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ABSTRACT

This study examined the effect of formal and concrete instruction upon science achievement and intellectual development of sixth grade students. Formal instruction, which emphasized oral and written language, included lecture, discussion, oral quizzes, written assignments, reading assignments, films, film strips, written tests, and quizzes. Students receiving formal instruction did not perform any laboratory investigations and did not manipulate science apparatus. Concrete instruction was organized around the three-phase learning cycle approach (exploration, conceptual invention, and discovery) and emphasized hands-on activities. Although the two treatment groups seemed not to differ in science achievement or cognitive development at the onset of the study, after a 9-month period, the concrete instruction group (N=57) scored higher in science achievement, delayed science, and cognitive development than the formal instruction group (N=58). Also, the percentage of students advancing from concrete to "transitional reasoning" was greater in the concrete instruction group than in the formal instruction group. These results are consistent with previous studies and add to the increasing body of evidence which points out the importance of hands-on science instructional activities in promoting intellectual development and science achievement. (JN)

A COMPARISON OF CONCRETE AND FORMAL SCIENCE INSTRUCTION UPON SCIENCE ACHIEVEMENT AND REASONING ABILITY OF SIXTH GRADE STUDENTS

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A long standing issue in science education involves the pedagogical purpose of laboratory instruction in the science programs of schools. Because laboratory instruction is a costly endeavor both in terms of fiscal resources and human resources, many educators have questioned its benefits.

In recent decades a growing body of educational literature suggests that science laboratory activities, or more generally "hands-on" activities, may play a role in two important educational outcomes, namely science achievement and cognitive development, at least for cases in which students are reasoning at a concrete level. It is important to note however, that not just any hands-on activity or laboratory instruction seems to enhance these two outcomes but rather a carefully planned sequence of instructional activities which generally proceed from rather loosely structured "exploratory" to more structured "verification" or "concept application" activities.

Several studies seem to suggest that this general approach, known as "concrete instruction" or "the learning cycle", is particularly effective in promoting gains in both achievement and cognitive development, especially for concrete learners (Linn and Thier, 1975; Purser and Renner, 1983; Schneider and Renner, 1980; Sheehan, 1970; Wollman and Lawson, 1978).

PURPOSE

This present study examined the effect of concrete and formal instruction upon science achievement and intellectual development of sixth grade students.

DESIGN

The study employed a pretest-posttest control group design. Four out of five intact classes of sixth grade students were randomly selected into two treatment groups; formal instruction and concrete instruction.

DESCRIPTION OF TREATMENTS

These treatments have been described by Schneider and Renner (1980). Formal instruction consisted of an emphasis upon oral and written language. Formal instructional activities included lecture, discussion, oral quizzes, written assignments, reading assignments, films, film strips, written tests and quizzes. It is important to emphasize that students in the formal instruction group did not perform any laboratory investigations and did not manipulate science apparatus. The concrete instruction was organized around the learning cycle approach and involved an emphasis upon hands on activities. The approach is described as consisting of three phases which are: exploration, conceptual invention, and discovery. During the exploration phase the students are involved in exploratory hands-on laboratory activities related to the concept under study. The concrete activities include observation, measuring, experimenting, interpreting, and predicting. Written instructions were provided to assist students in their interactions with the concrete materials, but no information concerning the concept being studied was provided during the exploration phase and a deliberate attempt was made to encourage students to explore materials and ideas with "minimal guidance or expectation of specific accomplishments" (Karplus, 1979). The conceptual invention phase consisted of teacher led discussions about the concrete activities of the exploration phase. The discussion can be described as "guided discovery" and culminated with explication of the concept.

The discovery phase follows the conceptual invention and expands the concept through further experimentation, discussion, reading, and audiovisual materials.

The investigation was conducted from August 22, 1982 to May 24, 1983.

All class periods were 45 minutes long and students followed the same class schedule Monday through Friday. Pretest and posttest measures were administered for the two dependent variables; reasoning, measured with Lawson's Classroom Test of Formal Reasoning (1978), and science achievement, measured with seven teacher made tests covering the following units in a sixth grade general science curriculum: Chemistry, Physics, Earth Science, Cells, Plants, Animals, and Ecology. Additionally, the seven unit tests were administered later as a delayed posttest in order to investigate retention.

RELIABILITY

Kuder-Richardson formula 20 gave a reliability estimate of .88 for science achievement and .63 for cognitive development.

FINDINGS

On the pretest of science achievement the means and standard deviations were respectively; concrete instruction 38.7 and 5.9; formal instruction 36.6 and 8.3. A t-test, for independent samples, of the null hypothesis or the pretest means was not significant at the .10 level; suggesting that the two treatment groups did not differ on the pretest. The alpha level of .10 was used in order to increase the chances of detecting a difference, if in fact there was one ie. decreasing the chance of making a type II error. (p. 162, Ferguson, 1976)

On the immediate posttest of science achievement the means and standard deviations were respectively; concrete instruction 69.3 and 4.3, formal instruction 60.8 and 3.9. The t-test was significant at alpha = .01, suggesting that the two groups differed on the posttest. On the delayed posttest of science achievement the means and standard deviations were

Table I about here

respectively; concrete instruction 58.9 and 4.2, formal instruction 53.2 and 3.8. Again the t-test was significant at alpha = .01, suggesting that the two groups differed on the delayed posttest.

On the pretest of cognitive development the means and standard deviations

Table 2 about here

were respectively; concrete instruction 2.2 and 1.9, formal instruction 2.2 and 1.7. A t-test of the null hypothesis for the means was not significant at the .10 level; suggesting that the two treatment groups did not differ on the pretest. On the posttest of cognitive development the means and standard deviations were respectively; concrete instruction 4.8 and 3.1, formal instruction 3.1 and 2.8. Again the t-test was significant at the .01 level suggesting that the two treatment groups differed on the posttest of cognitive development. A more detailed analysis of the posttest findings revealed a differential shift in the distribution of reasoning across the two treatment groups. Table three shows the numbers and percentages of students in each of the three catagories; concrete, transitional, and formal; at the beginning and end of the study. In the formal instruction group the percentage who were transitional reasoners increased from 10% to 21% during the course of the study, while in the concrete instruction group this percentage increased from 2% to 37%.

Table 3 about here

In summary, at the outset of the investigation, the two treatment groups seemed not to differ in science achievement or cognitive development. Upon completion of the treatments, a period of nine months, the concrete instruction group scored higher in science achievement, delayed science achievement and cognitive development than the formal instruction group, and the percentage of students advancing from concrete to "transitional reasoning" was greater in the concrete instruction group than in the formal instruction group.

These results are consistent with the studies mentioned above and add to the increasing body of evidence which points to the importance of hands-on science instructional activities in promoting intellectual development and science achievement.

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TABLE 1

A comparison between the concrete instruction group and the formal instruction group on science achievement.

	Concrete Instruction n=57		Formal Instruction n=58		T-Test
	Mean	S.D.	Mean	S.D.	
Pretest	38.7	5.9	36.6	8.3	0.55
Posttest	69.3	4.3	60.8	3.9	4.00 *
Delayed Posttest	58.9	4.2	53.2	3.8	2.71 *

* significant at alpha = .01

TABLE 2

A comparison between the concrete instruction group and the formal instruction group on cognitive development.

	Concrete Instruction n=57		Formal Instruction n=58		T-Test
	Mean	S.D.	Mean	S.D.	
Pretest	2.2	1.9	2.2	1.7	.00
Posttest	4.8	3.1	3.1	2.8	3.40 *

* = significant at alpha = .01

TABLE III

Distribution of percentages across reasoning levels for concrete and formal instruction on pretest and posttest.

	Reasoning Level		
	Concrete	Transitional	Formal
Concrete Instruction (n=57)			
Pretest	96%	2%	2%
Posttest	61%	37%	2%
Formal Instruction (n=58)			
Pretest	90%	10%	0%
Posttest	79%	21%	0%