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ABSTRACT

In order to investigate the effects of sequence and synthesis in the teaching of taxonomically-related concepts, a study was conducted in which 27 students from Syracuse University were asked to examine printed instructions dealing with kinds of sailboats and then to respond to a test based on those instructions. The synthesizing structure employed in the instructions was a "kinds-conceptual" taxonomy which shows the relationship between concepts. Six versions of the instructions were employed: three with a general-to-detailed presentation sequence and three with a detailed-to-general sequence. Each set of three included a version without a synthesizer, a version with a synthesizer at the beginning, and a version with a synthesizer at the end. Statistical analysis was performed on the test scores of the students. Though the results did not support the hypothesis that a general-to-detailed sequence is superior to a detailed-to-general sequence, an interaction between synthesizer position and the sequence of instructions was found: learning relationships are facilitated when a synthesizer is presented before detailed-to-general instructions and after general-to-detailed instructions. A reference list, five figures, and two data tables are included. (Author/JL)

INSTRUCTIONAL DESIGN,
DEVELOPMENT,
AND EVALUATION

WORKING PAPERS

THE USE OF SEQUENCE AND SYNTHESIS
FOR TEACHING CONCEPTS

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ABSTRACT

This research study investigated the effects of sequence and synthesis in the teaching of taxonomically related concepts. The two sequences were general-to-detailed and detailed-to-general, and the synthesis was provided by a "kinds-conceptual synthesizer", a tree chart in which the subordinate concepts are kinds of their superordinate concepts. The three levels of synthesis were synthesizer first, synthesizer last, and no synthesizer. The theories of Ausubel, Bruner, Gagne, and Reigeluth and Merrill provide the perspectives for the study. The concepts were kinds of sailboats, the dependent variables were concept classification and knowledge of relationships among the concepts, and the students were college freshmen. No significant main effects were found, most likely due to the shortness of the task; but a significant interaction was found, indicating that for a general-to-detailed sequence, it was better to place the synthesizer at the en of the instruction rather than at the beginning of the instruction, whereas for a detailed-to-general sequence the reverse was true.

INTRODUCTION

Several theories have been advanced related to the structuring of subject matter content. Two strategies for structuring subject matter are sequencing, which refers to the order in which elements of subject matter are presented during instruction, and synthesis, which refers to showing the relationships among those elements of subject matter. With respect to sequencing, Ausubel's (1963, 1968) subsumption theory suggests that instruction would be more meaningful if the most general ideas are presented first, followed by successively greater detail and specificity. Gagne's (1962, 1977) hierarchical approach to sequencing, on the other hand, has sometimes been interpreted as advocating that the most detailed and specific parts of a subject matter be learned before the most general concepts are learned.

With respect to synthesis, Ausubel (1968) advocates the use of advance organizers to structure subject matter so that students can relate subsequent materials to anchoring ideas. Bruner (1960) also proposes that learning the structure of a subject matter (how elements are related) permits more meaningful learning. Although Wilcox (1979) found that the presentation of a taxonomic structure increased posttest scores for concept classification, little research has been done on the sequencing and synthesizing of instruction in predominantly conceptual content.

The Elaboration Theory (Reigeluth, 1979) proposes that relatively large amounts of instructional content should have a general-to-detailed sequence, that pre and post synthesizers should be used, and that structure itself should be taught to facilitate the learning of interrelationships within the subject matter. This approach seems promising, but data are needed to test its usefulness. The Elaboration Theory suggests that subject matter can be organized on the basis of any one of three types of content: concepts, principles, or procedures. This study dealt only with concepts, which are classes of objects which share critical attributes and which have discriminately different individual members.

The problem of this study, then, was to investigate the effects of sequence and the use of a synthesizing structure in the teaching of concepts. The two independent variables were sequence and synthesis. Sequence refers to the order of presentation of the concepts. The levels of this variable were general-to-detailed and detailed-to-general. The synthesizing structure was a "kinds-conceptual" structure (Reigeluth & Stein, in press), a taxonomy which shows the super/co/subordinate relationships among concepts, where the subordinate concepts are all types of their superordinate concepts. The levels of this variable were synthesizer-first, synthesizer-last and no synthesizer. The dependent variables were concept classification and knowledge of interrelationships among the concepts. These variables are at the use (application) and remember (recall) levels, respectively, as suggested by the Component Display Theory (Merrill, Reigeluth, and Faust, 1979).

The first hypothesis was that a general-to-detailed sequence would be superior to a detailed-to-general sequence for teaching both the attributes of the concepts and the relationships among those concepts. The second hypothesis was that, the presence of a synthesizer (specifically, a kinds-conceptual structure) would facilitate the learning of concepts that bear such super/co/subordinate interrelationships, as well as facilitating the learning of the relationships among those concepts. The third hypothesis followed Ausubel's suggestions that providing a synthesizer at the beginning of the instruction (so that subsequent instruction could be related to it) should be superior to placing the synthesizer at the end of the instruction.

Methods

Subjects

From an initial group of 80 names selected from the Syracuse University psychology pool, 30 students (14 females and 16 males) agreed to participate in the study. The students were asked to report as a group to a classroom for one hour. Only 21 students attended at the scheduled time, so a make-up session was held one week later. Of those nine students failing to appear at the first session, six attended the make-up session. The total number finally participating was 27 (11 females and 16 males).

Design

The experimental design was a posttest only design. The statistical design was a 2X3 factorial design, and a two-way analysis of variance was used. The two factors were sequence and synthesizer. The two levels of sequence were general-to-detailed and detailed-to-general. The three levels of the synthesizer were absence of the synthesizer, presence of the synthesizer at the beginning of the instruction, and presence of the synthesizer at the end of the instruction. The six experimental groups are depicted below in Figure 1.

Insert Figure 1 about here

Instructional task and materials

The subjects were asked to study a printed instruction booklet dealing with kinds of sailboats and then to respond to a paper-and-pencil test based on the material in the booklet.

The booklets contained a definition (including a list of attributes), a pictorial example, and at least one practice item for each of the 16 related concepts shown in Figure 2. The material in the booklets was compiled from Webster's New Collegiate Dictionary, from Der Grosse Duden Bildwörterbuch (a picture dictionary), and from Dr. Robert Davidson, a sailing enthusiast. Figure 3 shows a sample of the instructional materials.

Insert Figures 2 and 3 about here.

Treatments

There were six versions of the instruction booklet: three with a general-to-detailed sequence and three with a detailed-to-general sequence. Each set of three consisted of one without a synthesizer, one with the synthesizer at the beginning of the instruction, and one with the synthesizer at the end of the instruction. The synthesizer was a tree-chart diagram of a kinds-conceptual structure (see Figure 2). The detailed-to-general sequence began with "sloop" and presented instruction on each of the other types of sailboats at that level of the structure before proceeding to the next superordinate level. The general-to-detailed sequence began with "square-rigged ships," and all concepts at one level were presented before proceeding to the next lower level. The instruction on each individual concept was identical for all treatment groups.

Tests and measures

The test was a 39-item paper-and-pencil test which was divided into two parts. The first part contained 18 items about the relationships among the various concepts at the recall level (the relationship test), and the second part contained 21 items requiring identification of unencountered examples of all the concepts (the attribute test) at the use-a-generality, or application level, as suggested by the Component Display Theory (Merrill, in press). Figure 4 shows the relationship test and half the attribute test.

Insert Figure 4 about here

Procedures

Upon reporting to the designated classroom, the students were randomly assigned to one of the six treatment booklets. Before beginning the booklet, the students were asked to complete an information sheet in which they were to indicate their sex, current grade point average and whether or not they had any previous knowledge of sailboats. They were also asked to keep track of and record the time they spent on the booklet and on the test. The students were allowed to begin reading the booklet individually, and were told they would be allowed a maximum of 35 minutes to study the booklet. The students were instructed to study each page in sequence, spending as much time as they felt they needed to learn the material on the page, but not to return to any previous page as they progressed through the booklet. After completing the booklet they were asked to turn in the booklet, and were then given the test. The students were allowed to spend whatever time remained in the one hour session, on the test. All students finished within the allotted time.

Results

Table 1 shows the mean number of correct responses on the relationship test (18 possible correct) and on the attribute test (21 possible correct). An analysis of variance procedure did not yield significant main effects for sequence or synthesizer on either the relationship test or the attribute test (see Table 2). Neither was the interaction significant on the attribute test. However, on the relationship test the sequence x synthesizer interaction was significant ($F = 4.17$, $p=.0299$). (See Figure 5.)

To identify the source of this significance, a 2X2 analysis of variance was performed. The first analysis was between sequence (detailed-to-general and general-to-detailed) and synthesizer (no synthesizer and synthesizer first). This comparison yielded no significant interaction between sequence and synthesizer. Then, in a second analysis between sequence and synthesizer, only the synthesizer-first and synthesizer-last data were used for the synthesizer factor. This analysis showed a significant interaction ($F=6.46$, $p=.0226$) between sequence and synthesizer position. The results indicate, therefore, that for learning the relationships among concepts with a detailed-to-general sequence, having the synthesizer at the beginning of the instruction is superior to having the synthesizer at the end of the instruction, whereas for the general-to-detailed sequence the superior position for the synthesizer was at the end of the instruction.

Insert Figure 5 about here

Discussion

The results of this study did not support the hypothesis that a general-to-detailed sequence is superior to a detailed-to-general sequence, nor did they support the hypothesis that the presence of a synthesizer (specifically, a kinds-conceptual structure) would facilitate learning the attributes of concepts and the relationships among those concepts. However, the most interesting result of the study was the unexpected finding that there was an interaction between synthesizer position and the sequence of the instructon. It would appear that learning relationships among the concepts may be facilitated when a synthesizer is presented before the instruction, if the instruction is arranged in a detailed-to-general sequence, but when the synthesizer is presented after the instruction, if the instruction is arranged in a general-to-detailed sequence.

Perhaps this result indicates that when instruction begins at the most detailed level, learners need to start with a synthesizer to provide context for each detailed concept. On the other hand, when the instruction is arranged in a general-to-detailed sequence, it would appear that the most general concepts themselves provide the context for the subsequent concepts, such that students do not benefit from a synthesizer as an initial overview of the set of concepts. Conversely, in the general-to-detailed sequence, students appear to need a synthesizer at the end of the instruction to review the relationships among the concepts, a function similar to that served by the general concepts presented at the end of a detailed-to-general sequence. There is increasing evidence that learning the relationships among concepts is important for building stable cognitive structures and for improving long-term retention and problem solving skills. Hence, using a synthesizer in the manner just described may be a promising instructional strategy.

Any effect that sequence and synthesizer have on the learning of the attributes of concepts is not apparent from this study. But it is important to note that the elaboration model proposes that neither sequence nor synthesis is likely to make any difference for relatively small amounts of interrelated content. The human mind is likely capable of compensating for poor sequences and lack of synthesizers when the amount of instructional content is small. Since the task in this study required less than an hour to complete, it is not surprising that no main effects were found. In fact, it is surprising that the interaction effect was found, especially considering the lower power associated with interaction effects.

The methodological approach of this study requires discussion at this point. First, the subject matter (in this case kinds of sailboats) was chosen because it was felt there would be little prior knowledge of sailboats among the subjects, thus alleviating the need for a pretest. Students were asked to indicate their prior knowledge of sailboats, and most indicated they had very little or none. The test scores of the few subjects who had indicated they had prior knowledge were not significantly different from those of subjects who had indicated they had no prior knowledge. The subject matter chosen was for the convenience of the study, but it is suggested that it would be instructive to conduct further research using traditional school content.

The small sample size, the variable time and effort spent by the students on the learning task, and the lack of any pilot testing of the materials and tests should cause the results of the study to be viewed with caution. Although the students were asked to proceed sequentially through the booklet, this could not be easily controlled. A better presentation medium might be slides or transparencies. Also, in this study, the students might have made better use of the synthesizer if an explanation of the purpose of the synthesizer had been included in the instruction booklet.

It is suggested that in any further research, a set of concepts should be chosen so that all the concepts have identification labels that are not the same as their attributes. In this study, one level of concepts included two categories: fore-and-aft rigged ships and square-rigged ships. Although these names were concept labels at a general level, they were also the critical attributes of those concepts. The results might have been different if the concepts had not indicated the concept attributes. This issue requires further study. Additional research could also explore the teaching of subject matter which is primarily theoretical or procedural, rather than conceptual.

REFERENCES

Ausubel, David P. *The Psychology of Meaningful Verbal Learning*. New York: Grune & Stratton, 1963.

Ausubel, David P. *Educational Psychology: A Cognitive View*. New York: Holt, Rinehart, and Winston, 1968.

Bruner, J. S. *The Process of Education*. New York: Random House, 1960.

Gagne, R. M. "Military training and principles of learning." *American Psychologist*, 1962, *17*, pp. 83-91.

Gagne, R. M. *The Conditions of Learning*. 3rd ed. New York: Holt, Rinehart and Winston, 1977.

Merrill, M. D., Reigeluth, C. M., and Faust, G. W. The instructional quality profile: A curriculum evaluation and design tool. In H. F. O'Neil, Jr. (Ed.) *Instructional Systems Development: Tools and Methodologies*. New York: Academic Press, 1979.

Reigeluth, C. M. "In search of a better way to organize instruction: The elaboration theory." *Journal of Instructional Development*, 1979, 2(3), pp. 8-15.

Reigeluth, C. M., Merrill, M. D., Wilson, B. G., and Spiller, R. T. *The Elaboration Theory of Instruction: A Model for Structuring Instruction*. in press.

Reigeluth, C. M., and Stein, F. S. The Elaboration Theory of Instruction. In C.M. Reigeluth (Ed.), *Instructional Design Theories and Models: An Overview of their Current Status*. Hillsdale, NJ: Erlbaum, in press.

Wilcox, W. C. *Effect of Teaching a Conceptual Hierarchy on Concept Classification Performance*. Unpublished Ph. D. dissertation. Brigham Young University, 1979.

FIGURE 1

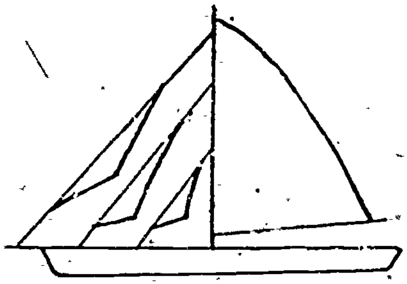
SYNTHESIZER

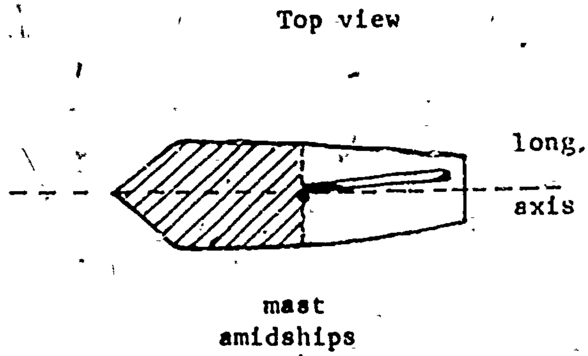
SEQUENCE

	No Synthesizer	Synthesizer First	Synthesizer Last
Detailed-to-General	D→G, none	D→G, first	D→G, last
General-to-General	G→D, none	G→D, first	G→D, last

CUTTER - A single-masted fore-and-aft rigged sailboat with mast amidships.

Example:



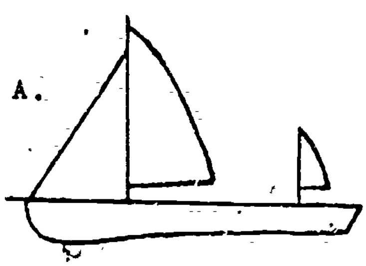


Attributes:

1. One mast
2. Fore-and-aft rigged (From the top view the sails are roughly parallel to the long axis of the boat.)
3. Mast amidships

Practice: Circle the cutter.

A.



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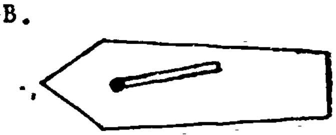
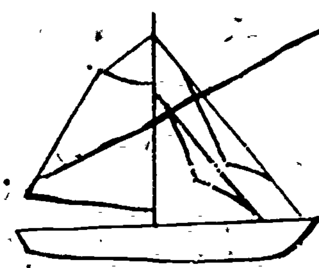


C.



Answer: C

FIGURE 2
3

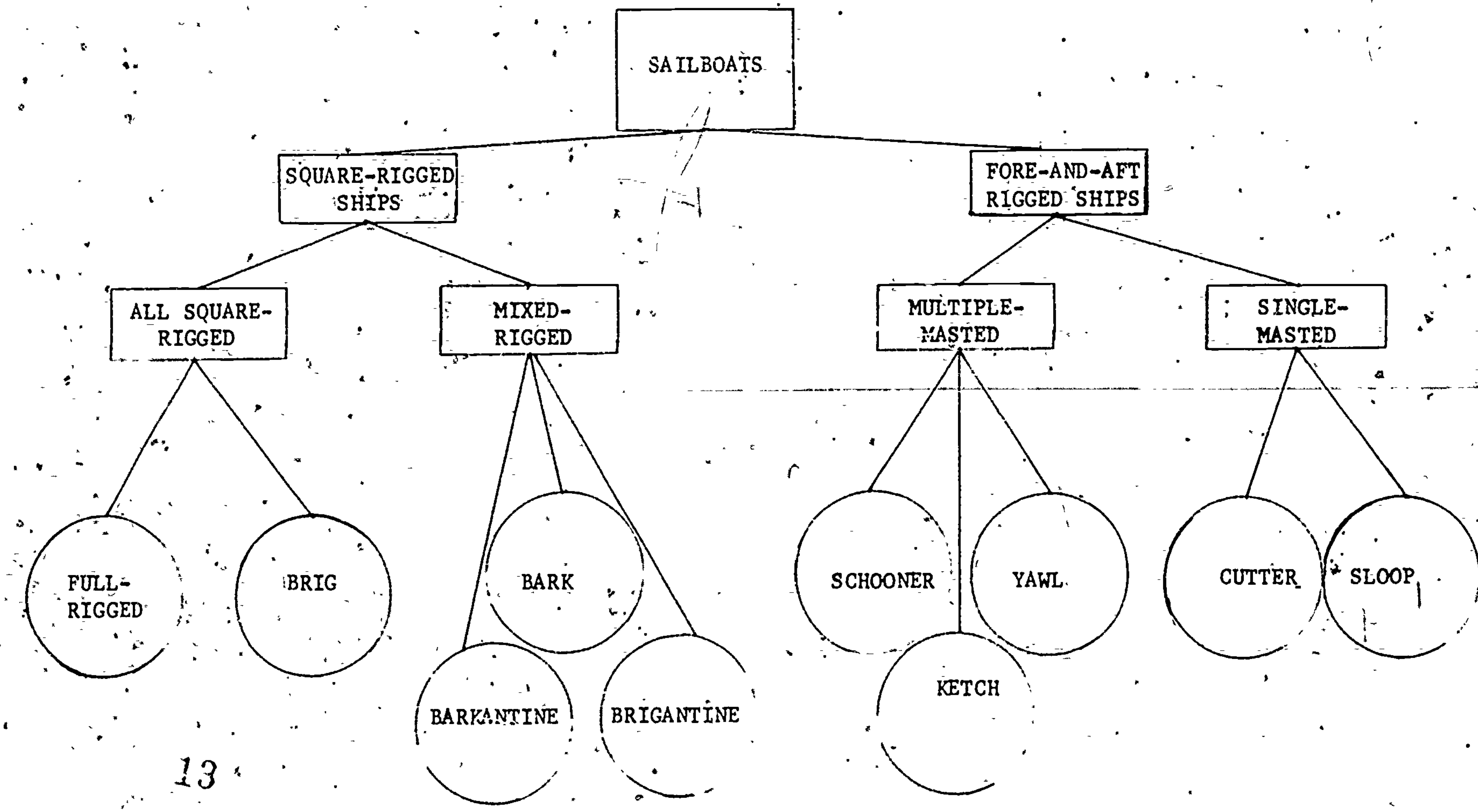


FIGURE 3: SYNTHESIZER

Test on Kinds of Sailboats

Part. I

A. Without using the general category "sailboats", list each of the superordinate categories to which the following sailboats belong.

1. Single-masted ships are a kind of ______________ ship.

2. Mixed-rigged ships are a kind of ______________ ship.

3. A yawl belongs to the ______________ category(ies).

4. A cutter belongs to the ______________ category(ies).

5. The brig and the bark are common to what category(ies)? ______________

______________.

6. The schooner and the sloop are common to what category(ies)? ______________

______________.

7. The barkentine and brigantine are common to what category(ies)? ______________

______________.

8. The ketch and the full-rigged ship are common to what category(ies)?

______________.

9. Schooners, yawls, and cutters are common to what category(ies)? ______________

______________.

10. Brigs, brigantines, and yawls are all common to what category(ies)?

______________.

B.

1. Into what two main categories can square-rigged ships be divided?

____

2. Into what two main categories can fore-and-aft rigged ships be divided?

____

3. What are the kinds of single-masted ships?

____

4. What kinds of sailboats have all square-rigged masts?

____

5. Name the fore-and-aft rigged ships with more than one mast.

____

6. Name the boats which have some masts square-rigged and some fore-and-aft rigged.

____

7. Name all the kinds of square-rigged ships.

____

8. Name all the kinds of fore-and-aft rigged ships.

____

FIGURE 4

TEST - Part II

Identify each sailboat below by writing its name under the picture. Use one of the following names: schooner, barkentine, brigantine, cutter, brig, bark, yawl, full-rigged, sloop, ketch. (You may use a name more than once.)

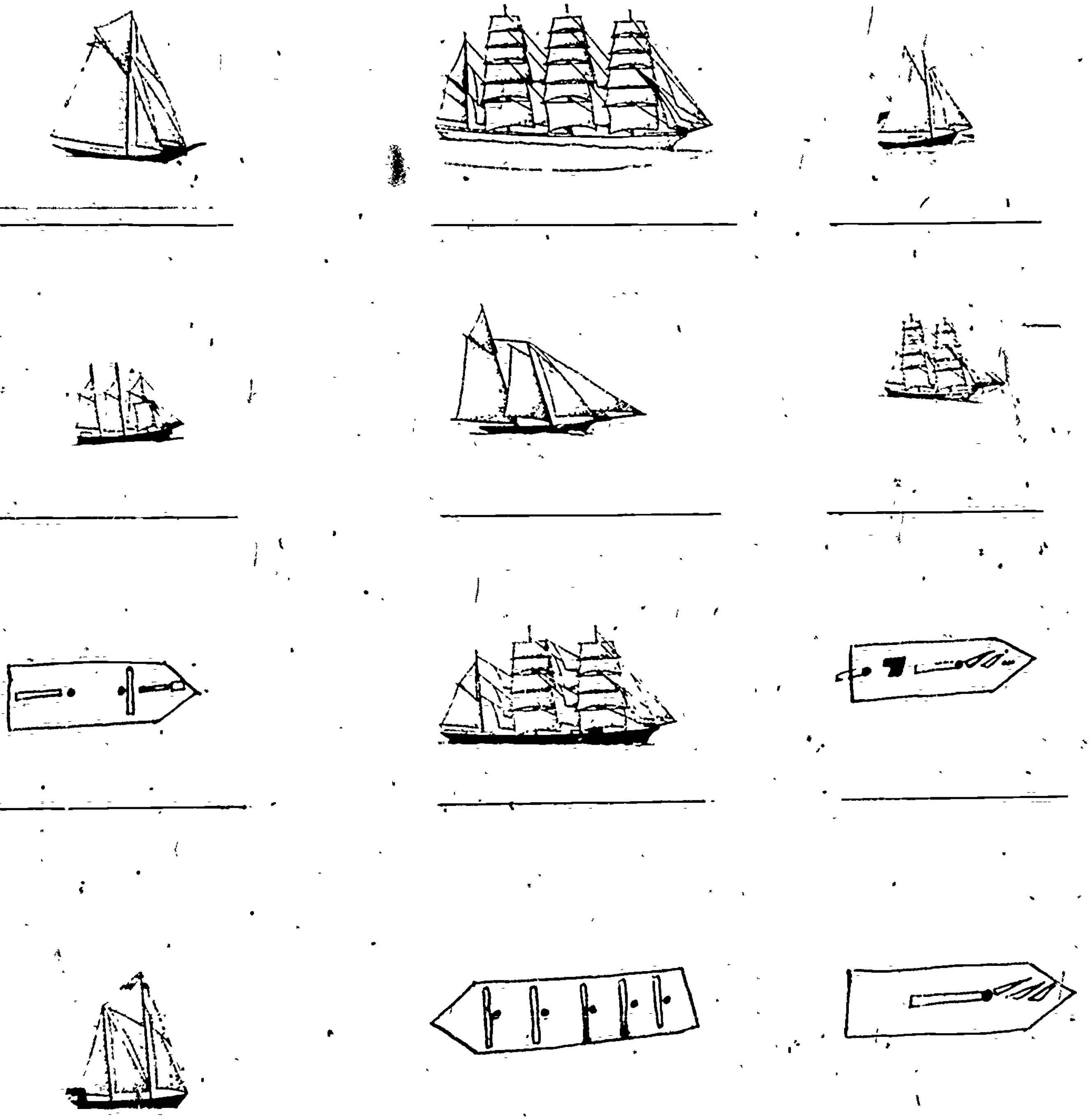


FIGURE 4 cont.

Table 1

Mean Number of Correct Responses on the Relationship Test (37 possible correct)

Sequence	no synthesizer	synthesizer first	synthesizer last	total
detailed-to-general	21.75 (4) S.D. = 3.95	23.8 (5) S.D. = 12.07	7.25 (4) S.D. = 10.05	18.1 (13)
general-to-detailed	14.0 (4) S.D. = 7.16	8.0 (5) S.D. = 8.22	16.8 (5) S.D. = 12.26	12.9 (14)
total	17.9 (8)	15.9 (10)	12.6 (9)	

Mean Number of Correct Responses on the Attribute Test (21 possible correct)

Sequence	no synthesizer	synthesizer first	synthesizer last	total
detailed-to-general	9.0 (4) S.D. = 5.09	8.4 (5) S.D. = 6.66	4.25 (4) S.D. = 2.22	7.3 (13)
general-to-detailed	5.5 (4) S.D. = 2.38	5.2 (5) S.D. = 5.54	6.8 (5) S.D. = 5.93	5.9 (14)
total	7.25 (8)	6.8 (10)	5.7 (9)	

(Numbers in parentheses represent n's for each group)

Table 2

Analysis of Variance
(General Linear Models Procedure)

Relationship Test

Source	Sums of Squares	df	F	pr > F
Synthesizer Position (A)	124.299	2	0.67	0.5238
Sequence (B)	169.726	1	1.82	0.1915
A X B	777.171	2	4.17	0.0299

Attribute Test

Source	Sums of Squares	df	F	pr > F
Synthesizer Position (A)	11.567	2	0.22	0.8039
Sequence (B)	12.959	1	0.49	0.4897
A X B	51.591	2	0.98	0.3904

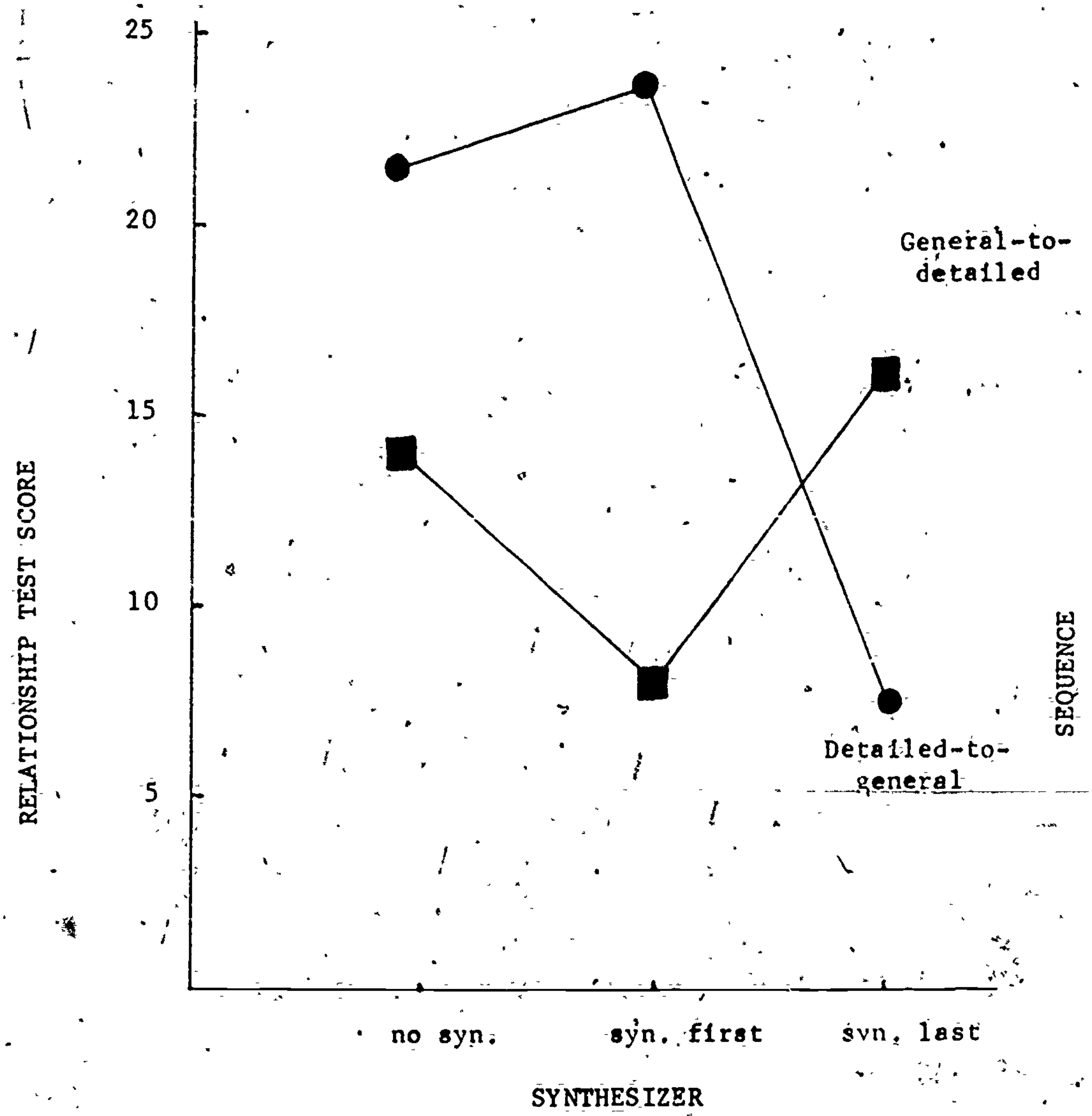


FIGURE 5. INTERACTION BETWEEN SEQUENCE OF INSTRUCTION AND SYNTHESIZER ON THE RELATIONSHIP TEST