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ABSTRACT

Investigated was the effect of systematically combined high and low level cognitive objectives upon the acquisition of science learning. An instructional unit based on a Biological Sciences Curriculum Study (BSCS) Inquiry Slide Set (structure and function, control of blood sugar, a homeostatic mechanism) was chosen because it included stimuli for knowledge and for higher than knowledge cognitive functioning. Forty students enrolled in an elementary science methods course were pretested, using the Process of Science Test (POST) and, based on POST scores, were randomly assigned to two treatment groups in a 2x2 design. Prior to the experiment, subjects read a passage which contained either behavioral objectives or a placebo. Those students receiving the placebo (a discussion on a recently developed science curriculum) had no special learning guidelines and relied entirely on the Inquiry Slide Set experience which was presented by an experienced biology teacher who also led the discussion, following suggested guidelines provided by the BSCS Inquiry Slides kit. Treatment time consisted of one 75-minute class period. Findings would appear to support the assumption that objectives enable learners to retain essential points and to organize complex cognitive processes needed for successful inquiry-oriented learning experiences. (Authors/PEB)

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BEHAVIORAL OBJECTIVES, SCIENCE PROCESSES, AND LEARNING FROM INQUIRY-ORIENTED INSTRUCTIONAL MATERIALS

by

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Rationale for the Study

Research into the effects of behaviorally-stated objectives on learning in various instructional programs has yielded mixed results. Perhaps this state of affairs reflects the notion that the utility of objectives is a function of other teaching variables, such as the appropriateness of the learning task or congruence with criterion instruments.

One powerful variable with potential to increase our understanding of the function of behavioral objectives is the cognitive level of the objectives. Since learners are likely to function differently in different cognitive domains, (Madaus, Woods, and Nuttal[1]) research on instructional approaches such as behavioral objectives should include a wide range of cognitive learning levels. Modest support for this notion comes from two sources: 1) research studies (Cook[2], Olsen[3], Stedman[4], Yelon and Schmidt[5], Loh[6]), and 2) the tendency of many instructional materials to concentrate upon the lowest levels of cognitive functioning. The latter point suggests that a fair test of effects of behavioral objectives upon learning outcomes should include a range of types of cognitive functioning.

Cook[2] investigated the effects on learning and retention of a group of students informed of the behavioral objectives and learning hierarchy of a new unit of instruction and a group of students receiving the same unit of instruction but not so informed of the behavioral objectives or learning hierarchy. Using a sample of elementary education majors in a mathematics course randomly assigned to four treatments, Cook concluded that the data did not substantiate the thesis that informing students of the behavioral objectives and the learning hierarchy enhanced their performance on an achievement test. However, the study did suggest that the instructional method of providing students with statements and examples of the behavioral objectives results in resistance to forgetting based on a two-week retention test of.

Olsen[3] wrote behavioral objectives for a unit of a published science curriculum and provided them to a class of ninth graders. Objectives significantly enhanced achievement and retention although the effects of initial achievement on the retention test were uncontrolled.

A paper presented at the Annual Convention of The National Association for Research in Science Teaching, Chicago, April, 1974.

Stedman[4] considered two sub-problems 1) does the specific form of behavioral objectives effect achievement?, and 2) will the affects of behavioral objectives be differentially effective across levels of knowledge, comprehension, application, and analysis? Stedman concluded that: 1) achievement was not significantly influenced by treatment which varied the nature of the objectives (behaviorally or non behaviorally-stated) received prior to a learning experience with programmed materials, and 2) significant differences were noted between the cognitive levels of comprehension and application. Comparisons of knowledge with comprehension, and application with analysis levels produced no achievement gains. Significant differences found between comprehension and application when no differences were noted between knowledge and comprehension or application and analysis leads to the inference that these levels may demand independent consideration in the cognitive processes involved. Stedman cautioned against generalizing these results beyond highly structured programmed instruction.

Yelon and Schmidt[5] investigated the effects of various combinations of objectives, instructions, and pre-criterion tests on students learning. Seventy-two graduate students were selected for the study. The findings indicated that the presence of objectives negatively affected the learners' ability to produce a specific pattern on a mechanical device with hidden decision rules (Think-A-Dot). They concluded that objectives, when utilized alone rather than in combination with other instructional aids, may indeed hinder learning.

Loh[6] investigated the effects of behavioral objectives upon six criterion variables: index and rate of learning, index and rate of forgetting, index of retention, and index of efficiency. Programmed instructional materials were arranged within the framework of a learning hierarchy and administered to low achieving students in a basic algebra course. It was assumed that the use of the learning hierarchy facilitated a procedure for separating behaviors not yet possessed by a student from behaviors previously acquired. Loh's findings were unable to support the use of behavioral objectives as a procedure for improving either measures of learning or measures of forgetting.

Based on the research reviewed here, it would seem plausible to conclude that behavioral objectives used in coordination with programmed instruction have little impact on learning outcome in typical school learning settings. It is indicated that in some situations behavioral objectives may hinder learning related to non-school tasks. Duchastel and Merrill[7] concluded that neither subject, level of schooling, nor time duration of experiment are capable of discriminating between studies which support or do not support use of behavioral objectives.

Numerous studies support the use of behavioral objectives as an adjunct to learning. Morse and Tillman[8] used undergraduates in an educational psychology course and concluded that objectives: 1) lead to increased achievement of a factual recall nature, and 2) do not constrict <u>Ss</u>' recall of information for which objectives were deleted. They also concluded that training in the proper use of the objectives had no effect upon factual recall.

Carter[9] found that the combination of behavioral objectives before each class and operational definitions afterward resulted in <u>Ss</u>' acquisition of significantly greater numbers of behaviors related to the teaching of elementary mathematics.

The research of Dalis[10] and Nelson[11] also affirm that objectives lead to enhanced achievement.

Statement of the Problem

This experimental research investigated the effect of systematically combined knowledge[12] and higher than knowledge level cognitive objectives upon acquisition of science learning in an inquiry environment rich in potential for higher level cognitive functioning. The evidence gained from these behavioral statements could be used to cross-check subjective judgments about the acquisition of more complex, more generalizable, and higher level goals of learning.[13] Duchastel and Merrill[7] observed that a number of individual differences have been found to interact with objectives. This study hypothesized an interaction between treatment and student facility with process skills. More specifically, the statement of the problem was: What is the effect of behavioral objectives on immediate learning from an inquiry-oriented instructional program which incorporates knowledge and higher than knowledge level cognitive behaviors as defined by Bloom?[12]

Experimental Design

Null Hypotheses

H_1 : There is no significant difference between learners who receive behavioral objectives and those who receive a placebo using the criterion of specific subject matter achievement.

H_2 : There is no significant difference between learners who score low or high on a test of ability to use scientific processes using the criterion of specific subject matter achievement.

H_3 : There is no significant interaction between the treatment conditions (behavioral objectives or placebo) and learner facility with scientific processes using the criterion of specific subject matter achievement.

Treatment

An instructional unit based upon BSCS Inquiry Slides: Structure and Function: Control of Blood Sugar: A Homeostatic Mechanism,[14] was chosen because it includes stimulii for knowledge and higher than knowledge cognitive functioning.

Sixteen knowledge and eight higher than knowledge objectives were developed for the slides.

Examples: Knowledge Level Behavioral Objectives:
Given four percent values the student will select the one that represents the average glucose concentration in the meal.

Examples: Higher than Knowledge Level Behavioral Objective: Given a set of hypotheses the student will select the one which is most likely to account for the difference between the expected curve and the actual curve plotted by the biologist.

The 24 behavioral objectives (16 were knowledge level and 8 were higher than knowledge level objectives) were submitted to a panel of science educators and were judged valid for the research task. A similar procedure was used for criterion test items.

Two weeks prior to the treatment the 40 Ss enrolled in an elementary science methods course in a major Eastern university completed the Process of Science Test (POST).[15] Based on these test scores, Ss were randomly assigned from two class sections to treatment groups in a 2 x 2 design. Control and experimental Ss were included in each section. Prior to the experiment Ss read a passage which contained either behavioral objectives or a placebo (unrelated discussion on a recently developed science curriculum). An experienced biology teacher presented the slides and conducted a discussion according to the suggested guidelines provided by the BSCS Inquiry Slides kit.

Those students receiving the placebo had no special learning guidelines and relied entirely on the Inquiry Slide Set experience. The treatment time consisted of one 75-minute class period. The criterion test was then administered and scores analyzed using a 2 factor unequal-cell ANOVA.

Instruments

The Process of Science Test (POST) was studies as an independent variable because it was felt that its emphasis on scientific process (and higher level thinking skills) made it congruent with the instructional treatment (Inquiry Slides). Students were divided into high and low groups based upon a median split. Those students scoring above 19 were assigned to the high group. Students scoring below 19 were assigned to the low group.

The criterion test was constructed for this study to evaluate the combined effect of both low and high level cognitive achievement based on the concepts developed in the BSCS Inquiry Slide program. The instrument had a total of 32-items and total KR-21 test reliability of .77 in a pilot study. The test was a criterion referenced instrument; its reliability was estimated using norm referenced assumptions. The cognitive level of the knowledge and higher than knowledge level test questions were verified by a panel of science educators. The test was designed with 16 knowledge level cognitive questions ($r = .65$) and 16 higher than knowledge cognitive level questions ($r = .60$).

Findings

The hypotheses that the experimental and control groups were randomly selected from the same population was rejected. ($F = 4.7, p < .05$) The groups which received the behavioral objectives scored significantly higher than the control group on the criterion test. The ANOVA summary table and group means are listed in Table 1 and 2 respectively.

Insert Table 1 about here

Insert Table 2 about here

The hypothesis that the high and low scorers on POST were randomly selected from the same population was also rejected. The high group on the POST earned significantly higher scores ($F = 12.4$, $p < .01$) on the criterion test than the low scorers.

No significant interaction between treatment and process skill was observed.

Discussion

The results of this study suggest that under inquiry-oriented instructional sequences which are designed to elicit both knowledge and higher than knowledge cognitive functioning, the use of behaviorally-stated learning outcomes facilitates immediate learning. An additional conclusion is that facility with scientific process skills enhanced achievement from inquiry-oriented biological science materials.

These results seem to support the findings of Olsen,[3] Morse and Tillman,[8] Carter,[9] Dalis,[10] and Nelson[11] on immediate learning and retention; however, they do not support the findings of Cook[2] on immediate achievement. This discrepancy may have resulted from Cook's using objectives in conjunction with a learning hierarchy which may have confounded the issue. The findings of Yelon and Schmidt[5] and Loh[6] are also refuted in this study based on immediate learning outcomes.

Several explanations for the discrepancies lie in the intricate designs used in research. Behavioral objectives are indeed different in the mind of the researchers and can be stated in specific, general, behavioral, non-behavioral, or process oriented terms. Some are simply presented to the learner at a low cognitive level (knowledge) while others are complex and written at a higher cognitive level (higher than knowledge) systematically designed in congruence with the learning task. Some studies use programmed materials and others use non-programmed instructional units. With such research variation, implications must be cautiously interpreted when evaluating the effects of behavioral objectives on learning outcomes.

This study reinforces the assumption that objectives enable learners to retain essential points and to organize complex cognitive processes needed for successful inquiry-oriented learning experiences. The degree of facilitative effect objectives provide is probably directly related to the quantity and quality of the learning material with which the student must deal.

In conclusion it seems likely that serious consideration should be given to the role of objectives in science learning where high and low level cognitive objectives are involved. Further research to investigate the independent and joint contribution of objectives to immediate and delayed learning of science seems to be warranted. Research should also be concerned with the identification of those subgroups of learners for whom behavioral objectives are maximally and minimally effective.

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TABLE 1

Unequal Cell Analysis of Variance on Achievement

Source	D. F.	Sum of Squares	Mean of Squares	F-ratio
Treatment (A)	1	83.0	83.0	4.7*
POST (B)	1	218.3	218.3	12.4**
Error	37	653.0	17.6	
S. D.	4.2			

* p> .05
** p>>.01

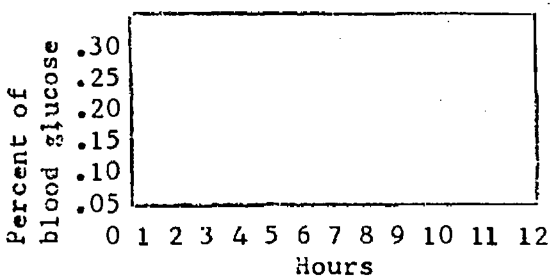
TABLE 2

Group Means and Cell Size

		Objectives	
	Source	Experimental (A)	Control (B)
POST	Hi	X = 24.6 N = 12	X = 21.1 N = 10
	Lo	X = 19.3 N = 10	X = 17.1 N = 8

SLIDE 15-3 | BEHAVIORAL OBJECTIVES | CRITERION TEST QUESTIONS

Before the meal, blood samples taken from large arteries showed an average glucose concentration of 0.09%.



Show on the graph what you would expect if samples were taken every hour after the meal.

The following paragraphs describe the behavioral objectives THE STUDENT IS SUPPOSED TO REACH AFTER HAVING SEEN SLIDE 15-3.

1- Given four percent values the student will select the one that represents the average glucose concentration in the large arteries of the animals before the meal.

2- Given four groups of two variables including independent and dependent variables, the student will select the pair that represents the independent and dependent variables shown in the graph (Slide 15-3).

10- Which of the values below represents the exact value of the average glucose concentration in the large arteries of the animals measured before the meal?
- a) 0.900%
- * b) 0.090%
- c) 0.009%
- d) 9.000%

11- Which of the pairs below represents the independent and dependent variables in this order?
- a) Percent of blood glucose and time past after the meal.
- b) Number of muscular activity and percent of blood glucose
- c) Time interval in seconds and volume of glucose
- * d) Time interval in hours percent of blood glucose

The following paragraphs describe the behavioral objectives the students are supposed to reach after having seen slide 15-3.

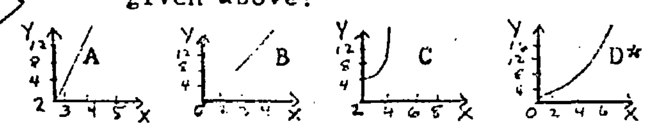
1- Given a set of data composed of two variables X and Y, their respective assumed values, and four graphs the student will choose the graph that better represents the set of data.

2- Given four graph lines the student will choose the one that better represents independence of variable X on variable Y.

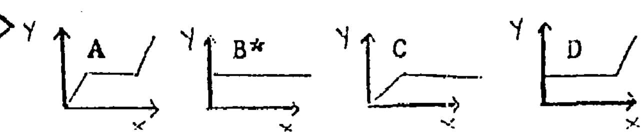
17-

X	2	3	7
Y	4	9	49

Which graph better represents the data plot in the table given above?



18- Select the graph that represents independence of variable Y on X.



Supplement to Anderson, DeMelo, Szabo, Toth Study, NARST 1974.

FLOWCHART OF ANDERSON, DEMELO, SZABC, TOTH STUDY: NARST 1974