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ABSTRACT

This project was designed to investigate the effect of the use of cause-and-effect activities in the science curriculum on the locus of control of the learner. The purpose of this research is to find the effect of the activities on the learner's locus of control and attitude toward science at grades 7 through 10. A multivariate analysis of covariance was carried out using pretest scores. Science activities emphasizing cause-and-effect relationships increased the internal locus of control of students in the eighth grade. However, at the ninth grade level the opposite occurred. Two possible reasons for the contrary results were discussed. There were significant treatment effects on the attitudes towards the social implications of science, normality of scientists, and inquiry. Implications for science activity and further research were suggested. Activities used in the project by grade are listed in the appendix. (YP)

USING SCIENCE ACTIVITIES TO INTERNALIZE LOCUS OF CONTROL

Final Report

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Final Report

Introduction

The purpose of the school-based research program is to facilitate collaborative research on significant problems in public school instruction. The Using Science Activities to Internalize Locus of Control (USAIL) project was designed to investigate the effect of increasing the use of cause-and-effect activities in the science curriculum on the locus of control of the learner. This research was based on claims (Rowe, 1978) that such activities should increase the internality of students. Kahle (1982) has suggested that such activities would cause a shift in locus of control that would be especially important for externally oriented minority students.

An important component of science literacy is a positive attitude toward using scientific inquiry and toward science as an activity. Rowland and Stuessy (1989) have shown that a positive attitude towards science is correlated with an internal locus of control. Consequently, one would expect an increase in internality to be accompanied by an improvement in attitude towards science. However, according to the social learning theory on which locus of control is based (Rotter, 1966), one might also predict a decoupling of locus of control from attitudes as the attitudes become more directly based on specific experiences and the generalized view (represented by locus of control) becomes a less important influence.

Research Objective

The purpose of the research was to answer the following questions:

(1) Do science activities emphasizing cause-and-effect relationships cause the learner's locus of control to become more internal?

(2) Is the change in locus of control accompanied by a change in science related attitudes?

(3) At what grade level is intervention in locus of control most effective?

Methodology

The study employed a quasi-experimental nonequivalent control group design (Campbell & Stanley, 1963). Roughly equivalent intact classrooms were assigned to either treatment or control groups. Pretests and posttests were used to determine the influence of the treatment.

Subjects: The subjects for this study were seventh and eighth grade science students from Pantego Junior High School and ninth grade physical science students and tenth grade biology students from Tarboro High School. One seventh grade classroom, two eighth grade classrooms, three ninth grade classrooms and one tenth grade classroom were designated as treatment groups and matched with control classrooms at the same school and grade level. All procedures were in compliance with American Psychological Association Guidelines for Research with Human Subjects.

Pretests: During January, pretests were administered to all participants. These pretests included the Nowicki-Strickland Abbreviated Scale 7-12 (Nowicki & Strickland, 1973) to measure locus of control (high score indicating an external locus of control) and a modification of the Test of Science Related Attitudes (Fraser, 1981) to measure attitude toward science. The modification of the Test of Science Related Attitudes (TOSRA), based on factor analyses of prior use of the instrument, used only four of the original seven subscales: Society and Science, Normality of Scientists, Attitude Towards Inquiry, and Enjoyment of Science Classes. Each subscale consisted of eight questions and each question was scored on a scale of one to five with higher scores indicating a more positive attitude. A sum of the scores of the questions on each subscale yielded the subscale score.

Treatment: Following administration of the pretests, the treatment classrooms took part in weekly science activities designed to illustrate cause-and-effect relationships. All activities were designed by science education graduate assistants in cooperation with the classroom teacher and integrated with the ongoing curriculum (see Appendix A). The activities were jointly taught by the classroom teacher and the graduate assistant.

Most of the activities were conducted in the students' classroom, however, a few were carried out at East Carolina University. Those activities conducted at the university included ones that utilized microcomputer based laboratories, computer based graphing, and computer simulations. In addition, the activities included field trips to facilities that demonstrated strong cause-and-effect relationships in science. The symbolic representation of relationships using graphs was also emphasized to demonstrate the mathematical nature of some cause-and-effect relationships.

In the control classrooms, the teachers presented the existing curriculum in the normal manner. Teachers in the control groups were not told the purpose of the project until after the posttest period.

Posttests: During May, the same instruments administered as pretests were administered to students in both control and treatment classrooms.

Analysis of Data

The treatment effects were analyzed using an analysis of covariance of the locus of control scores and the scores on the subscales of the Test of Science Related Attitudes. A multivariate analysis was carried out first and appropriate univariate analyses were conducted at each grade level to determine the most appropriate level of intervention.

Results

Instruments. The Nowicki-Strickland instrument reliability (Cronbach's alpha) was .69 on the pretest and .72 on the posttest. For the TOSRA Social Implications of Science subscale (SUBS) the pretest reliablity was .49 and the posttest reliabilty was .59. Reliabilties for the Normality of Scientists subscale (SUBN) were .47 for the pretest and .55 for the posttest. The Attitude To Inquiry subscale (SUBI) had reliabilities of .73 (pretest) and .78 (posttest). The highest reliabilities were for the Enjoyment of Science Lessons (SUBE): .90 and .91 on the pretest and posttest respectively.

Locus of control. Means and standard deviations of the locus of control scores are shown in Table 1. In general, there was a decrease in externality, however two sets of data (seventh grade experimental and eight grade control) indicated some increase.

A multivariate analysis of covariance, using the pretest score as the covariate, indicated no main effect on locus of control due to treatment, $F(1, 234) = 0.41$, $p >$ .53. Likewise, the effect due to grade was not significant, $F(3, 234) = 1.52$, $p > .21$. However, an interaction between treatment and grade was found to be significant, $F(3, 234) = 4.51$, $p < .004$. Univariate analyses of covariance "by grade" revealed that there were no significant differences due to treatment at the seventh and tenth grade levels (see Table 2). At the eighth grade level there was a significant treatment effect resulting in an increase in internality in the experimental group (see Table 2 and the means in Table 1). At the ninth grade level a significant difference indicated a greater increase in internality within the control group as compared to the experimental group (see means in Table 1 and ANCOVA in Table 2).

Attitudes towards science. An examination of the mean scores of the four attitude subscales (Tables 3, 4, 5, and 6) revealed a general but slight improvement in attitude in all areas except Enjoyment of Science Lessons. The multivariate analysis of covariance (see Table 7) showed significant treatment effects in improving the attitudes towards Social Implications of Science, Normality of Scientists, and Inquiry, while a grade effect was found for the Enjoyment of Science Lessons subscale. Followup tests (LSD) of the Enjoyment of Science Lessons subscale means indicated that the eighth grade attitudes ($M = 27.4$) were more positive than seventh ($M = 24.3$), ninth ($M = 23.6$), and tenth grade ($M = 25.1$) attitudes at the .05 level.

Discussion and Conclusions

Locus of Control. Doing science activities that emphasized cause and effect relationships increased the internal locus of control of students in the eighth grade. However, at the ninth grade level the opposite occurred. The control group became more internal while the experimental group remained unchanged. This contrary result may have occurred for any of several possible reasons.

First, the ninth grade experimental classes were characterized both by their teacher and by the graduate assistant working with them as "full of discipline problems." The graduate assistant frequently returned from her sessions with that group frustrated with how little they had done or under.tood. Class time was reduced due to discipline problems. It is likely that in this type of situation the discipline procedures, based on the authority of a "powerful other," interfere with the internalization process. Students receiving discipline comments from teachers may come to see powerful others as being in control of their lives. This concern with powerful others may result in the failure by students to discover the cause-and-effect relationships in their science activities or a failure to carry the concept of causation over to the areas measured by the locus of control instrument.

Second, the graduate assistant working with the ninth and tenth grade students was an inexperienced teacher while the graduate student the in the junior high had nine years of science teaching experience. It may be that new teachers are not effective at providing the environment necessary for students to discover and internalize cause and effect relationships. Indeed, the combination of discipline problems and inexperience might be synergistic in preventing an increase in the internalizing of locus of control.

Attitudes. Doing science activities that emphasize cause and effect relationships improves attitudes towards Social Implication of Science, Normality of Scientists, and Inquiry. It is interesting that such activities do not contribute to the enjoyment of science classes. It is likely that the enjoyment of science classes is a subset of enjoyment of school, a factor that appears to decline as a function of schooling (Mullis and Jenkins, 1988).

Of the attitude subscales, the Inquiry scale is most interesting. Attitudes toward inquiry are an essential component of the scientific attitude (Deiderich, 1967). In the North Carolina Course of Study one of the key learning outcomes is "attitudes (positive) toward the use of scientific inquiry . . . ." (p. 269, North Carolina Department of Public Instruction, 1985). Thus, it was heartening to find that doing science activities consistently (see Table 5) increased the students desire to use the inquiry process for learning. This finding is especially interesting in that the students in the experimental groups improved their attitude towards inquiry despite the lack of improvement in their attitude toward enjoying the class. In the long run, it is more important for students to use the inquiry approach to learning than it is to have them indicate they enjoy their science classes.

The inquiry subscale is also of interest because it fits into the attitudes definition used by social psychologists Ajzen and Fishbein (1980) of leading to an intention to perform a particular behavior. It appears that an important variable to alter an individual's attitude toward inquiry is experience doing science activities. The Ajzen and Fishbein (1980) Theory of Reasoned Action and the subsequent revision by Ajzen and Madden (1986) may provide a theoretical basis for further investigations of attitudes toward inquiry and perceived behavioral control (i.e. locus of control).

Implications

The most direct in-school application of the findings of this research is to include a wealth of hands-on science activities that demonstrate cause and effect relationships at the eighth grade level. It appears that the opportune time to internalize locus of control through science activities is at the eighth grade. Science classes that lack such activities may be depriving students of opportunities to reshape their approach to not only science but to life in general. Given the numerous advantages to an internal locus of control (see Phares, 1976), failure to provide the activities that can internalize that control would be to provide a poor education.

In addition, the use of science activities is also justified as a means of meeting the goal of improving science attitudes, especially the attitude toward doing inquiry. It is important not to confuse the "liking of a science class" with the more important "attitude towards inquiry." It is probably not that important to find out whether or not students like their classes. However, it is important to determine whether or not those classes are increasing the likelihood that students will use inquiry methods.

Finally, like most school-based research, this study has raised as many questions as it has answered. The research needs are great. Further research in other settings is needed to obtain generalizability of these findings. Research is needed to determine whether or not the ninth grade is also a possible "window of opportunity" given a different set of circumstances. Further research on the attitudes toward inquiry based on the Theory of Reasoned Action is needed to determine how we best reach the goal of an inquiring public.

Despite the problems associated with such short-term, school-based research, it is satisfying to realize that we can increase the knowledge base for education by working in the school setting. We can confidently claim that science activities in grades seven through ten improve students' science attitudes. If we are serious about developing a public that is scientifically literate, we should demand that schools offer those activities, and we should be willing to pay the costs of materials development, teacher training, and supplies for doing those activities. We <u>can</u> improve science education.

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Table 1

Means, Standard Deviations, and Number of Subjects for External Locus of Control on Posttest (POST) and Pretest (PRE) for Control (CNTL) and Experimental (EXPT) Students.

	Grade				
	7	8	9	10	ALL
CNTL POST	10.3 (3.7)	11.6 (3.0)	8.4 (3.8)	8.6 (3.5)	9.7 (3.7)
N	24	40	49	25	138
CNTL PRE	11.1 (3.0	11.2 (3.8)	9.6 (3.5)	8.9 (4.0)	10.2 (3.7)
N	22	35	44	24	132
EXPT POST	11.6 (3.5)	7.2 (4.1)	9.3 (3.7)	9.0 (3.6)	9.1 (4.0)
N	25	37	41	25	128
EXPT PRE	11.3 (4.0)	7.7 (3.2)	9.4 (3.3)	9.4 (3.4)	9.3 (3.6)
N	23	34	38	23	126

Table 2

Values of *F* and Their Le'el of Significance from the Analysis of Covariance for the Treatment Effect on Locus of Control, by Grade.

Grade	*F*	*p*
7	2.18	.14
8	6.62	.01
9	4.00	.05
10	0.00	.95

Table 3

Means, Standard Deviations, and Number of Subjects for TOSRA Social Implications of Science Subscale on Posttest (POST) and Pretest (PRE) of Control (CNTL) and Experimental (EXPT) Students.

	Grade 7	Grade 8	Grade 9	Grade 10	ALL
CNTL POST	24.1 (4.2)	25.8 (4.1)	24.5 (3.3)	23.1 (3.4)	24.5 (3.9)
N	23	37	46	23	138
CNTL PRE	26.4 (4.4)	26.0 (3.2)	23.9 (3.5)	23.7 (3.1)	24.8 (3.6)
N	22	36	44	24	133
EXPT POST	26.0 (3.3)	26.3 (3.2)	24.8 (3.3)	25.1 (4.0)	25.4 (3.5)
N	23	36	36	24	128
EXPT PRE	25.2 (3.6)	25.7 (3.7)	23.9 (3.5)	23.7 (3.1)	24.8 (3.5)
N	24	34	38	23	127

Table 4

Means, Standard Deviations, and Number of Subjects for TOSRA Normality of Scientists Subscale on Posttest (POST) and Pretest (PRE) of Control (CNTL) and Experimental (EXPT) Students.

	Grade				
	7	8	9	10	ALL
CNTL POST	27.3 (3.2)	28.1 (3.5)	26.7 (4.4)	26.8 (3.9)	27.2 (3.8)
N	23	37	46	23	138
CNTL PRE	27.1 (4.1)	27.1 (3.6)	26.6 (3.7)	27.3 (2.5)	26.9 (3.6)
N	22	36	44	24	133
EXPT POST	29.0 (4.0)	28.9 (4.4)	27.9 (3.2)	27.5 (3.8)	28.4 (3.8)
N	23	36	36	24	128
EXPT PRE	27.4 (3.6)	27.4 (3.2)	27.8 (4.1)	27.5 (3.8)	27.5 (3.7)
N	24	34	38	23	127

Table 5

Means, Standard Deviations, and Number of Subjects for TOSRA Attitude To Inquiry Subscale on Posttest (POST) and Pretest (PRE) of Control (CNTL) and Experimental (EXPT) Students.

	Grade				
	7	8	9	10	ALL
CNTL POST	26.9 (7.3)	30.3 (6.5)	30.0 (5.3)	29.6 (6.2)	29.3 (6.1)
N	23	37	46	23	138
CNTL PRE	29.1 (6.9)	28.6 (4.8)	28.1 (4.6)	29.0 (5.6)	28.4 (5.2)
N	22	36	44	24	133
EXPT POST	31.7 (4.8)	33.4 (4.4)	30.2 (5.2)	29.8 (5.1)	31.2 (4.9)
N	23	36	36	24	128
EXPT PRE	31.0 (5.2)	31.3 (5.3)	28.6 (6.4)	27.2 (4.4)	29.8 (7.3)
N	24	34	38	23	127

Table 6

<u>Means, Standard Deviations, and Number of Subjects for TOSRA Enjoyment of Science Lessons Subscale on Posttest (POST) and Pretest (PRE) of Control (CNTL) and Experimental (EXPT) Students.</u>

	Grade				
	7	8	9	10	ALL
CNTL POST	23.8 (10.4)	28.4 (7.6)	24.4 (8.0)	23.4 (6.3)	25.1 (8.2)
N	23	37	46	23	138
CNTL PRE	26.3 (8.5)	27.7 (6.8)	21.7 (8.9)	22.8 (7.2)	24.4 (8.2)
N	22	36	44	24	133
EXPT POST	21.6 (8.3)	26.5 (7.1)	26.1 (8.5)	25.5 (7.4)	25.1 (5.5)
N	23	36	36	24	128
EXPT PRE	22.8 (6.7)	27.0 (7.1)	25.3 (8.2)	27.2 (5.1)	25.5 (7.3)
N	24	34	38	23	127

Table 7.

MANCOVA's of Attitude Subscales of Revised TOSRA.

Source	df	F	p
Society and Science			
Treatment	1	6.45	.012
Grade	3	2.17	.092
Treatment x Grade	3	2.08	.104
Normality of Scientists			
Treatment	1	4.54	.034
Grade	3	2.07	.105
Treatment x Grade	3	0.93	.427
Attitude Towards Inquiry			
Treatment	1	4.36	.038
Grade	3	2.15	.094
Treatment x Grade	3	1.54	.205
Normality of Scientists			
Treatment	1	0.89	.345
Grade	3	2.92	.035
Treatment x Grade	3	0.23	.877

Appendix A

Activities Used in USAIL Project

Date	Activity	Topic
	Seventh Grade	
2/3/89	Separation of Minerals	Geology/Soils
2/10/89	Stream Table Erosion I	Geology/Erosion
2/17/89	Stream Table Erosion II	Geology/Erosion Control
3/9/89	Acid Rain	Meterology/Air Pollution
3/15/89	Convection Currents	Oceanography/Currents
	Home Energy Simulation	Energy Use
	Grizzly Bears	Ecology/Habitats
4/14/89	Oil Spill	Water Pollution
	Observing Adaptations at the NC Aquarium	Ecology/Adaptations
4/21/89	Yeast	Ecology/Populations
4/28/89	Food Chain	Ecology/Food chains
5/4/89	Worm Behavior	Animal Behavior
	Eighth Grade	
2/3/89	Solubility	Chemistry/Elements
2/10/89	Chemical Changes	Chemistry/Compounds
2/17/89	Acids and Bases	Chemistry/Reactions
3/9/89	A Common Chenical Change	Chemistry/Reactions
3/15/89	Heat, Temperature and Phase	Chemistry/Energy
	Home Energy Simulation	Energy Use
	Grizzly Bears	Ecology/Habitats
4/14/89	Oil Spill	Water Pollution
	Observing Adaptations at the NC Aquarium	Ecology/Adaptations
4/21/89	Rockets	Space Travel
4/28/89	Rockets	Space Travel
5/4/89	Electric Circuits	Electricity

Ninth Grade

2/2/89	Waves	Sound
2/9/89	Light and Heat	Energy
2/16/89	Family of Elements	Chemistry/Elements
2/23/89	Combining Elements	Chemistry/Compounds
3/16/89	Ionic Interactions	Chemistry/Reactions
3/30/89	Heat, Temperature and Phase	Chemistry/Energy
	Home Energy Simulation	Energy Use
	Grizzly Bears	Ecology/Habitats
4/6/89	Carbon compounds	Organic chemistry
4/13/89	Reactions - Acids and Bases	Chemistry/Reactions
4/20/89	Field trip to NC Museum of Life and Science	

Tenth Grade

2/2/89	Enzyme Activity I	Biochemistry
2/9/89	Enzyme Activity II	Biochemistry
2/23/89	Pulse rate	Circulatory Syst.
3/16/89	Lung Capacity	Respiratory Syst.
3/31/89	Heat, Temperature and Phase	Chemistry/Energy
	Home Energy Simulation	Energy Use
	Grizzly Bears	Ecology/Habitats
4/6/89	Senses	Nervous System
4/13/89	Support and Locomotion	Skeletal System
4/20/89	Field trip to NC Museum of Life and Science	
5/4/89	Learning	Behavior