) cool the outside of the piece more rapidly than the inside during heat treatment;
(c) heat treat and temper the piece in an atmosphere of ordinary air;
(d) heat treat and temper the piece in an atmosphere of carbon gases;
(e) harden the piece and then reheat only the surface.

30. Which of the following statements about 0.80% carbon steel is <u>not</u> true?
(a) Its lower and upper critical temperatures are the same;
(b) It is more brittle than 0.40% carbon steel;
(c) Its carbide starts going into solution at a lower temperature than the carbide of 0.40% carbon steel;
(d) It may be hardened at a lower temperature than 0.40% carbon steel;
(e) It is harder than 0.60% carbon steel.

31. Steel is:
(a) a compound of iron and carbon;
(b) a solution of iron and iron carbide;
(c) a solution or mixture of iron and iron carbide;
(d) a solution or mixture of iron and carbon;
(e) a solution of iron and carbon.

32. Before a soft carbon steel can be hardened it must be changed:
(a) from a mechanical mixture to a solid solution;
(b) from a liquid solution to a mechanical mixture;
(c) from a mechanical mixture to a solid solution and back to a mechanical mixture;
(d) feom a solid solution to a mechanical mixture;
(e) from a solid solution to a mechanical mixture and back to a solid solution.

NAME KEY

ANSWER SHEET

	A	B	C	D	E		A	B	C	D	E
1.	(X)	( )	( )	( )	( )	17.	( )	( )	( )	(X)	( )
2.	( )	( )	( )	(X)	( )	18.	( )	( )	( )	(X)	( )
3.	( )	( )	( )	( )	(X)	19.	( )	( )	( )	( )	(X)
4.	( )	( )	( )	(X)	( )	20.	( )	(X)	( )	( )	( )
5.	( )	( )	( )	( )	(X)	21.	( )	( )	( )	(X)	( )
6.	( )	( )	(X)	( )	( )	22.	(X)	( )	( )	( )	( )
7.	( )	(X)	( )	( )	( )	23.	( )	(X)	( )	( )	( )
8.	( )	( )	(X)	( )	( )	24.	( )	( )	( )	( )	(X)
9.	(X)	( )	( )	( )	( )	25.	( )	( )	(X)	( )	( )
10.	( )	( )	( )	( )	(X)	26.	( )	( )	(X)	( )	( )
11.	( )	( )	(X)	( )	( )	27.	( )	( )	( )	( )	(X)
12.	( )	( )	(X)	( )	( )	28.	(X)	( )	( )	( )	( )
13.	( )	( )	(X)	( )	( )	29.	( )	( )	( )	(X)	( )
14.	( )	( )	( )	(X)	( )	30.	( )	( )	(X)	( )	( )
15.	( )	( )	( )	( )	(X)	31.	( )	( )	(X)	( )	( )
16.	(X)	( )	( )	( )	( )	32.	( )	( )	(X)	( )	( )

(The score for this test is the number correct.)

NAME ____________________

AGE ____________ M___ F____

ANSWER SHEET

	A	B	C	D	E		A	B	C	D	E
1.	( )	( )	( )	( )	( )	17.	( )	( )	( )	( )	( )
2.	( )	( )	( )	( )	( )	18.	( )	( )	( )	( )	( )
3.	( )	( )	( )	( )	( )	19.	( )	( )	( )	( )	( )
4.	( )	( )	( )	( )	( )	20.	( )	( )	( )	( )	( )
5.	( )	( )	( )	( )	( )	21.	( )	( )	( )	( )	( )
6.	( )	( )	( )	( )	( )	22.	( )	( )	( )	( )	( )
7.	( )	( )	( )	( )	( )	23.	( )	( )	( )	( )	( )
8.	( )	( )	( )	( )	( )	24.	( )	( )	( )	( )	( )
9.	( )	( )	( )	( )	( )	25.	( )	( )	( )	( )	( )
10.	( )	( )	( )	( )	( )	26.	( )	( )	( )	( )	( )
11.	( )	( )	( )	( )	( )	27.	( )	( )	( )	( )	( )
12.	( )	( )	( )	( )	( )	28.	( )	( )	( )	( )	( )
13.	( )	( )	( )	( )	( )	29.	( )	( )	( )	( )	( )
14.	( )	( )	( )	( )	( )	30.	( )	( )	( )	( )	( )
15.	( )	( )	( )	( )	( )	31.	( )	( )	( )	( )	( )
16.	( )	( )	( )	( )	( )	32.	( )	( )	( )	( )	( )

APPENDIX E

CRITERION TEST SCORES

TEACHER EDUCATION SCORES

Advance Organization		Post Organization		Advance/Post Organization		Non Organization	
10	11	8	7	11	9	12	9
17	15	10	11	18	13	9	10
24	20	13	10	10	7	7	8
13	12	20	12	12	15	27	15
9	6	12	13	10	9	18	13
22	19	17	16	11	8	13	8
21	15	16	11	14	13	13	12
10	13	8	15	11	8	12	7
18	15	10	7	17	11	13	12
12	9	22	11	13	11	13	13
8	10	15	10	7	6	11	10
13	7	14	13	17	11	9	7
14	14	16	13	13	10	20	15
11	7	11	9	11	9	16	12
23	12	13	9	11	10	10	7
14	12	12	15	5	9	8	7
12	9	12	12	9	5	10	7
15	10	12	10	13	9	7	10
10	8	13	11	8	5	15	13
8	7	11	13	6	7	12	5

Note: The first score for each group is for immediate recall; the second is for retention three weeks following the initial learning.

SCIENCE MAJOR SCORES

Advance Organization		Post Organization		Advance/Post Organization		Non Organization	
21	18	14	7	23	19	16	13
19	12	20	15	14	11	7	5
13	12	16	12	11	8	23	21
16	13	22	15	16	10	21	20
13	13	15	12	18	10	19	18
23	16	22	16	24	18	13	13
22	20	13	12	13	12	27	26
22	14	20	15	22	20	9	9
24	12	10	8	28	23	14	12
18	12	17	10	17	14	22	16
20	9	18	8	19	12	17	12
26	23	20	20	22	16	19	19
20	14	18	8	25	22	19	8
21	11	22	12	17	15	10	12
20	16	18	11	15	9	21	11
11	9	22	12	14	10	22	12
14	11	12	5	14	11	12	13
18	11	16	10	10	10	14	8
21	12	18	12	12	12	16	11
15	14	13	9	18	14	9	7

Note: The first score for each group is for immediate recall; the second is for retention three weeks following the initial learning.

INDUSTRIAL EDUCATION SCORES

Advance Organization		Post Organization		Advance/Post Organization		Non Organization	
8	8	14	13	23	19	10	5
10	12	6	7	15	10	23	15
16	14	15	10	20	15	18	14
19	15	7	6	25	20	13	9
22	17	22	21	15	15	17	17
23	23	5	7	22	20	14	10
20	13	9	6	9	6	17	15
16	12	11	8	21	13	28	24
14	14	11	7	23	24	13	10
16	10	28	20	12	14	9	9
17	16	11	8	13	10	8	10
7	12	12	14	18	14	16	11
11	13	22	13	20	18	14	10
22	13	16	17	15	12	16	14
24	22	22	18	12	10	10	7
23	18	20	18	22	18	14	9
18	17	13	11	20	14	18	16
20	18	16	13	19	17	11	10
16	15	10	10	20	16	12	9
14	13	18	17	16	16	16	12

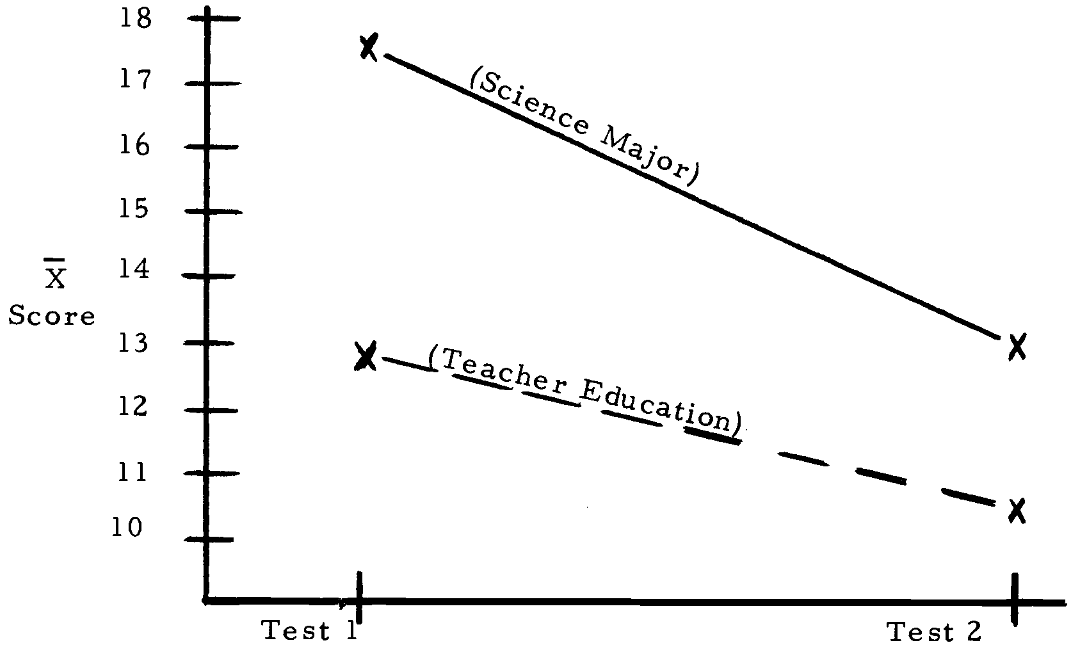
Note: The first score for each group is for immediate recall; the second is for retention three weeks following the initial learning.

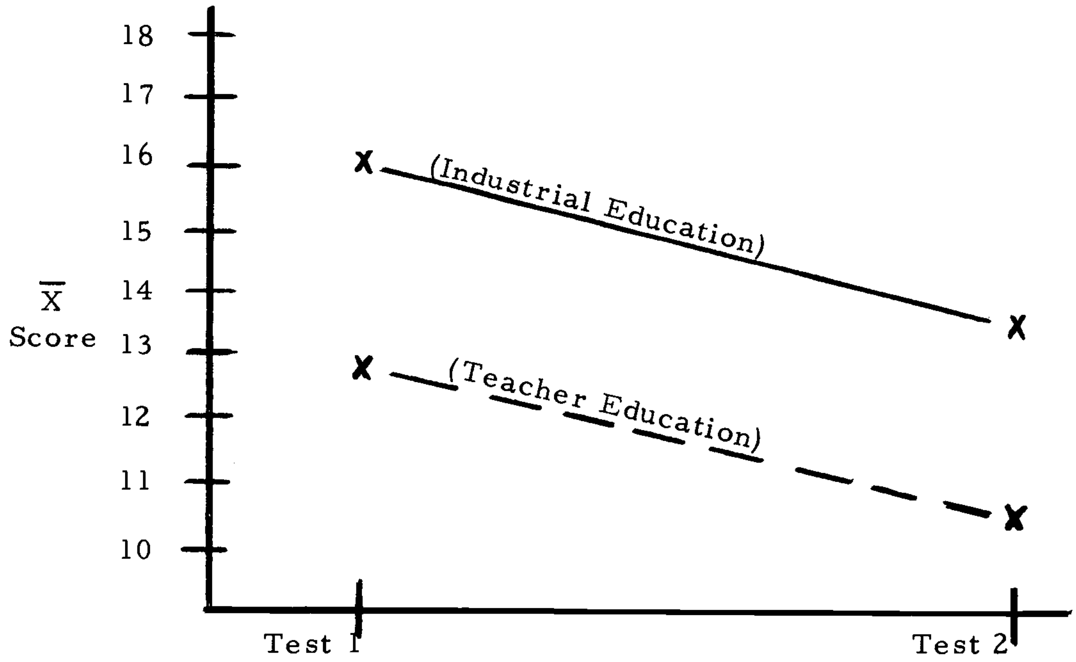
APPENDIX F

INTERACTION PATTERNS

INTERACTION

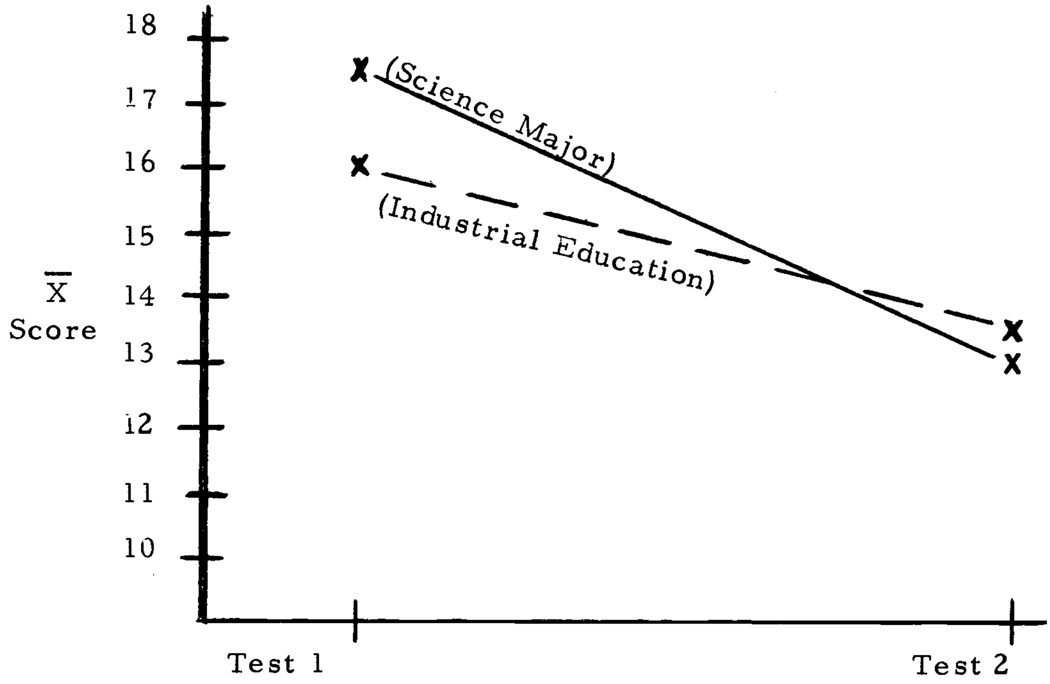
Student Type X Time





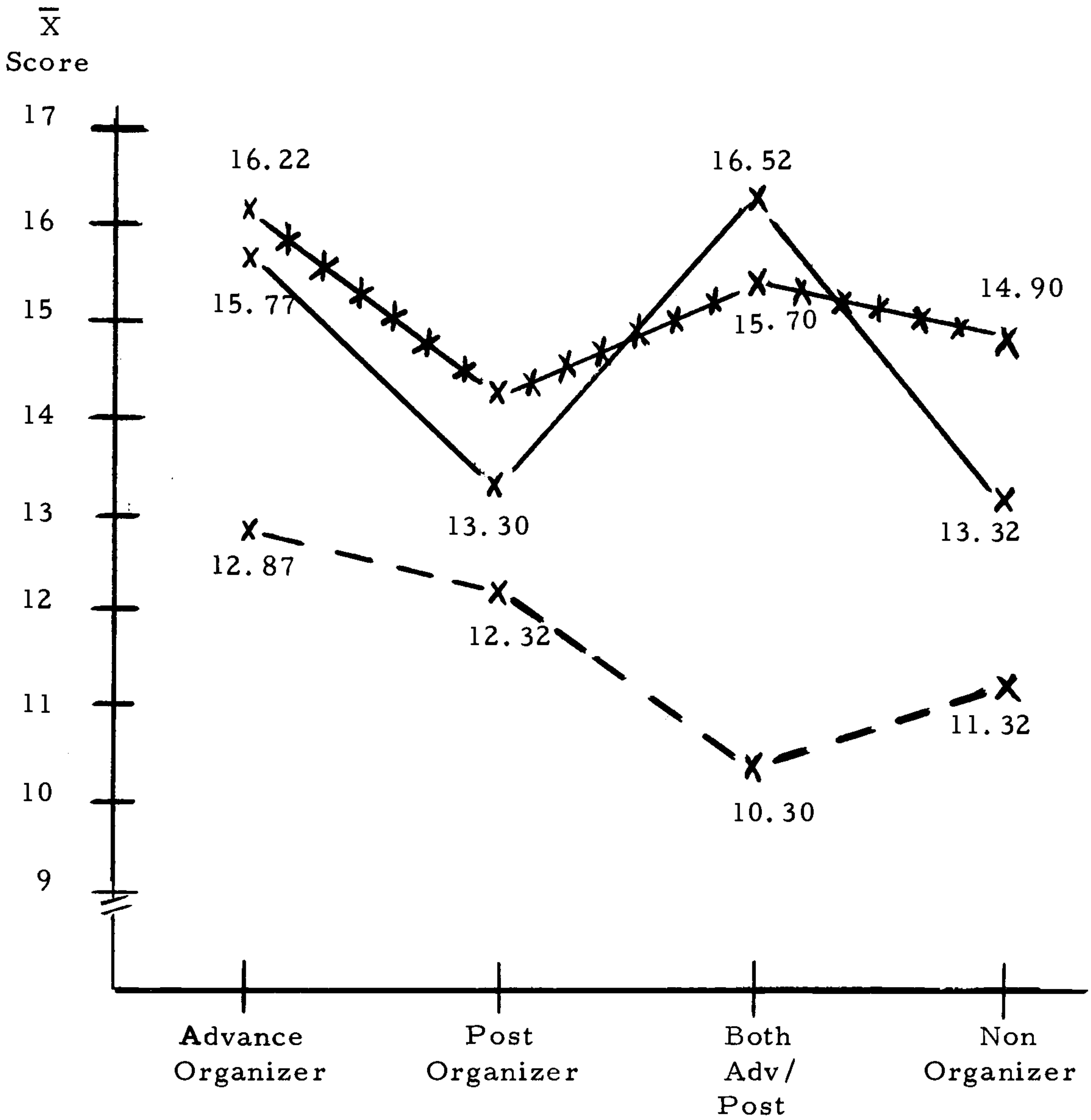
INTERACTION

Student Type X Time (continued)



INTERACTION

Organization Type X Student Type



Legend:

— — — — = Teacher education subjects.

-x-x-x-x- = Science major subjects.

———— = Industrial education subjects.

APPENDIX G

AGREEMENT TO PARTICIPATE FORM

DOCTORAL DISSERTATION LEARNING STUDY

AGREEMENT TO PARTICIPATE

I, ________________________________ would like to participate in the learning study.

I understand the experiment will consist of:

1. Reading a verbal organizer passage containing background information; 8 minutes.

2. Reading and studying an academic unit of instruction involving the qualities of plain carbon steel; 20 minutes.

3. Reviewing the verbal organizer; 8 minutes.

4. Responding to a 32-item multiple choice test covering the learning material; only the mean score of your group will be used.

I give permission for the above examination and agree that information collected in this study may be published so long as my name is not attached to it.

Signature: ____________________________________ Group Number _____

Address: ____________________________________

____

Investigator: ________________________________