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ABSTRACT

The authors briefly review some of the empirical studies which have compared discovery learning with expository learning. Essentially, their study replicates an earlier one in which these learning strategies were compared on two dimensions: (1) immediate acquisition; and (2) retention of concepts. Subjects were 228 seventh graders who had not previously mastered the four geometry concepts-quadri-lateral, rhombus, trapezoid, and parallelogram. A complete description of the experimental procedure is presented. Results show that students in the expository groups spent less time studying the lessons than those in the discovery groups, yet had superior immediate acquisition scores and equal retention scores. The superiority of the expository method is thus indicated, at least for the dimensions measured. Concluding qualifications suggest areas where the discovery method may prove superior to the expository method. (TL)

Discovery Learning Versus Expository Learning: New Insight into an Old Controversy

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Proponents of the discovery method of learning laud its superiority over the more conventional expository method of learning. Wittrock (1966) has summarized some of their claims:

> . . . learning by discovery produces knowledge which transfers to new situations. Through practice at problem solving it develops problem solving ability. It is intrinsically motivating and is its own reward. By being taught to solve problems, to behave in a scientific and inductive fashion, and to go beyond the data, a student is helped to become a mature person. It is a useful conceptualization for the teaching of many subjects. . . . It is an important end in its own right. . . . One must learn to produce rather than to reproduce answers and knowledge. (P. 36)

Many, if not most, of these claims are based on intuition rather than empirical evidence. The results from studies comparing discovery with expository learning have not been conclusive. In fact, they have resulted in inconsistent and even contradictory conclusions. For example, six studies have compared discovery with expository learning over periods ranging from 17 days to 7 months, and measured learning immediately after the close of the instructional period. Of the six studies, two found expository learning superior (McConnell, 1934; Worthen, 1968), two found discovery learning superior (Swenson, 1949; Thiele, 1938) and two found no difference between discovery and expository learning (Anderson, 1949; Nichols, 1956). Two other outcomes of discovery learning have been more consistently observed. First, discovery and expository learning lead to equal performance on tests given immediately after lessons taught over a period of only one or two days (Ray, 1961; Scott, 1970). Second, discovery learning is superior to expository learning on long-term retention (Ray, 1961; Scott, 1970; Swenson, 1949; Worthen, 1968). These results suggest that retention rather than original learning might be a key advantage of the discovery method.

Unfortunately, methodological problems in many of the studies showing better long-term retention for discovery learning lessen our confidence in this conclusion. For example, in Swenson's (1949) study, each teacher taught only one class and used the method, discovery or expository, which most closely approximated his natural teaching style. Teachers were allowed to adjust time and materials to differences among classes and students. This procedure may have introduced a teacher bias. Unlike earlier studies which relied mainly on teachers' verbalizations, Ray's (1961) study used written materials in addition to teachers' verbalizations. However, the proportions of time spent with each medium of instruction were not equal between treatments. The expository method involved mainly teacher verbalization, while the discovery method involved both verbalization and written materials. In addition, students in the discovery group learned individually.

These comments point up the need for treatment conditions which hold constant confounding variables such as teacher bias, media of instruction, and size of the instructional group. Scott and Frayer (1970) have outlined a standardized learning task which allows presentation of the same material by different methods while minimizing teacher and media differences. In this task, all material is presented in written form, keeping the amount of information the same for both treatments.

Scott (1970) used this type of task in comparing discovery and expository methods of teaching geometry concepts to sixth graders. Students learned the concepts quadrilateral, parallelogram, trapezoid and rhombus through written lessons employing either an expository or discovery approach. The expository approach differed from the discovery approach in the sequencing of examples and definitions of the concepts and in the type of

statements accompanying each figure. Scott found no difference in immediate acquisition between the discovery and expository groups. However, he found a significant interaction between method of presentation and retention. Over a 21 day retention interval the scores of students who learned by the discovery method increased over time, while the scores of students who learned by the expository method decreased over time. The study reported here is basically a replication of part of Scott's study.

Subjects. The subjects were 228 seventh graders who had not previously mastered the four geometry concepts taught in the experimental lessons.

Materials. The materials consisted of two introductory lessons; two quadrilateral lessons each written in two styles, discovery and expository; and a test.

INTRODUCTORY LESSONS Two introductory lessons provided the information prerequisite to understanding the quadrilateral concepts.

QUADRILATERAL LESSONS Five examples, three positive and two negative, in the sequence +, -, +, -, +, were given for each of the four concepts, quadrilateral, rhombus, trapezoid, and parallelogram. After two concepts were presented in the above fashion, each of the two concepts was presented again using four examples in the sequence +, -, +, +. The concepts were presented in this manner and sequence in both the expository and discovery methods. The differences between the expository and discovery lessons occurred in the sequence of definition and examples for each concept and in the statements accompanying each example. In the expository lessons, the definition preceded the examples; in the discovery lessons, the definition followed the examples. In the expository lessons each example was accompanied by statements such as: "Look at this figure. This figure is a

trapezoid. Note that side AB is parallel to side AC.

In the discovery lesson the figures were not labeled as examples or non-examples. Each figure was accompanied by statements such as: "Look at this figure. Measure side AB. Measure side AC. What do you find? How is this figure like the figure in the last question?" No feedback was provided for these questions. Feedback for two summary questions at the end of the presentation of each concept told the student which examples were alike and provided the definition of the concept.

TEST OF GEOMETRY KNOWLEDGE A 28-item multiple choice test assessed recognition of attribute examples, concept examples and non-examples, relevant attributes and the concept definition for the concepts quadrilateral, rhombus, trapezoid, and parallelogram.

Procedure. Subjects were ranked on the basis of scores on the Applied Arithmetic subtest of the Stanford Achievement Test. The first eight subjects in the ranking were randomly assigned to eight experimental groups. The second eight subjects were then randomly assigned and so on until all subjects had been assigned to experimental groups. There were six treatment and two control groups. The six treatment groups studied the introductory lessons on days 1 and 2, followed by either the discovery or expository quadrilateral lessons on days 3 and 4. Groups 1-3 received the discovery lessons and Groups 4-6 received the expository lessons. Control Groups 7 and 8 studied lessons which dealt with arithmetic concepts not related to geometry on all four days. Each subject was allowed to work at his own pace on the lessons and was required to record his starting time and finishing time for each lesson. Groups 1 and 4 were tested immediately after completion of the lessons. Groups 2, 5, and 7 were tested 1 day after

completion of the lessons and were retested after 21 days. Groups 3, 6, and 8 were tested 21 days after completion of the lessons.

Design. The experimental design was a 3 x 3 x 3 incomplete randomized block design with three levels of arithmetic achievement (high, medium, and low), three types of lessons (discovery, expository, and control), and three retention intervals (immediate, 1 day, and 21 days).

Results. Subjects in the 1-day retention groups were retested at 21 days. This permitted a repeated measures analysis as well as an independent groups analysis of the effects of discovery and expository learning on retention. The results from these two analyses will be discussed separately.

INDEPENDENT GROUPS ANALYSIS The number of subjects, means, and standard deviations for each of the treatment by achievement groups are given in Table 1. An analysis of variance was performed on this data. The results of this analysis are shown in Table 2.

A significant difference between discovery and expository modes of presentation on immediate acquisition was found. After removing this difference between groups on immediate acquisition, no difference between discovery and expository groups during the retention interval was noted. A comparison between the average of the discovery and expository group scores (adjusted for differences in immediate acquisition) and the control group scores revealed that the learning materials were effective, since the performance of the discovery and expository groups were superior to that of the control groups during the retention interval. The fact that the achievement by time and the achievement by treatment by time interactions were not significant suggests that the relative effectiveness of discovery

Table 1

Number of Subjects, Observed Means and Standard Deviations of Scores for Treatment Groups by Achievement Level

Arithmetic Achievement	Treatment Group								M
	Discovery			Expository			Control		
	Immediate	1 day	21 days	Immediate	1 day	21 days	1 day	21 days	
High	23.43 (5.26) N = 7	23.11 (5.49) N = 8	17.83 (6.01) N = 6	27.00 (1.49) N = 10	25.00 (5.00) N = 7	21.00 (4.80) N = 7	14.75 (4.59) N = 8	17.89 (5.99) N = 8	21.25 N = 61
Medium	18.20 (5.97) N = 15	13.36 (4.86) N = 11	13.88 (4.46) N = 16	21.63 (6.00) N = 11	16.75 (6.38) N = 12	14.63 (5.56) N = 16	11.27 (4.45) N = 13	9.73 (3.85) N = 11	14.93 N = 105
Low	12.75 (2.22) N = 4	9.36 (3.20) N = 11	9.57 (1.99) N = 7	17.50 (6.95) N = 10	14.50 (7.46) N = 8	10.25 (3.96) N = 8	8.86 (4.22) N = 7	8.00 (2.52) N = 7	11.35 N = 62
M	18.13[a] N = 26	15.28 N = 30	13.76 N = 29	22.04 N = 31	18.75 N = 27	15.29 N = 31	11.63 N = 28	11.87 N = 26	15.84 N = 228

Note. - Standard deviations are given in parentheses.
[a] Unweighted mean for high, medium, and low achievement groups.

Table 2

Analysis of Variance of Geometry Test Scores in the Independent Groups Design

Source	df	MS	F ratio	Probability
Mean				
Between Achievement Blocks	2	1621. 46	63.60	<0.0001*
Time				
Immediate Recall vs Recall during Retention Interval	1	1738.28	68.18	<0.0001*
1 day Retention vs 21 day	1	44.34	1.74	<0.19
Achievements Blocks x Time	4	5.30	0.21	<0.93
Treatments				
D vs E on Immediate Recall	1	105.81	4.15	<0.04*
D vs E during Retention given the Immediate Recall Differences	1	1.71	0.07	<0.80
Control vs average of D + E during Retention	1	663.62	26.03	<0.0001*
Treatment x Time during Retention				
D vs E at 1 day vs D vs E at 21 days	1	32.32	1.27	<0.26
Control vs average of D + E at 1 day vs 21 days	1	49.17	1.93	<0.17
Achievement Blocks x Treatment & Achievement Blocks x Treatment x Time	10	34.34	1.35	<0.25
Between Subjects within Cells (error)	208	25.50		

*Significant at or beyond the .05 level chosen.

and expository learning does not vary with the achievement level of the student.

REPEATED MEASURES ANALYSIS Students in the 1-day retention group were tested 1 day after completion of the lessons and were retested 21 days after completion. An analysis of variance was performed on the changes in scores between the two testings. The means for the two testings and the change scores are presented in Table 3. An analysis of variance was carried out on these change scores. The results of this analysis are shown in Table 4.

Table 3

Mean Scores and Changes in Scores for Repeated Administration of the Same Test To Discovery, Expository, and Control Groups at 1 Day and 21 Days

	Treatment		
	D	E	C
1 day	14.71	18.22	11.53
21 Day	15.03	15.81	12.13
Change (1 day to 21 day)	+0.32	- 2.41	+ +0.60

There was a significant difference in change scores among the three groups. The expository group differed significantly from both the discovery group and the control group. The expository group decreased in performance from 1 day to 21 days, while the discovery and control groups did not decrease.

Table 4

Analysis of Variance of Change Scores in the Repeated Measures Design

Source of Variation		df	MS	F	Probability
Mean Change	(After allowing for Treatment X Time)	1	23.21	1.70	<0.20
Change Comparisons[a]		2	79.09	5.79	<0.004*
D vs E[b]		1	112.91	8.26	<0.005*
Control vs average of D + E[b]		1	56.46	4.13	<0.045*
Lack of Fit[c]	(Achievement Blocks X Time and Treatments X Achievement Blocks X Time)	8	11.40	0.83	<0.58
Subjects X Time Within Cells		3	13.67		

* Significant at or beyond the .05 level chosen.

a Assuming no lack of fit (as shown above the data do not show significant lack of fit).

b Each 1 df test was done after SS for the other 1 df source had been removed.

c One cell is missing.

Discussion. There appears to be a contradiction between the results of the independent groups analysis and repeated measures analysis. The independent groups analysis revealed no difference among groups over the retention interval. The repeated measure analysis revealed that there was a difference. This contradiction can be attributed, in part, to the relative sensitivity of the analyses. The estimate of change is about the same for the independent groups analysis as for the repeated measures analysis. However, the standard error for the repeated measure approach is only 50 to 60 percent as large as the standard error for the independent groups design.

The results of the repeated measures analysis correspond more closely to Scott's results than do the results from the independent groups analysis. In Table 3 it can be noted that the scores of the discovery group actually increased over time from 14.71 to 15.03, while the scores of the expository group decreased from 18.22 to 15.81. However, it should be noted that even with the increase in the performance of the discovery group and the decrease of the expository group, the mean score of the expository group was still slightly higher than that of the discovery group.

Conclusions. The main conclusion of the present study is that method of presentation differentially affected immediate acquisition and may have differentially affected retention. The expository method led to superior initial acquisition, but in terms of mean performance after 21 days both methods were equally effective.

Another factor must also be considered when weighing the relative merits of discovery and expository learning. Students in the discovery group spent about 50 minutes completing the two quadrilateral lessons, while

students in the expository group spent about 15 minutes completing the lessons. Thus, students in the expository groups spent less than one-third as much time studying the lessons than the students in the discovery groups, yet had superior immediate acquisition scores and equal retention scores. These results do not support the claims of many who feel that the discovery method is superior to the expository method. To the contrary, they tend to indicate the superiority of the expository method over the discovery method.

The results of this study should not, however, lead one to conclude that the expository method is superior to the discovery method under all conditions. This study has compared only immediate acquisition and retention of concepts. The validity of many of the claims of advocates of the discovery method were not tested. Additional research is needed to determine whether discovery learning has effects not tested in this study. For example, is discovery learning intrinsically motivating? Does it develop problem solving ability? The specific effects of discovery learning should be delineated to permit the teacher to make a wise choice of teaching method to reach particular objectives.

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