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AUTHOR Henson, Stanley
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ABSTRACT

Three studies are reported for children participating in the Elementary Science Study (ESS) program. They are the cognitive and affective performances and the classroom learning environment. Three groups of ESS children were evaluated: nine-year-olds, ten-year-olds, and eleven-year-olds. Each age group contained 30 randomly selected subjects. The hypothesis was tested by a pre- and post-test treatment. The results revealed in this study were (a) nine-year-olds increased their achievement in knowledge, comprehension, and application of science; ten-year-olds increased in knowledge and comprehension; and eleven-year-olds increased in comprehension; (b) all three groups showed no significant gains in their attitudes toward science; (c) no change was shown in the classroom learning environment in competitiveness, difficulty, cohesiveness, and satisfaction. However, classroom friction increased. Implications of the findings show that children can make significant achievement in the ESS program. Evidence from the classroom learning environment suggests that the ESS provides opportunity for creativity. (Author)

A STUDY OF THE COGNITIVE AND AFFECTIVE PERFORMANCE OF CHILDREN IN THE ELEMENTARY SCIENCE STUDY PROGRAM

Stanley Henson, Arkansas Tech

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BY

STANLEY HENSON

INTRODUCTION

Probably one of the most neglected subject areas in the elementary school has been in elementary science education. Thus, the National Science Foundation has provided funds for the development of several programs in science for elementary children. One of the programs has been adopted by Sequoyah Elementary School in Russellville, Arkansas. The program that has been implemented is the Elementary Science Study (ESS) which was developed by the Educational Development Center in Newton, Massachusetts. The primary advantage of the ESS program is that it has been field tested throughout the United States; however, it is a new program and not much research has been done to investigate the cognitive and affective performance of children in the Elementary Science Study program.

ESS is one of the most recognized elementary science curricula because of its inquiry approach in learning science. Although the ESS curriculum does not emphasize cognitive growth as a primary factor in elementary science, it has been of considerable interest to some science educators to see if ESS students can maintain any significant gains in science achievement. ESS emphasizes the exploratory aspects of learning science through informal and open-ended investigations; it is concerned with the style of teaching, classroom environment, and attitudes of children. Therefore, its primary concern is working with children in developing their affective performance in the classroom.

STATEMENT OF THE PROBLEM

This paper proposes to investigate the cognitive and affective performance of children in the Elementary Science Study program. In order to evaluate the program, the objectives in the study are the following:

(1) to measure a significant difference in the science achievement of three age groups of elementary children participating in the Elementary Science Study program

(2) to measure a significant difference in the science attitudes of three age groups of elementary children participating in the Elementary Science Study program

(3) to measure a significant difference in the social classroom climate of three age groups of elementary children participating in the Elementary Science Study program

Therefore, the problem in this study consists of three criteria. First, is there any significant difference in children's science achievement in the ESS program? Second, does the ESS program show any significant difference in the children's attitude toward science? Third, is there any improvement in the social climate of the classroom in the ESS program?

DELIMITATIONS

The subjects involved in this study will consist of elementary school children of ages nine to eleven. The children will come from the small town community of Russellville, Arkansas. The subjects will be randomly selected ESS participants in Sequoyah Elementary School, a nongraded school.

DEFINITION OF TERMS

Attitude (Non-Verbal) - Pupil's attitude toward science. This attitude scale was given to the pupils as a written test. (Affective)

Attitude (Verbal) - Deals with the pupil's attitude toward science. This attitude scale was given to the pupils orally. (Affective)

Application - Consists of the ability to apply scientific principles to actual situation. (Cognitive)

Competitiveness - A central concept in group dynamics. The extent to which pupils consider class rivalry.

Cohesiveness - This property separates members of the group from non-members.

Comprehension - Consists of the ability to put science communications into another form, to comprehend interrelationships, and to go beyond science data to implications of major ideas. (Cognitive)

Difficulty - Consists of the measurement of the difficulty of cognitive learning in the classroom.

Friction - Measures from the pupils viewpoint essentially three observational categories , "shows disagreement", "shows tension", and "shows antagonism" of the interaction process. Friction means that certain students are considered uncooperative in class.

Knowledge - Measures the pupils recall of science materials to which they were previously exposed in the classroom. (Cognitive)

Satisfaction - Whether or not pupils are well-satisfied with the work of the class.

METHOD OF PROCEDURE

Subjects and Experimental Design - This study was conducted in Sequoyah Elementary School in Russellville, Arkansas. Ninety subjects were engaged in the evaluation program. The subjects were randomly selected and classified in

three groups by age: nine, ten, and eleven years old. There were thirty subjects in the nine year old age group, and thirty subjects in the ten year old age group, and thirty subjects in the eleven year old age group.

Analysis of the differences among the three different groups was completed by two statistical procedures, the t-test and the analysis of variance. The three age groups were pre-tested and post-tested in science achievement, science attitudes, and classroom environment. In order to examine these three factors the t-test for related samples was used. In this manner, the degree of consistent differences between the ESS students pre-test and post-test scores can be measured by the t-ratio. The advantage of this statistical technique gives the investigator the magnitude and direction of the repeated measure. By using the difference between the pre- and post-test, the investigator also eliminated variations between the students and only considers the differences in the pre- and post-scores.

The single analysis of variance was used to measure the difference in the nine, ten, and eleven year olds in science achievement, science attitudes, and classroom climate. The advantage of the single analysis of variance is that it can be used for all three age groups simultaneously, and that an F-ratio can show any variances between the three groups. In order to find where the significant differences between the three groups the Scheffe test was implemented.

Procedure - The pre-tests were administered to 30 nine year old students, 30 ten year old students, and 30 eleven year old students. The pre-testing was conducted at the beginning of the school year. Post-testing was administered during the last week of April. Thus, eight months lapsed before the post-testing was administered to the same group of subjects that were pre-tested. The groups were administered the science achievement, science attitude, and classroom environment examinations simultaneously during pre-testing and post-testing.

Instruments - The subjects' science achievement was measured by the STEP II science achievement test, form 4A. The same form of the science achievement test was administered in the post-testing because the eight month interval period allowed no overlap.

The attitude of the children toward science was measured by the Semantic Differential Scale adapted for the American Association for the Advancement of Science. The attitude scale was the same test administered in pre- and post-testing.

The classroom climate was measured by the Learning Environment Inventory. The instrument yields fourteen factor analytically derived cluster scores which, for individuals, range in corrected split-half reliability from .41 to .86. The Learning Environment Inventory was administered as a pre-test and as a post-test. The same test form was used in both testing procedures. The factors under investigation of the classroom climate scale were friction, satisfaction, cohesiveness, competition, and difficulty.

RESULTS

The cognitive development of the three age groups is summarized in Table 1. The nine year olds made significant gains in knowledge, comprehension, application, and total science achievement. The ten year olds made significant gains in knowledge, comprehension, and total science achievement. The eleven year olds made significant gains only in the area of comprehension of science.

TABLE 1

Pre- and Post-Test t-Scores for the Three Age Groups in Science Achievement

	9 Year Olds	10 Year Olds	11 Year Olds
Knowledge	4.92*	3.80*	1.53
Comprehension	3.83*	3.17*	2.08*
Application	5.19*	0.77	0.44
Total Science Achievement	6.30*	2.73*	0.58

* $p < .05$

The affective performance of the three age groups was a measure of attitude by the semantic differential. Table 2 recognizes a significant difference in the t-scores of the 10 and 11 year old pupils on the pre- and post-test scores of their verbal attitude scale. There was no significant difference in the non-verbal attitude scale of all three age groups.

TABLE 2

Pre- and Post-Test t-Scores for the Three Age Groups in Attitudes Toward Science

	9 Year Olds	10 Year Olds	11 Year Olds
Attitude (Verbal)	-1.48	-2.30*	-3.43*
Attitude (Non-Verbal)	0.87	-0.08	-0.31

*$p < .05$

Table 3 describes the t-scores for the three age groups in their classroom learning environment pre- and post-test scores. Only friction in the three age groups was measured significant.

TABLE 3

Pre- and Post-Test t-Scores for the Three Age Groups in Classroom Learning Environment

	9 Year Olds	10 Year Olds	11 Year Olds
Competitiveness	0.96	-0.36	0.33
Friction	2.19*	3.64*	1.76*
Difficulty	1.45	-1.40	1.44
Cohesiveness	1.59	-0.64	0.89
Satisfaction	-1.18	-0.34	0.44

*$p < .05$

Tables 4 through 17 indicate the results from the one-way analysis of variance on the three age groups. The F value is given for each factor in the cognitive, affective, and learning environment categories. The F value is used to identify any significant variation between the age groups.

Tables 4 through 8 reveal any significant difference in the three age groups in their Classroom Learning Environment.

TABLE 4

Analysis of Variance for Three Age Groups in Competitiveness

Source	df	Mean Squares	F
Three Age Groups	2	3.34	0.41
Error	87	8.09	

*$p < .05$

TABLE 5

Analysis of Variance for Three Age Groups in Friction

Source	df	Mean Squares	F
Three Age Groups	2	4.67	0.69
Error	87	6.77	

*$p < .05$

TABLE 6

Analysis of Variance for Three Age Groups in Difficulty

Source	df	Mean Squares	F
Three Age Groups	2	22.53	2.77
Error	87	8.12	

*p < .05

TABLE 7

Analysis of Variance for Three Age Groups in Cohesiveness

Source	df	Mean Squares	F
Three Age Groups	2	9.70	1.24
Error	87	7.84	

*p < .05

TABLE 8

Analysis of Variance for Three Age Groups in Satisfaction

Source	df	Mean Squares	F
Three Age Groups	2	14.23	0.81
Error	87	17.51	

*p < .05

Tables 9 through 15 indicate any significant difference between the three age groups in their cognitive development in science.

TABLE 9

Analysis of Variance for Three Age Groups in Application of Science

Source	df	Mean Squares	F
Three Age Groups	2	61.87	7.20*
Error	87	8.59	

*p < .05

In this particular case the Scheffe test was administered to Table 9 because of the significance of the F value. The location of the significant differences between the age groups is indicated in Table 10.

TABLE 10

Scheffe Test of Significant Differences Between the Three Age Groups in Application of Science

Source	F
9 and 10 Year Olds	10.11*
9 and 11 Year Olds	8.36*
10 and 11 Year Olds	0.05

*$p < .05$

TABLE 11

Analysis of Variance for Three Age Groups in Comprehension of Science

Source	df	Mean Squares	F
Three Age Groups	2	4.90	1.13
Error	87	4.35	

*$p < .05$

TABLE 12

Analysis of Variance for Three Age Groups in Knowledge of Science

Source	df	Mean Squares	F
Three Age Groups	2	56.07	4.76*
Error	87	11.78	

*$p < .05$

Since the F value was significant the Scheffe Test was administered to locate the significant difference. The results are given in Table 13.

TABLE 13

Scheffe Test of Significant Differences Between the Three Age Groups in Knowledge of Science

Source	F
9 and 10 Year Olds	0.46
9 and 11 Year Olds	9.50*
10 and 11 Year Olds	2.62

*p < .05

TABLE 14

Analysis of Variance for Three Age Groups in Total Science Achievement

Source	df	Mean Squares	F
Three Age Groups	87	240.57	8.91*
Error	2	27.01	

*p < .05

Once again, the Scheffe Test was used to locate the significant differences in the three age groups. The results are indicated in Table 15.

TABLE 15

Scheffe Test of Significant Differences Between the Three Age Groups in Total Science Achievement

Source	F
9 and 10 Year Olds	6.92*
9 and 11 Year Olds	17.74*
10 and 11 Year Olds	2.38

*p < .05

Tables 16 and 17 indicate any significant differences in the three age groups in their affective performance. The affective aspect of attitude was used in the results.

TABLE 16

Analysis of Variance of the Three Age Groups in Their Attitude Toward Science (Verbal Test)

Source	df	Mean Squares	F
Three Age Groups	87	237.37	0.50
Error	2	474.02	

*p < .05

TABLE 17

Analysis of Variance of the Three Age Groups in Their Attitudes Toward Science (Non-Verbal Test)

Source	df	Mean Squares	F
Three Age Groups	87	7.43	0.40
Error	2	18.50	

*p < .05

DISCUSSION

The reason for analyzing the classification of cognitive development is to find some evaluation for desired outcomes in science instruction. Since ESS is interested in developing meaningful science materials to allow a flow of ideas originating from the curiosity of children it is interesting to investigate the cognitive growth of the ESS pupils. Also, since cognitive growth receives most of the teachers attention, it will be examined in detail.

Table 1 summarizes the significant differences in the pre- and post-test cognitive scores at the .05 level of confidence. The most noticeable cognitive performance is the nine year olds. The nine year olds achieved significantly higher in all four categories of science achievement than the ten and eleven year olds. A closer examination of the data reveals that the pupils participating in the ESS program tend to have fewer significant t-scores as they progress from the nine year olds to the eleven year olds. The first science category that was not significant in the ten year olds was application. Application of science principles is a higher level of learning in the cognitive domain and shows that this is the first category the ESS pupils lose in their progress. Comprehension is the only significant science category for the eleven year olds.

Table 2 indicates the three age groups attitudes toward science after experiencing six months in the ESS program. A significant difference was shown in the ten and eleven year olds on the verbal attitude scale. Since there was no significant differences on the non-verbal attitude t-scores, it can be noted that the attitudes of the three age groups were not as favorable during the post-testing as they were during the pre-testing. However, Tables 16 and 17 show that there is no significant difference in the progress of the three age groups in their attitudes toward science.

Table 3 shows the pre- and post-test t-scores of the three age groups in classroom learning environment. The three age groups show no significant gains in the competitiveness among the pupils. Also, the three age groups showed no significant gains in difficulty with the subject matter. This can also be seen in the cognitive t-scores in Table 1.

There was no significant gains in the cohesiveness of the three age groups. Anderson has pointed out that when several individuals interact for a period of time a feeling of intimacy or cohesiveness may develop. He also points out that small classes are more cohesive than are large classes. Since the classes of ESS pupils were 60-pupil or more this may have had some influence on the results of cohesiveness of the three age groups. However, Anderson points out that classes of teachers inexperienced with a new course are perceived as more cohesive than those taught by teachers familiar with the course. In some cases cohesive classes sanction only goal directed behavior; if the group norm

includes learning, cohesiveness contributes to increased learning; for non-learning oriented classes, cohesiveness acts against those pupils who want to learn.

The three age groups also showed no significant difference in their satisfaction of the class. Anderson and Walberg have indicated that satisfaction is negatively related to class size, and this may have been the influential factor of no significant difference in the satisfaction of the pupils.

Friction was the only scale of the Classroom Environment Inventory that was found significant. All three age groups showed significant increases in friction in the classroom during the school year. Anderson has indicated that energy expanded in conflict cannot be channeled in other directions and the emotional upset resulting from extensive or continual conflict can be expected to impair learning. However, Anderson has shown that relationships were found to be more complex such that high friction was advantageous for certain combinations of pupil sex, IQ, and learning measures. In general, friction may be considered advantageous when the learning criterion includes comprehension of complex concepts and demonstrable creativity.

When observing the progress that is being made by the three age groups, only Tables 9, 12, and 14 show a significant difference between the three age groups. Tables 9 and 10 show that the ESS pupils made significant progress in the application of science from age nine to ten. After age ten their progress in the application of science decreased. Tables 12 and 13 show that there is significant progress being made by the ESS pupils from age nine to eleven but not each consecutive year. Tables 14 and 15 show significant progress being made in the ESS pupils total science achievement scores. The nine and ten year olds made significant improvement in their total science achievement; however, the progress between the nine and eleven year olds showed the greatest significance.

CONCLUSIONS

This investigation has shown that significant progress in cognitive development can be made by children in the ESS program. Although the three age groups did not show significant development in all the cognitive categories, the present results show that children can achieve significant cognitive growth through intuitive thinking. Such research should lead to an understanding that intuitive learning in science can help children solve concrete and abstract problems if they are given the opportunity.

In many cases the results of the student attitudes toward science does not differ from previous investigations about children's attitudes toward science. Since the attitudes of the pupils were not as positive at the end of the ESS program as they were at the beginning, research is needed to analyze the ESS pupils attitudes toward science.

Such research should lead to an understanding of factors that may influence the change of attitudes toward science as children progress through the elementary school.

In addition, the present study shows that the classroom climate has changed after the ESS program was implemented. The primary consideration is that classroom characteristics affect learning, and that the ESS program did not produce any competitiveness, difficulty, cohesiveness, or satisfaction in the classrooms. The program did affect the friction in the classroom. This could mean that the ESS program provided more opportunity for creativity and interaction with complex problems.

In general this study presents evidence that the ESS program has provided for an improved science curriculum, and classroom learning environment. Further research is needed to confirm these findings.