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ABSTRACT

This 10-day study compared the effects of alternative ways of using microcomputer simulations on the achievement and attitudes of sixth- and seventh-grade science students (N=173). Nine classes were randomly assigned to one of four treatments: (1) microcomputer simulations; (2) laboratory activities; (3) a combination of simulation and laboratory activities; and (4) conventional instruction. Topics covered during lessons included the process skills of observing, hypothesizing, testing, classifying, and recording data. Simulations were completed as a class with the teacher operating the microcomputer and simulation programs. Students worked in groups of two or three during laboratory activities. Simulations were presented prior to activities in the combination treatment. Results show: that simulations, activities, and combination of these two instructional strategies results in higher achievement than conventional instruction; no achievement or attitude differences among groups receiving computer simulations, laboratory activities, or a combination of the two; and no attitude differences among the four groups. Other findings show: that students at the high and middle levels of logical reasoning ability out-achieved students at the low level of logical reasoning ability; no differences in attitudes among these three groups; and the effects of alternative instructional strategies to be consistent across levels of logical reasoning ability. (Author/JN)

Effects of Microcomputer Simulations on Achievement and Attitudes of Middle School Students

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Purpose of Study

The purpose of this study was to compare the effects of alternative ways of using microcomputer simulations on the concept identification achievement and attitudes toward computers and science instruction of middle school students. The instructional treatments compared were computer simulation only, laboratory activities only, a combination of simulation and laboratory activities, and conventional classroom instruction (See Figure 1) .

Theoretical Basis for Study

Computer-assisted instruction (CAI) has been defined as using computer technology and applying it to educational/training processes (Burns and Bozeman, 1981). CAI helps students obtain, review, and apply knowledge through one or a mixture of several modes that include tutoring, drill and practice, problem solving, gaming, simulation, inquiry, and dialogue (Dence, 1980).

In general, student experience with CAI leads to an improvement in achievement and positive attitudes towards learning (Hallworth and Brehner, 1980). In a review of CAI studies, Burns and Bozeman (1981) reported gains in achievement when CAI was used in conjunction with traditional classroom instruction.

Generally simulations are designed for acquiring skills, problem solving, or obtaining concepts. Simulations enable students to focus their attention on common parts of concepts. For some students, using simulations results in a moderate attitude change. This change has been attributed to several factors such as increased tolerance for fellow students, sensitivity to other's needs, and increased peer and teacher interactions (Shay, 1980). Recent research (eg., Marks & Bartholomew, 1981; Shaw, Waugh, and Okey, 1984; Wise, 1983) revealed favorable student responses toward the use of microcomputers, CAI, and simulations.

A factor closely associated with the attainment of science concepts is the level of the students' cognitive development. Children in middle schools are most often classified as concrete operational and as a result they solve logical problems through direct experiences. Although there is little reported research dealing with various levels of cognitive development and microcomputer simulations, it is logical for high cognitive level students to score high on performance tasks which involve simulations as an instructional strategy.

Procedure of the Study

Students enrolled in sixth and seventh grade at an intermediate school in rural northeast Georgia during the 1983-84 school year were subjects in this study. Six science classes from two teachers were assigned to three treatment groups. Students for the comparison group were from other science classes not involved in treatments. In addition, the comparison group was composed of students from English and Social Studies classes taught by the third teacher.

The students were evaluated for their levels of logical reasoning ability. Students were stratified into three levels of logical reasoning ability labeled as low, middle, and high. The score on the Group Assessment of Logical Thinking (GALT), developed by Roadrangka, Yeany, and Paddilla (1982), was used to assess student logical reasoning ability.

Concept identification achievement was measured following treatments involving computer simulations, laboratory activities, simulations plus laboratory activity, and conventional classroom instruction. Concept identification achievement was measured with a 30-item, multiple-choice instrument. The 30 items were keyed to the instructional objectives in the study. The reliability estimate of the test was .67, using Cronbach's alpha

(Nie, Hull, Jenkins, Steinbrenner, and Bent, 1975), based on scores resulting from this study.

Attitudes toward computers and science instruction were measured at the completion of the various treatments. The attitude measure consisted of a pool of 33 Likert scale items. Students from all four groups responded to 20 of the items. In addition, subjects in each of the groups responded to special items which were related only to the instructional treatment in which they were participants. The relability of the 20-item attitude measure (Cronbach's alpha) was .56.

Subjects experienced the use of four microcomputer presented science process skill simulations as the teaching strategy. The four simulations selected were: "Gertrude's Puzzles," "Gertrude's Secrets," " Moptown Parade," and "Moptown Hotel" (The Learning Company, 1982).

The laboratory activity materials were from the ESS (Elementary Science Studies, 1968) series. The activities were from the Attribute Games and Problems which included "A Blocks," "Color Cubes," "People Pieces," and "Creature Cards."

Both the computer simulations and laboratory activities provided students with experience in observing, classifying, ordering, hypothesizing, and testing. In addition, both were designed to enable students to develop abstract thinking, logical thinking, use of strategy, and problem-solving skills.

In the computer simulation treatment group, teachers controlled the tempo and direction of the lesson by running the microcomputer. A total of 24 simulations were completed. In the laboratory activity treatment group, students were broken into groups of two or three. Teachers managed students by introducing the concepts before each activity and circulating among the groups to help students remain on task. A total of 40 laboratory activities were completed.

In the combination treatment g up, computer simulations were presented first followed by an appropriately selected laboratory activity. Approximately equal time was devoted to computer or laboratory activites on each day of the treatments. Students completed approximately 12 simulations and 27 related activities selected from among those used in the simulation only and laboratory only groups. A complete listing of all simulations and laboratory activities are found in the Appendix.

Final test questions were keyed to the objectives and were broken into subscales (definition, attributes, values, classification, and rule determination) for further analyses. Analysis of covariance procedures, with mathematics scores from the California Achievement Test as the covariate, were used to identify main and interaction effects on achievement and attitude scores. Sample test items for each subscale are found in the Appendix.

Results

Analysis of variance and covariance procedures were applied to the 4x3 (treatment by levels of logical reasoning ability) fixed factor design specified for this study. The covariate used in the analysis of covariance procedure was the score from the mathematics portion of the California Achievement Test. No _a prioi_ levels of significance were specfied. The SPSS program (Nie et al., 1975) was selected for analysis of data gathered in this study. The Newman-Keuls multiple comparision procedure was used to test pairwise contrasts.

Analyses revealed a significant effect of instructional treatments on achievement of middle school students. Multiple comparison procedures indicated that the three groups receiving instructional treatments performed significantly better on the achievement measure than the comparison group (See Table 1).

Analyses of concept identification subscales indicated significant treatment effects on definition, attributes, and values. In each analysis, instructional treatment groups did significantly better than the comparison group. The values subscale revealed significant differences between the combination and simulation groups and between the combination and comparison groups. No significant differences between the instructional treatments occurred on the classification and rule determination subscales (See Figure 2).

A significant relationship between logical reasoning ability and concept identification achievement was revealed. Multiple comparison procedures indicated that the high group performed significantly better than the middle and low groups.

A significant relationship was revealed between concept identification and logical reasoning ability on the subscales for values, classification, and rule determination. In the classification, values, and rule determination groups, significant differences occurred between the high and both middle and low groups (See Figure 3).

Analyses revealed no significant effects of instructional treatments on attitudes toward computers and science instruction. In addition, no significant relationships occurred between logical reasoning ability and attitudes towards computers and science instruction nor were any significant interactions found between levels of logical reasoning ability and levels of instructional treatment.

Implication for Teaching Science

Results of this study indicated that the three instructional approaches to concept identification instruction examined (simulation only, laboratory activity only, or combination simulation and laboratory activity) were equally effective for teaching concept identification skills to middle school students. If the sole objective is to introduce concept identification skills, perhaps the simulation approach is the method of choice. Factors such as laboratory equipment, space, and management of hands-on activities do not pose a problem when using computer simulations. If on the other hand, the overall objectives of the science program include mastery of skills, such as classifying and ordering objects, instruction that includes activities would be the choice. In addition, less incidential learning would probably occur during instruction using computer simulations because students have no opportunity to interact with materials on their own.

Students having trouble mastering certain skills or science concepts might benefit from instruction using both computer simulations and laboratory activities. The computer simulations and hands-on activities may reinforce learning which might occur.

Generally students involved in studies in which computer simulations were compared against conventional classroom instruction have indicated positive attitudes toward computers and simulations. This study fails to support this position. It is possible that a two-week study cannot influence the attitudes of students towards computers and science instruction especially in a school where computers were not a novelty.

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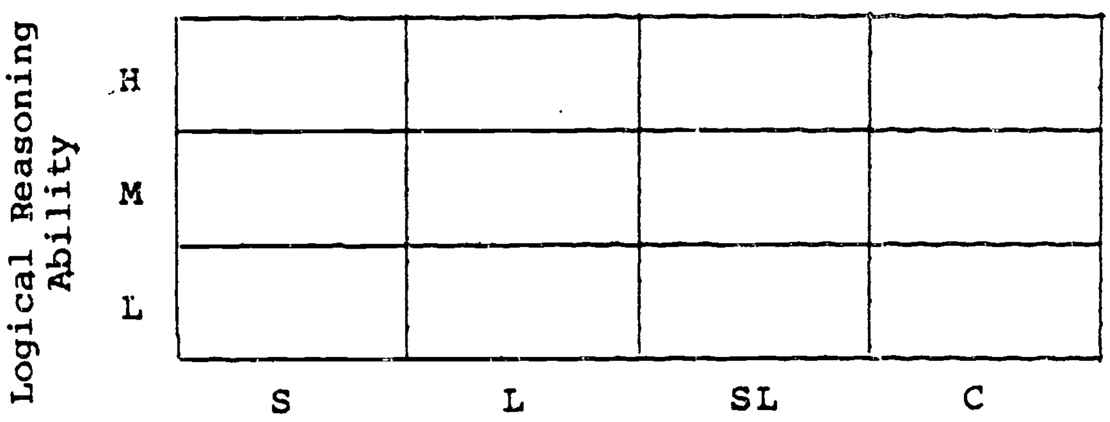


Instructional Strategy

4x3 Design

Logical Reasoning Ability

H = High

M = Middle

L = Low

Instructional Strategy

S = simulation approach

L = laboratory activity

SL = combination of two

C = comparison group

Figure 1. A 4x3 factorial design to study the effects of the use of microcomputer simulations on concept identification achievement and attitudes toward computers and science instruction of middle school students of various levels of logical reasoning ability.

Measure	Group Means			
Concept Identification Achievement	$\bar{X}_C$	$\bar{X}_S$	$\bar{X}_L$	$\bar{X}_{SL}$
Concept Identification Subscales				
Definition	$\bar{X}_C$	$\bar{X}_L$	$\bar{X}_S$	$\bar{X}_{SL}$
Attributes	$\bar{X}_C$	$\bar{X}_{SL}$		$\bar{X}_S$
Values	$\bar{X}_S$	$\bar{X}_C$	$\bar{X}_L$	$\bar{X}_{SL}$
Classification	$\bar{X}_C$	$\bar{X}_S$	$\bar{X}_{SL}$	$\bar{X}_L$
Rule Determination	$\bar{X}_C$	$\bar{X}_L$	$\bar{X}_{SL}$	$\bar{X}_L$
Attitudes	$\bar{X}_C$	$\bar{X}_S$	$\bar{X}_L$	$\bar{X}_{SL}$

*Any means not underscored by the same line are different (alpha = .05).

Note:
S = Simulation
L = Laboratory
SL = Combination of the two
C = Comparison Group

Figure 2: Multiple Comparison Summary of Treatment Effects on Concept Identification Achievement and Attitudes.*

Measure	Group Means		
Concept Identification Achievement	$\bar{X}_M$	$\bar{X}_L$	$\bar{X}_H$
Concept Identification Subscales			
Definition	$\bar{X}_L$	$\bar{X}_M$	$\bar{X}_H$
Attributes	$\bar{X}_H$	$\bar{X}_M$	$\bar{X}_L$
Values	$\bar{X}_M$	$\bar{X}_L$	$\bar{X}_H$
Classification	$\bar{X}_L$	$\bar{X}_M$	$\bar{X}_H$
Rule Determination	$\bar{X}_L$	$\bar{X}_M$	$\bar{X}_H$
Attitudes	$\bar{X}_L$	$\bar{X}_M$	$\bar{X}_H$

*Any means not underscored by the same line are different (alpha = .05).

Note: L = Low
M = Middle
H = High

Figure 3: Multiple Comparison Summary of the Relationship of Logical Reasoning Ability to Concept Identification Achievement and Attitudes.*

Table 1

Analysis of Covariance Summary Table for Concept Identification Achievement

Source of Variation	d.f.	Mean Square	*F*	*P*
Treatment	3	64.57	7.30	.001
Logical Reasoning Ability	5	50.46	5.71	.004
Treatment X Logical Reasoning Ability	6	9.266	1.05	.396
Residual	160	8.84		

Appendix

List of Daily Activities

	Simulation	Laboratory Activity	Simulation and Laboratory Activity	Comparison Group
Day 1	Moptown Parade Make My Twin What's the Same? Moptown Hotel Spot Me	A Blocks Cards 4-7	Moptown Parade What's the Same? Who Comes Next? A Blocks Cards 4 & 5	Balancing Chemical Equations
Day 2	Moptown Parade Who's Different? Who Comes Next? Moptown Hotel Change Me	A Blocks Cards 17 & 25	Moptown Hotel Change Me A Blocks Cards 6 & 7	Balancing Chemical Equations
Day 3	Gertrude's Secrets Trains (1 & 2) Gertrude's Puzzles Network Puzzles (1)	Color Cubes Cards 7 & 12 People Pieces Cards 3 & 4	Moptown Parade Moptown Parade People Pieces Cards 3 & 4	Balancing Chemical Equations
Day 4	Gertrude's Secrets Trains (3) Gertrude's Puzzles Network Puzzles (2)	A Blocks Cards 31 & 32 Cards 36-38	Gertrude's Puzzles Box Puzzles (1 & 2) A Block Cards 36-38	Balancing Chemical Equations
Day 5	Review of Day 1 to Day 5	Color Cubes Cards 1-4 Cards 13 & 14	Gertrude's Secrets Arrays (1 & 2) Color Cubes Cards 13 & 14 People Pieces Card 8	Balancing Chemical Equations
Day 6	Gertrude's Puzzles Box Puzzles (1 & 2) Gertrude's Secrets Arrays (1 & 2)	People Pieces Cards 5,8,11, and 13	Gertrude's Puzzles Loop Puzzles A Blocks Cards 2 & 25	Identifying acid and base
Day 7	Moptown Hotel Whose Birthday? Secret Pal Moptown Parade Moptown Parade	A Blocks Cards 24 & 24 Creature Cards Cards 1 & 2	Moptown Parade Clubhouse Creature Cards Cards 1-5	Identifying acid and base

	Simulation	Laboratory Activity	Simulation and Laboratory Activity	Comparison Group
Day 8	Gertrude's Secrets Loops (1 & 2) Gertrude's Puzzles Loop Puzzles (1 & 2)	Creature Cards Cards 3-8	Moptown Hotel Secret Pal Creature Cards 6-10	Identifying acid and base
Day 9	Moptown Hotel Moptown Hotel Moptown Parade Clubhouse	Creature Cards Cards 9-15	Creature Cards 11-15	Identifying acid and base
Day 10	Testing	Testing	Testing	Testing

Concept Identification Subscales
Test Items

Subscale Definiton

16. Which of the following is the correct definition of an attribute?

*A. General characteristic of an object or person
B. Specific characteristic of an object or person
C. Neither A or B
D. Both A and B

Subscale Attributes

17. Which of the following are examples of an attribute?

A. water, snow, ice
*B. color, shape, size
C. grass, trees, bushes
D. cats, dogs, fish

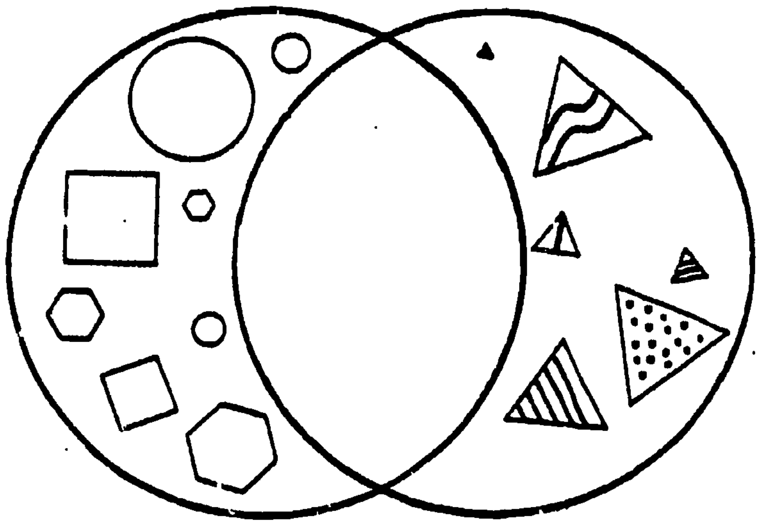
Subscale Values

Below are several objects:

18. which of the objects is large and <u>not</u> striped?

A. a
*B. b
C. c
D. d

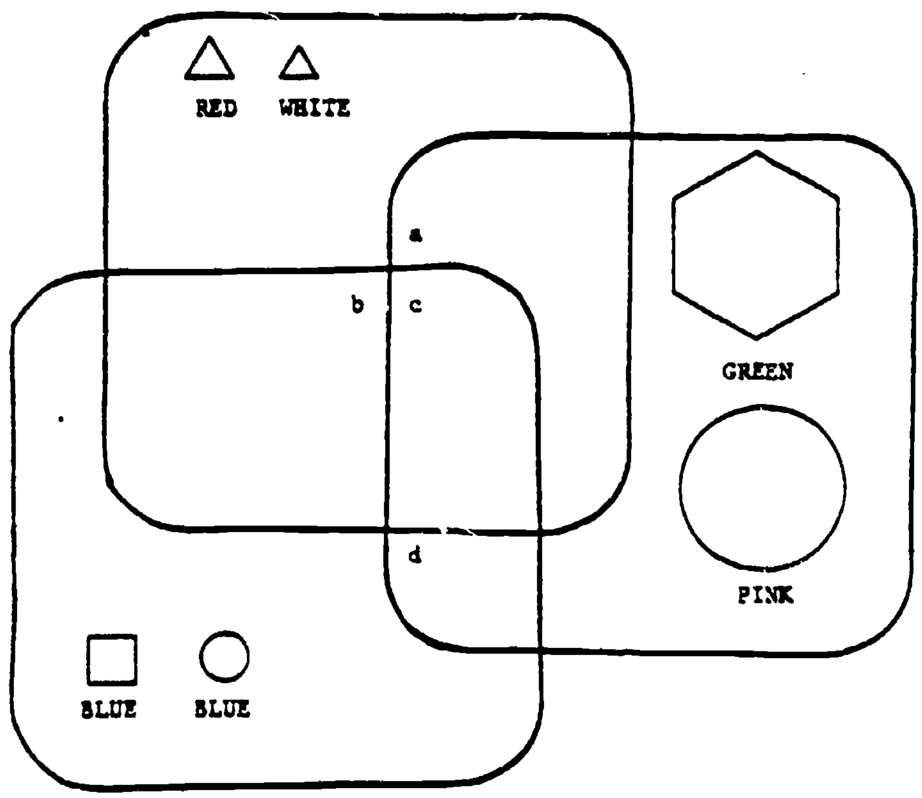
Subscale Classification



19. Why would a large white triangle be placed in the overlapping area?

A. Because it is white
B. Because it is large
C. Because it is a large object and is white
*D. Because it has three sides and is white

Subscale Rule Determination



24. Within which area would a large blue triangle be placed?

A. a
B. b
*C. c
D. d

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