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ABSTRACT

This study was performed in order to test the author's notion that advance organizers operate because (1) they provide stable anchorage for concepts to be learned and (2) in order to operate they must be relatable by the student to the new material. To test this hypothesis the author constructed materials for each of ten treatments as defined by two levels of abstractness of the advance organizer used and five levels of recalling the organizer to the learner. One-hundred thirty-two pre-service elementary teachers were randomly assigned to treatments which were administered in 13-page booklets. Immediately after the 50-minute treatments, a 23-item test was administered; this experimenter-developed test included a skill subscale and a theory subscale with KR-20 reliability of .690 and .665, respectively. Data were submitted to three analyses of variance. Interaction of the two main variables when the skill subscale was analyzed was the only significant effect (p less than .05). The author suggests that the advance organizers used may not have been stable enough for the population, and that forced recall may have disrupted the cognitive processes of subjects. He also suggests that prior knowledge may have affected the results. (SD)

RECALL OF ADVANCE ORGANIZERS AS PART OF MATHEMATICS INSTRUCTION

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This study was designed to determine whether programmed recall of an advance organizer (AO) during instruction would enhance achievement as a result of a strengthened cognitive association between the AO and the material to be learned. The question was viewed as an extension of previous investigations of the effects of AO's (Peterson, Lovett, Thomas and Bright 1973; Sowder, Musser, Flora and Bright 1973) and was considered meaningful in working toward a solution to the problem of effective uses of AO's in structured instructional settings.

Even cursory examination of the AO literature reveals that there is considerable lack of agreement on the nature of an advance organizer. Ausubel (1963) stated that learning might be facilitated by presenting an AO prior to instruction. This organizer should be more general and more inclusive than the material to be learned (p. 214). At the same time, the organizer must be anchorable in the cognitive structure of the learner, for if it is rotely learned and consequently unstable, then it cannot be expected to provide adequate anchorage for the material to be learned. That is, the organizer must be built from concepts that are familiar to the learner and that are at a cognitively more general and inclusive level than the material to be learned. For example, the use of operations on rational numbers as an AO for instruction of whole

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numbers for young children would be inappropria . Certainly such material is mathematically more general and inclusive, but it would probably not be relateable by the learner to anything in his cognitive system. There is also some question whether the cognitive generality of operations on rational numbers is any greater than operations on whole numbers. That is, is psychological generality present in this situation even though logical generality certainly is?

Much work has been done to determine the extent to which the results of Ausubel (1960), Ausubel and Fitzgerald (1961, 1962), and Ausubel, Stager and Gaite (1968, 1969) can be generalized, but in general the "advance organizers" are too discrepant to be compared. For example, Dvergsten (1971) used a list of major concepts appearing in the learning passage, Peterson (1971) used a description of a puzzle, and Weisberg (1970) used diagrams as advance organizers. There does not seem to be any good way to determine which, if any, of these are legitimate AO's.

In mathematics concept learning the available data is very limited. Romberg and Wilson (1970) observed an unpredicted interaction between a prose organizer used before instruction and the same content used as an organizer after instruction. The organizer related the instructional content, the mathematics of radioactive decay, to simple information on fission and radioactive decay. Peterson (1971) and Peterson, et al. (1973) were not able to replicate this effect. Their organizer was the Königsberg bridge problem, and the instructional content was graph theory.

Most studies (e.g., Eastman 1972; and Sowder, et al. 1973) have failed to demonstrate differential effects between organizer and non-organizer groups. Other studies (e.g., Scandura and Wells 1967) have demonstrated the existence of such differential effects in restricted instances, but it is not clear how these situations might be characterized.

The present study was designed to take advantage of the idea that an AO operates because it provides stable anchorage for the concepts to be learned. The seeming ineffectiveness of AO's in previous studies might be explained by the fact that the relationship between the organizer and the material to be learned was not sufficiently well established. Such a lack of relationship might be caused by the physical unavailability of the organizer during instruction, by the failure of the Ss to relate the AO to appropriate parts of the content, or by failure to recall the content of the AO. Increasing the likelihood of recall might enhance the effectiveness of the AO by balancing the suggested causes of ineffectiveness.

HYPOTHESES

The hypotheses and procedures of this study were based on those of Sowder, et al., (1973). Stated in null form the hypotheses were as follows:

(1) The level of abstractness and inclusiveness of advance organizers does not effect learning of the concepts of integer addition among prospective elementary school teachers.

(2) Repeated recall of an advance organizer during instruction does not affect learning of the concepts of integer addition among prospective elementary school teachers.

METHOD

<u>Materials</u>: The learning material for this study was modified from that used by Sowder, et al. (1973) and consisted of a 13-page printed booklet adapted

from the script of that study's TV tape on addition of integers.

The advance organizers were also taken from that study. One was a listing of the axioms of a mathematical field and one was a definition of a mathematical system. For each organizer, three paragraphs were written to be inserted in the instructional booklet. These paragraphs were designed to recall the respective organizer, or parts thereof, into the cognitive field of the learner and to help relate the organizer to the material to be learned.

A test of immediate learning was developed by the experimenter. The test consisted of 23 items, 12 to test computation skill and 11 to test recognition and recall of the structural properties of integer addition. These subscales were called "skill" and "theory," respectively.

Subjects: The subjects for the study consisted of those students enrolled in two sections of the first-semester mathematics content course for elementary education majors at Northern Illinois University. Seventy-seven per cent of these students were freshmen, and 93 per cent were female. The study was conducted in November 1972.

Design and Procedures: The study employed a 2×5 factorial design, the first factor being type of organizer, and the second factor being number of instances of recall. The two organizers were used and recalled from zero to four times (hence, five levels for the second factor) with the recall passages being the paragraphs previously described.

Booklets were constructed to accommodate the ten treatments. These booklets were randomly ordered and distributed sequentially to the subjects at the beginning of the study. The subjects were told that they would have one class period (50 minutes) to study the material in the booklet and to complete the test which was included in the booklet. No subject took more than 45 minutes to complete the booklet and test. All hypotheses were tested at the .05 level.

RESULTS

Both hypotheses were tested for the "skill" and "theory" subscales as well as for the total score. The means and standard deviations for all ten groups and for all three scales for each group are presented in Table 1.

INSERT TABLE 1 ABOUT HERE

KR-20 reliabilities were computed for both subscales and for the total test score. These reliabilities were as follows: subscale skill .690, subscale theory .665, and total .784.

The hypotheses were tested by using a 2×5 ANOVA (table 2).

INSERT TABLE 2 ABOUT HERE

Only one of the F ratios was significant at the .05 level. Since none of the main effects were significant, neither of the hypotheses could be rejected.

A plot of the group means was made (Figure 1).

INSERT FIGURE 1 ABOUT HERE

Inspection of the graphs of those groups which received the AO's revealed an unusual pattern. Five of these six graphs were roughly in the shape of a U. If one considers all possible graphs of four points, heeding only the relative positions of neighboring points, there are eight possible graphs (Figure 2).

INSERT FIGURE 2 ABOUT HERE

Of these eight graphs, two are roughly in the shape of a U; i.e., the probability of a U-shape is 1/4. The probability of five independent occurrences of such an event from a sample of six trials would be about .00465. A pattern of an inverted U must be considered equivalent to this, so the probability is larger by an unknown amount.

In order to clarify the pattern observed in the graphs as well as the nature of the significant interaction reported in Table 2, the data of the eight AO groups were reanalyzed by a 2×4 ANOVA (Table 3).

INSERT TABLE 3 ABOUT HERE

Two of the F ratios were significant at the .025 level. Both of these were main effects for type of AO.

DISCUSSION

The lack of significant main effects in the ANOVA of Table 2 together with the existence of a significant main effect for type of AO in the ANOVA of Table 3 suggests that the effect of the AO's among the AO groups was different than the effect between the no-AO (control) and the AO groups. This discontinuity appeared in the guise of interaction in the ANOVA of Table 2. At the same time, the lack of a significant interaction in Table 3, suggests that the statistical results are unstable and hence probably not meaningful in any practical sense.

One of the most intriguing results is the seeming quadratic nature of the AO group means (Figure 1). This was suggested by the large difference between the observed probability (.833) and the predicted probability (.0093) of observing five U-shaped graphs in six trials. If such a description were accurate, then the linear model assumption of the 2×4 ANOVA of Table 3 ought not to be sufficient, and there should be a significant F ratio for interaction (Snedecor and Cochran, 1967, p. 346). Since none of the interaction ratios in Table 3 were significant, the existence of a quadratic relationship is discounted. The apparent discrepancy between the data and the assumed linearity of the model probably does not warrant further attention.

In the context of the instruction and the supplementary material of this study, there does not seem to be any reason to believe that recall of AO's enhances learning. It must be remembered, however, that the instruction was begun and concluded in less than one hour. The results of this study do not preclude the possibility that recall of an AO during longer-term instruction might enhance its effectiveness. Too, the AO's of this study may not have been cognitively stable enough for the learners to permit meaningful recall. The enforced recall may have served to disrupt the Ss' cognitive structure, and hence to increase the difficulty of using the already unstable anchorage.

The trends toward statistical significance seemed to be more pronounced for the subscale, skill, than for the subscale, theory. Ausubelian theory would predict this, since the AO was at an abstraction level higher than the concepts tested by the skill subscale, while the AO was nearly at the same abstraction level as the concepts tested by the theory subscale.

Finally, covariance on prior knowledge might have provided a more sensitive analysis, though measuring the subjects' prior knowledge might also have provided additional instruction that would have overpowered the effects of the treatments. Too, generalizations of the results must at best be guarded, for the processes of mathematics concept learning among prospective elementary school teachers are possibly quite different from the processes of other students. The treatments did have some differential effects, and the nature of these effects should be more extensively studied.

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TABLE 1

Means and Standard Deviations: All Groups

Number of Instances of AO and Recall	N	Scale: Skill $\overline{x}^a$	s.d.	Theory $\overline{x}^b$	s.d.	Total $\overline{x}^c$	s.d.
Type of AO: Field Axioms							
0	13	9.92	2.02	7.92	2.22	17.85	3.56
1	12	10.83	1.03	9.25	1.71	20.08	2.54
2	14	11.50	.85	8.14	1.56	19.64	1.74
3	13	10.15	2.34	7.77	2.24	17.92	4.23
4	14	11.57	.94	8.57	1.79	20.14	1.70
Type of AO: Mathematical System							
0	14	10.57	1.60	8.79	1.63	19.36	2.73
1	15	11.07	1.10	8.40	1.59	19.53	2.26
2	14	9.86	2.63	7.50	2.35	17.36	4.24
3	12	9.83	1.53	7.67	1.92	17.42	2.97
4	11	10.09	1.81	8.00	1.18	18.09	2.66

[a]possible score = 12 [b]possible score = 11 [c]possible score = 23

TABLE 2

Two-Way ANOVA: All Scales

Source	SS	df	MS	F
	Subscale: Skill			
Type of AO	8.60	1	8.60	3.03
Number of Instances	16.87	4	4.22	1.49
Interaction	27.74	4	6.93	2.45*
Error	345.86	122	2.83	
	Subscale: Theory			
Type of AO	2.23	1	2.23	.65
Number of Instances	21.05	4	5.26	1.53
Interaction	12.59	4	3.15	.91
Error	420.74	122	3.45	
	Total Score			
Type of AO	19.74	1	19.74	2.22
Number of Instances	64.65	4	16.16	1.82
Interaction	62.03	4	15.51	1.74
Error	1084.45	122	8.89	

*p < .05

TABLE 3

Two-Way ANOVA: AO Groups Only

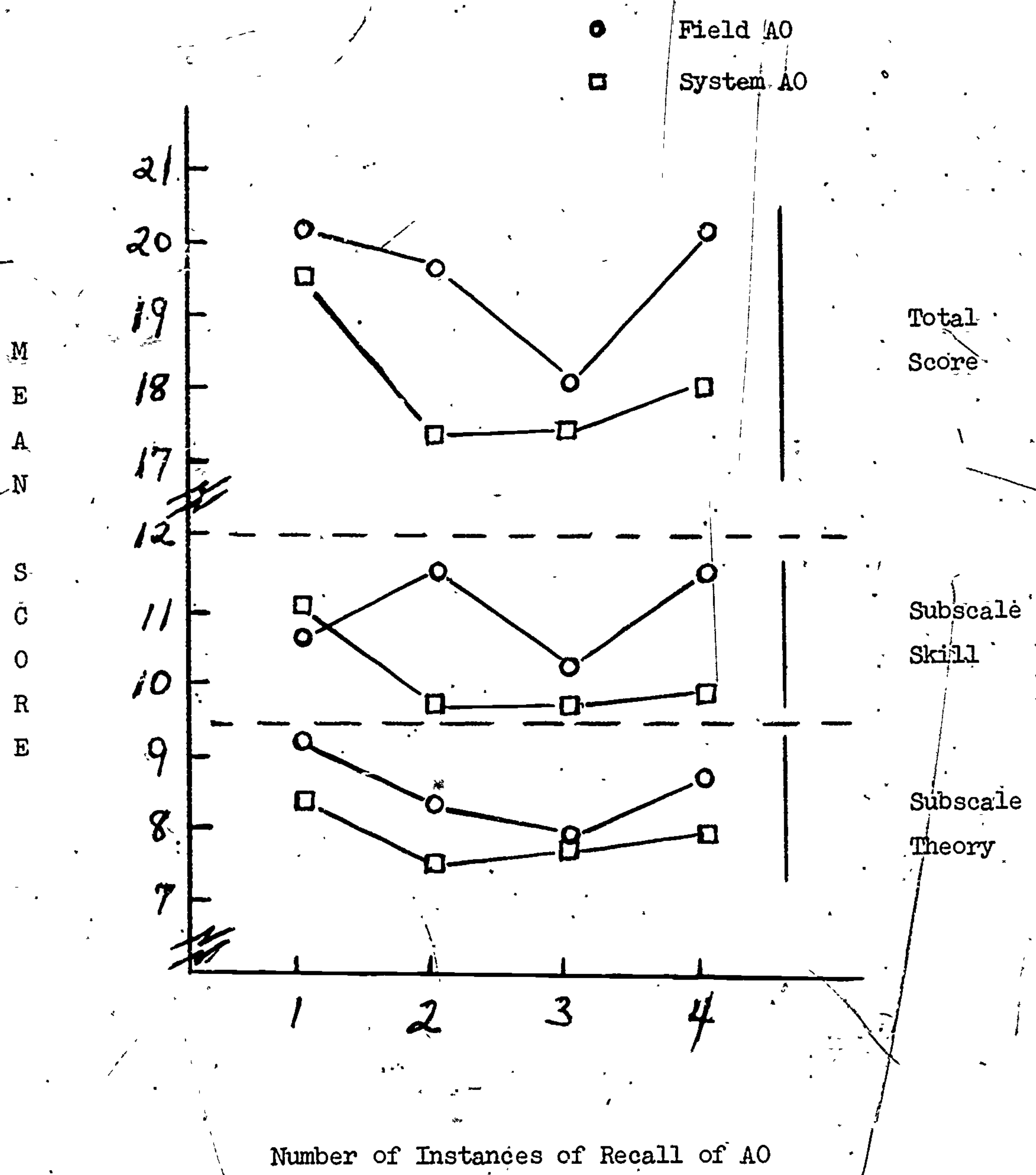
Source	SS	df	MS	F
		Subscale: Skill		
Type of AO	16.75	1	16.75	6.17*
Number of Instances	13.89	3	4.63	1.70
Interaction	16.38	3	5.46	2.01
Error	263.51	97	2.72	
		Subscale: Theory		
Type of AO	7.63	1	7.63	2.26
Number of Instances	20.27	3	6.76	2.00
Interaction	1.91	3	.64	.19
Error	327.47	97	3.38	
		Total Score		
Type of AO	47.28	1	47.28	5.49*
Number of Instances	63.95	3	21.32	2.47
Interaction	17.87	3	5.96	.69
Error	835.54	97	8.61	

*$p < .025$

FIGURE CAPTIONS

Figure 1. Plot of Mean Scores for Groups Receiving Advance Organizers

Figure 2. Graphs of Four Points



Field AO
System AO
MEAN SCORE
21
20
19
18
17
12
11
10
9
8
7
Total Score
Subscale Skill
Subscale Theory
1
2
3
4
Number of Instances of Recall of AO