Effect of Teaching a Conceptual Hierarchy On Concept Classification Performance

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Abstract. Sixty-four adults, divided into four groups, individually studied a lesson about six types of sailboats. One group studied a lesson in which the hierarchical relationships among sailboat types were depicted both graphically (through a tree diagram), and verbally (through a description of the tree diagram). The second and third groups studied lessons containing either the graphic or verbal representation of the hierarchical relationships, while the fourth group studied a lesson containing neither. On a posttest, which required classification of unencountered instances, administered immediately, and on a similar posttest administered one week later, the participants in the first three groups scored higher than those in the fourth group. The results support the proposition that instruction designed to teach concepts belonging to a conceptual hierarchy should explicitly portray (graphically and/or verbally) the hierarchical relationships among those concepts.

Concepts may be grouped on the basis of shared features. The resultant categories may, in turn, be chunked or classified into other categories, which may be further subclassified. Such recursive categorization generates a *conceptual hierarchy*, a term used by Wittrock and Carter (1975). A conceptual hierarchy is not merely a tree structure of concept labels. Each location or node of a conceptual hierarchy represents one or more features that its branching or lower-level nodes have in common. Synonyms for conceptual hierarchy include decision tree (Hunt, 1962), organizational hierarchy (Mandler, 1968), hierarchical retrieval plan (Bower, 1972), hierarchical conceptual structure (Underwood & Zimmerman, 1973), conceptual network (Markle, 1978), and kinds taxonomy (Reigeluth, Merrill, Wilson, & Spiller, Note 1).

Collins and Quillian (1969), Bobrow (1970), Bower (1970), and Meyer and Schvaneveldt (1976) reported considerable evidence that people can sometimes organize what they learn in the form of conceptual hierarchies. Furthermore, Bower (1972) proposed that hierarchical organization of information in memory provides an effective plan for retrieving that information.

At least eight research findings support Bower's proposition. First, persons who grouped randomly ordered words into categories had higher recall of those words than persons who did not group them into categories (Kulhavy, Haynes, & Dyer, 1975; Mandler, 1967; Ornstein, Trabasso, & Johnson-Laird, 1974).

Second, persons made aware of possible categories for grouping information they were given recalled more of that information than persons not made aware of those categories (Balser, 1972; Strand, 1975). Third, persons were better able to recall lists composed of words from several categories than to recall lists composed of unrelated words (Bower, 1970, p.37; Cofer, 1967, p.182-183; Pellegrino & Battig, 1974; Puff, 1970).

Fourth, persons exhibited greater recall on information when it was presented in a blocked fashion than when it was presented in a mixed fashion (Balser, 1972; Ceppi, 1973; Cofer, Bruce, & Reicher, 1966; Dallett, 1964; DiVesta, Schultz, & Dangel, 1973; Frase, 1969, 1973; Myers, 1974; Myers, Pezdek, & Coulson, 1973; Perlmutter & Royer, 1973; Puff, 1966; Schultz & DiVesta, 1972; Strand, 1975; Underwood, Shaughnessy, & Zimmerman, 1974; Underwood & Zimmerman, 1973; Yekovich & Kulhavy, 1976). In a blocked presentation, all the information pertaining to a particular category is presented before information pertaining to the next category. In a mixed presentation, information pertaining to a particular category is spread throughout the other information. The facilitative effect of a blocked presentation probably occurs because it helps persons recognize the category membership of what they study.

Fifth, the number of levels of specificity in a conceptual hierarchy of which persons were made aware was proportionate to the amount of most specific or lowest-level information of the hierarchy that they recalled (Friedman & Creitzer, 1972; Underwood & Zimmerman, 1973; Wortman, 1975). For example, Underwood and Zimmerman (1973) observed that college students who were made aware of the categories *living* and *nonliving* as well as the more specific categories *animals, vegetables, musical instruments,* and *weapons* recalled more words belonging to those categories than students who were made aware of only the categories *living* and *nonliving*.

Sixth, persons who viewed a tree diagram of concept labels, systematically arranged in a general-to-specific fashion, were more successful in recalling those labels than persons who viewed a randomly arranged tree diagram of the same labels (Bower, Clark, Lesgold, & Winzenz, 1969; Wittrock & Carter, 1975). A randomly arranged tree diagram of concept labels is one in which the labels are randomly assigned to positions or nodes in the diagram. A systematically arranged tree diagram of concept labels better represents a conceptual hierarchy than a randomly arranged tree diagram of labels.

Seventh, persons supplied with an outline representing a conceptual hierarchy recalled a greater number of verbatim statements they had read in a prose passage constructed from the information in that hierarchy than persons not supplied with an outline (Glynn & DiVesta, 1977).

Eighth, persons tended to recall category labels in a general-to-specific or top-to-bottom order (Bower, Clark, Lesgold, & Winzenz, 1969; Segal, 1969). This indicates that during recall, the more general, higher-level nodes in a conceptual hierarchy act as retrieval cues for their lower-level nodes, which, in turn, act as retrieval cues for their lower-level nodes.

The only measure of learning employed in any of these studies was verbatim recall of response items. Anderson (1972), however, pointed out that verbatim recall is not a valid measure of concept comprehension, whereas classification of unencountered instances is. Nevertheless, in order to correctly classify unencountered instances of a concept, a person must be able to recall the set of distinguishing or critical features associated with that concept.

As previously mentioned, a number of research findings support Bower's (1972) proposition that hierarchical organization of information aids in retrieving that information. According to this proposition, recall of sets of critical features may be improved by organizing them in memory as a conceptual hierarchy. It follows that in teaching concepts belonging to a conceptual hierarchy, it would be beneficial to make their superordinate and subordinate (hierarchical) relationships conspicuous so that students are more likely to mentally organize a conceptual hierarchy that contains those concepts. This proposition was advocated by Susan Markle (1978) and David Merrill (Note 2), two instructional designers known for their work in teaching concepts. But these designers have not presented empirical evidence that directly supports their stand. The purpose of this experiment was to obtain such evidence.

We arbitrarily selected two of many possible methods of making conspicuous the hierarchical relationships among six sailboat concepts in a conceptual hierarchy. One method consisted of displaying the decision diagram shown in Figure 2. The other consisted of providing verbal messages about the diagram's nodes (e.g., "First consider the number of masts" and "A ketch's tiller or wheel is located behind the second mast") in a one-branch-at-a-time, top-to-bottom sequence. These two methods were employed in an experiment with the following treatments:

1) Diagram with verbal messages (diag-verb)
2) Diagram without verbal messages (diag-no verb)
3) No diagram but with verbal messages (no diag-verb)
4) No diagram and no verbal message (no diag-no verb)
5) No instruction (control)

In this experiment, each of the participants, except those in the control group, studied a definition and three examples of each sailboat type.

At the conclusion of the instruction, the participants were given a posttest that required them to classify unencountered pictures of sailboats. A similar test was administered one week later. We hypothesized that participants who viewed the decision diagram and received a verbal description of its nodes would score higher on the posttests than participants who either viewed the decision diagram or received a verbal description of its nodes. We further hypothesized that participants who either saw the diagram or received a verbal description of its nodes would score higher than those who neither saw the diagram nor received a description of its nodes. Those in the control group, who were not exposed to any instruction, were expected to perform more poorly than instructed participants.

Method

Subjects

Eighty persons (41 males and 39 females) took part in this study. Their ages ranged from 18 to 53 years, and their mean age was 24.45 years. Each subject received a movie ticket for participating.

Materials

We prepared a separate tray of color slides for each treatment group. The contents of these slide trays are depicted in Figure 1.

We photographed 11 different pictures of each of 6 types of sailboats. From each set of 11 slides, we randomly selected 3 to be used as examples. These example slides do not appear in Figure 1, but the position of each in each treatment sequence of slides is designated by a two-letter abbreviation (CA-catboat), CU-cutter, KE-ketch, SC-schooner, SL-sloop, YA-yawl) followed by a number. The remaining 8 slides in each set were used in the immediate and delayed posttests.

All of the slide trays contained the same series of introductory slides (slides Aa-Ea) that explained the purpose of the lesson and pictorially described certain terms used to define the six types of sailboats. Every slide tray also contained a definition slide and three example slides for each type of sailboat. Definition slides (slides Ib, Lb, Oa, Rb, Ub, Xa) list the critical attributes that define the six types of sailboats.

After the introduction, we included a slide of the decision diagram (slide Fa) in the trays of the diag-verb and diag-no verb treatment groups. The decision diagram appears in Figure 2.

In these same two slide trays, we placed another decision diagram slide immediately following each definition slide (slides Ja, Ma, Ob, Sa, Va, Xb). Each of these decision diagram slides, however, indicated the path through the decision diagram associated with the definition slide to which that decision diagram slide was paired. No decision diagram slides were present in the trays of the no diag-verb and no diag-no verb treatment groups. We inserted slides that helped describe the attribute decisions of the decision diagram (slides Fb, Ga, Gb, Ha, Hb, Ia, Kb, La, Nb, Qa, Qb, Ra, Tb, Ua, Wb) into the trays of the diag-verb and no diag-verb treatment groups. But we left these slides out of the trays of the diag-no verb and no diag-no verb treatment groups.

We also arranged the slides in the trays of the diag-verb and no diag-verb treatment groups so that each attribute decision was presented according to an order suggested by the decision diagram. The first decision concerned the number of masts. It was followed by decisions about the number of sails and the location of the mast and by decisions about the height of the first mast and the location of the tiller or wheel. In the slides of the diag-no verb and no diag-no verb treatment groups, however, the order of the segments, each composed of a definition and its examples, was random. The

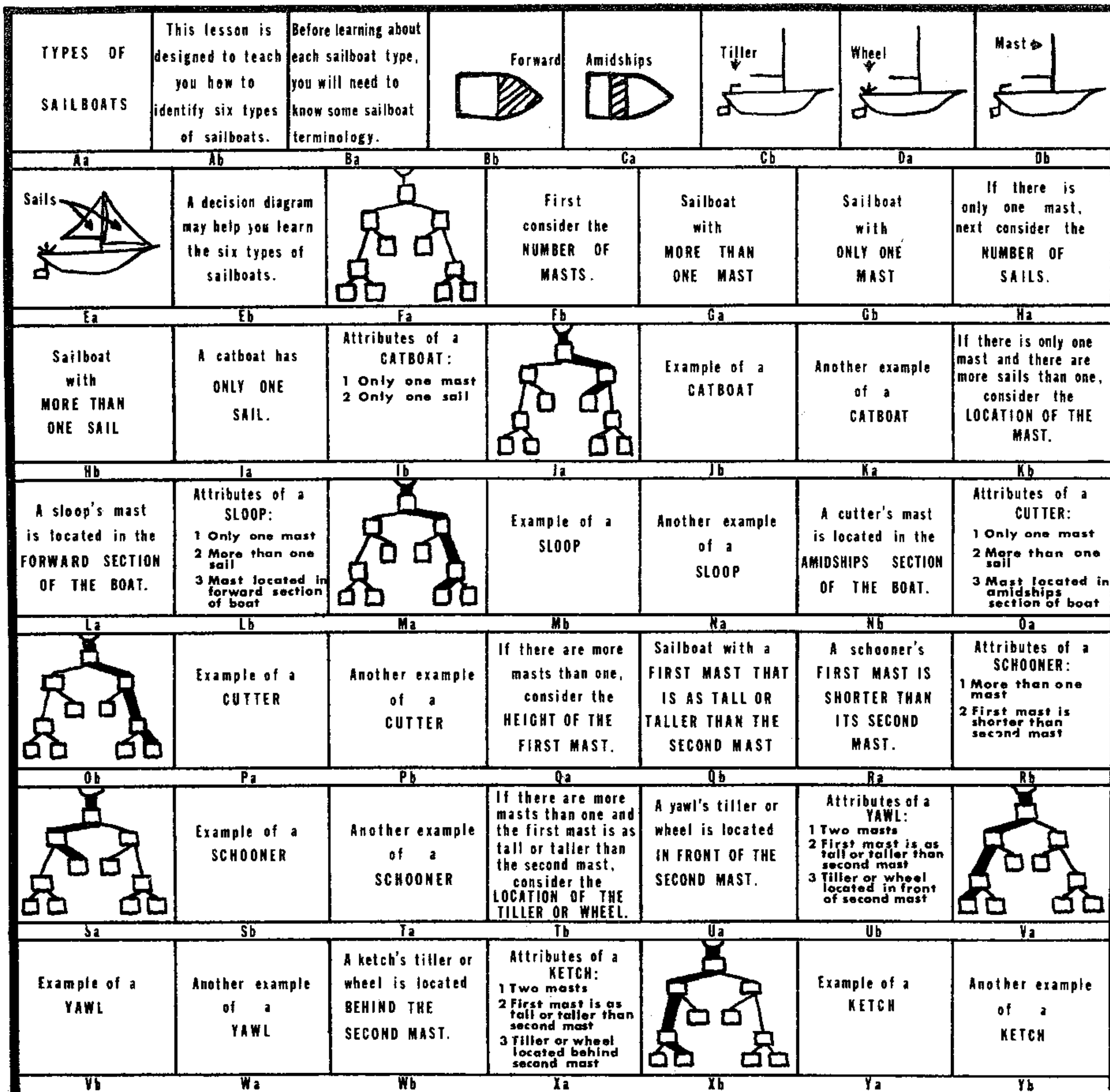

Diagram-Description Treatment Group

Slide Sequence	Aa	Ab	Ba	Bb	Ca	Cb	Da	Db	Ea	Eb	Fa	Fb	Ga	SC1	Gb	CA1	Ha	Hb	SL1	Ia	Ib	Ja	Jb	CA2	Ka	CA3	Kb	La	Lb	Ma	Mb	SL2	Na	SL3	Nb
Display Time	3	8	8	5	5	5	5	5	5	8	28	12	9	5	9	5	12	9	5	10	15	15	3	5	3	5	12	10	15	15	3	5	3	5	10
Continued	Oa	Ob	Pa	CU1	Pb	CU2	Pb	CU3	Qa	Qb	YA1	Ra	Rb	Sa	Sb	SC2	Ta	SC3	Tb	Ua	Ub	Va	Vb	YA2	Wa	YA3	Wb	Xa	Xb	Ya	KE1	Yb	KE2	Yb	KE3
	15	15	8	5	3	5	3	5	12	9	5	10	15	15	3	5	3	5	12	10	15	15	3	5	3	5	10	15	15	3	5	3	5	3	5

Diagram-No Description Treatment Group

Slide Sequence	Aa	Ab	Ba	Bb	Ca	Cb	Da	Db	Ea	Eb	Fa	Lb	Ma	Mb	SL1	Na	SL2	Na	SL3	Xa	Xb	Ya	KE1	Yb	KE2	Yb	KE3	Rb	Sa	Sb	SC1	Ta	SC2	Ta
Display Time	3	8	8	5	5	5	5	5	5	8	28	39	15	3	5	3	5	3	5	39	15	3	5	3	5	3	5	39	15	3	5	3	5	3
Continued	SC3	Oa	Ob	Pa	CU1	Pb	CU2	Pb	CU3	Ib	Ja	Jb	CA1	Ka	CA2	Ka	CA3	Ub	Va	Vb	YA1	Wa	YA2	Wa	YA3									
	5	39	15	3	5	3	5	3	5	39	15	3	5	3	5	3	5	39	15	3	5	3	5	3	5									

No Diagram-Description Treatment Group

Slide Sequence	Aa	Ab	Ba	Bb	Ca	Cb	Da	Db	Ea	Fb	Ga	SC1	Gb	CA1	Ha	Hb	SL1	Ia	Ib	Jb	CA2	Ka	CA3	Kb	La	Lb	Mb	SL2	Na	SL3	Nb	Oa	Pa	CU1
Display Time	3	8	8	5	5	5	5	5	5	12	9	5	9	5	12	9	5	10	36	3	5	3	5	12	10	36	3	5	3	5	10	36	3	5
Continued	Pb	CU2	Pb	CU3	Qa	Qb	YA1	Ra	Rb	Sb	SC2	Ta	SC3	Tb	Ua	Ub	Vb	YA2	Wa	YA3	Wb	Xa	Ya	KE1	Yb	KE2	Yb	KE3						
	3	5	3	5	12	9	5	10	36	3	5	3	5	12	10	36	3	5	3	5	10	36	3	5	3	5	3	5						

No Diagram-No Description Treatment Group

Slide Sequence	Aa	Ab	Ba	Bb	Ca	Cb	Da	Db	Ea	Lb	Mb	SL1	Na	SL2	Na	SL3	Xa	Ya	KE1	Yb	KE2	Yb	KE3	Rb	Sb	SC1	Ta	SC2	Ta	SC3	Oa	Pa	CU1	Pb
Display Time	3	8	8	5	5	5	5	5	5	60	3	5	3	5	3	5	60	3	5	3	5	3	5	60	3	5	3	5	3	5	60	3	5	3
Continued	CU2	Pb	CU3	Ib	Jb	CA1	Ka	CA2	Ka	CA3	Ub	Vb	YA1	Wa	YA2	Wa	YA3																	
	5	3	5	60	3	5	3	5	3	5	60	3	5	3	5	3	5																	

Figure 1. General appearance of lesson slides, their sequence in the slide tray of each treatment group, and the number of seconds each slide in each tray was displayed. Abbreviations: CA-catboat, CU-cutter, KE-ketch, SC-schooner, SL-sloop, YA-yawl.

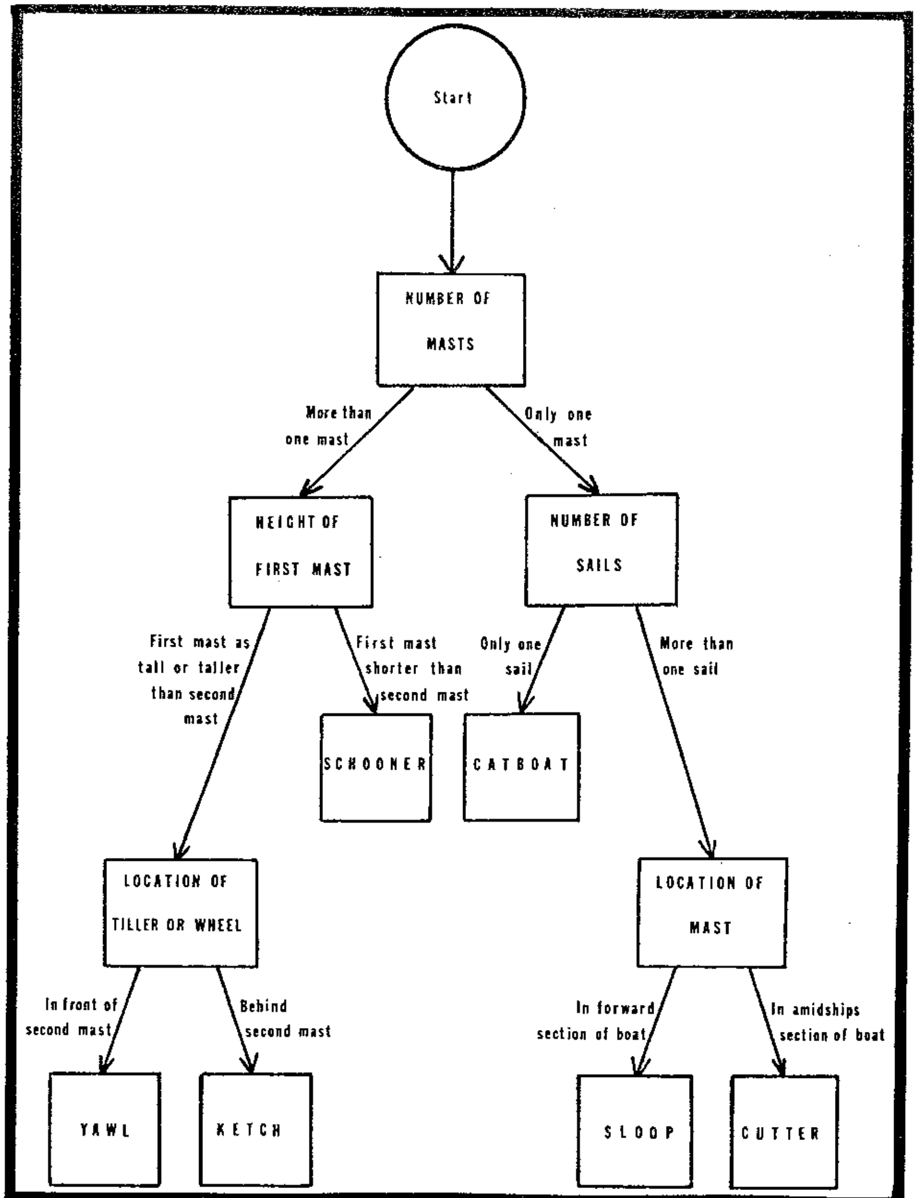

Figure 2. Decision diagram shown to subjects in the diagram-description and diagram-no description treatment groups.

random order was sloop, ketch, schooner, cutter, catboat, and yawl.

Each slide of each treatment tray was displayed for the number of seconds specified in Figure 1. These time lengths were established from data collected during a pilot study. Although each tray had a different number of slides, overall lesson presentation time was kept the same for each treatment group by varying the display times of definition slides.

Research indicates that varying display time beyond the time necessary to read the slide would have no measurable effect. The display time in all cases was clearly sufficient for even a poor reader.

We developed two, twenty-four question, multiple-choice posttests, each consisting of four slides of each sailboat type; the response sheet alphabetically listed the sailboat names for each test item. The slides were randomly ordered.

Apparatus

Signals recorded on a cassette tape controlled the rate of presentation of the lesson, which was viewed on a Singer Caramate Projector. The posttests were administered with a Kodak Carousel Slide Projector.

Design

A 2 X 2 posttest only factorial design with an added uninstructed control group was employed. The two factors were 1) decision diagram at two levels, presence or absence; and 2) description of the decision diagram at two levels, presence or absence.

Procedure

An advertisement offering a movie ticket in exchange for participation in this experiment was circulated at a university married students housing complex. Those who responded were randomly assigned to treatment groups and given an appointment.

Upon arriving at the appointed time, each participant in the instructed treatment groups was asked to read this passage:

> You will be asked to study a lesson about sail boats. This lesson will consist of a series of slides. The amount of time each slide is displayed will be controlled by the machine (a Caramate Projector). Please be attentive once the lesson has begun because some slides will be shown for very short time intervals. At the conclusion of the lesson, you will receive a 24-item test. For each test item, 1) you will be given the same set of six alternative responses (catboat, cutter ketch, schooner, sloop, yawl), 2) you will be shown a picture of a sailboat that you have never seen before, and 3) you will be requested to circle the response that you think indicates the type of sailboat displayed in the picture. After the test, you will be asked to take another test one week from now. This second test will be similar (same length and same kind of questions) to the first test. Once you have completed the second test, you will be given a movie ticket. Please do not take any notes during the lesson.

Information pertaining to the lesson was omitted from the passage each member of the uninstructed control group was asked to read.

Just before receiving the immediate posttest, the participants were requested to provide their name, age, and sex. The posttest had no time limits. However, a participant, having made a response to any one question, was not allowed to change that response. Participants were told not to search for information about sailboats until after they had taken another posttest one week later. They were also informed that there would be no review of the lesson. The delayed posttest was administered in the same fashion as the immediate posttest.

Table 1
Means and Standard Deviations of Each Dependent Measure for Each Treatment Group

	Dependent Measure			
	Immediate posttest score		Delayed posttest score	
Treatment group	M	SD	M	SD
Diagram-verbal	18.00	4.50	16.75	5.61
Diagram-no verbal	15.31	5.44	14.37	5.58
No diagram-verbal	15.44	5.03	14.25	5.25
No diagram-no verbal	12.56	2.76	10.25	3.28
Control	4.94	2.23	5.00	2.45

Note. There were 16 subjects in each treatment group. The maximum score on each posttest was 24.

Results

Table 1 reports the means and standard deviations of the immediate and delayed posttest scores for each treatment group.

Two-Way Analysis of Variance

A two-way ANOVA was conducted with the immediate and with the delayed posttest data of the instructed treatment groups. Control group data was excluded from both of these analyses.

A significant diagram main effect was found for the immediate posttests, $F(1,60) = 5.46$, $p = .023$, and for the delayed posttest, $F(1,60) = 6.95$, $p = .011$. A significant description main effect also was observed for the immediate posttest $F(1,60) = 5.98$, $p = .017$, and for the delayed posttest, $F(1,60) = 6.44$, $p = .014$; the interaction was not significant for the immediate posttest, $F(1,60) = .007$, $p = .935$, nor for the delayed posttest, $F(1,60) = .418$, $p = .520$.

Instructed Versus Control

A one-way ANOVA with planned orthogonal contrasts was conducted with the immediate posttest data and with the delayed posttest data. The instructed groups scored higher than the control group on the immediate posttest, $F(1,75) = 78.74$, $p < .0001$, and on the delayed posttest, $F(1,75) = 47.45$, $p <$ 0001.

Pairwise Comparisons

For immediate posttest scores, Newman-Keuls pairwise comparisons of means showed that the diag-verb treatment group excelled the no diag-no verb treatment group, and that each of the instructed treatment groups surpassed the control treatment group. For delayed posttest scores, pairwise comparisons of means indicated that the diag-verb, diag-no verb, and no diag-verb treatment groups performed better than the no diag-no verb treatment group and that each of the instructed treatment groups outdid the control treatment group. All other pairwise comparisons of means were nonsignificant ($p > .05$).

Discussion

The results of this experiment indicate that making apparent the hierarchical relationships among concepts of a conceptual hierarchy enhances learner performance in classifying unencountered instances of those concepts. This finding supports the recommendation of Markle (1978) and Merrill (Note 2) that instruction designed to teach concepts belonging to a conceptual hierarchy should portray the hierarchical relationships among those concepts.

The two methods used in this experiment are not necessarily the "best" ones to depict hierarchical relationships among concepts. Other methods, such as the classification table (Horn, 1976) or an outline (Glynn & DiVesta, 1977), also might prove to be effective ways of conveying information about hierarchical relationships in a concept learning situation. A combination of methods might be even more effective. In this experiment, for instance, both methods together produced somewhat higher scores than either method by itself.

Conceptual hierarchies abound. For example, you probably have studied taxonomies of living organisms, minerals, musical styles, painting styles, and equations. You also likely have developed instruction designed to teach concepts that are hierarchically related. When you develop instruction to teach concepts with shared features, our advice based on this experiment's finding is as follows:

1. Figure out how the concepts are hierarchically related. In other words, fit them together into a hierarchy.
2. Show off the conceptual hierarchy. In this experiment, we did this by displaying a decision tree representation of the hierarchy, verbally describing the hierarchy, and sequencing the definitions and examples according to the hierarchy.

Yes, there is more to teaching certain concepts than merely presenting definitions, examples, and non-examples.

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