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ABSTRACT

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THE EFFECTS OF MANDATORY, COMPETITIVE SCIENCE FAIRS ON FIFTH GRADE STUDENTS' ATTITUDES TOWARD SCIENCE AND INTERESTS IN SCIENCE

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ABSTRACT

This quasi-experimental study evaluated the effects of levels of participation and award structure of science fairs on elementary students' attitudes toward science and interests in science. Fifth grade students participated in one of four science fairs: mandatory/competitive, mandatory/noncompetitive, voluntary/competitive, or voluntary/noncompetitive. They were given five weeks to complete a science project to present at a fair. Their attitudes toward science and interests in science were measured before and after implementation.

Analysis of the mandatory groups was made to determine the effects of award structure on attitudes and interests. The results indicated that attitudes were not significantly affected by different award structures; however, students who participated in the noncompetitive fair did display an increase in attitudes. Differences were found in students' interests in science. Those students that participated in a noncompetitive fair scored higher than those students who were involved in a competitive fair.

The aptitude treatment interaction analysis revealed that low ability students would be expected to respond with a greater increase in interests in science when the award structure is noncompetitive. However, high ability students respond negatively under the same conditions.

INTRODUCTION

Background and Purpose

Science fairs have existed ince the 1920s, with the first National Science Fair in 1950. The earliest fairs allowed competition between only the top high school juniors and seniors. A Junior Division for grades seven through nine was incorporated in the late 1950's.

In 1965, the National Science Fair competition joined with other countries and became the International Science and Engineering Fair. There are now 44 states, the District of Columbia, Puerto Rico, and 9 foreign nations involved with the fair. All seventh through twelfth grade students may compete at the local level, with "winners" advancing on to district, state, and international competitions.

Science fairs also exist in most elementary schools. These events, along with art exhibits and math competitions, aid in getting young children involved in their studies by allowing students to apply their knowledge of topics taught in the classroom to real problems (Frankovits, 1990). A well-organized science fair can turn the research and creation of any project into a learning experience. This experience may initiate a deeper interest in science (National Science Teachers Association [NSTA], 1990).

Teachers should encourage students to participate in science fairs for all of these reasons. However, most research agrees that "students should never be required to compete" (Kutscher, p.12). The current Elementary Science Fair Handbook, written by Florida's Brevard County School Board, encourages competitive fairs at the local level by allowing only the first place winners in each division from grades three through six to compete at the district level.

For elementary students, the science fair experience may leave them disenchanted with science because of the emphasis placed on competition. This change in attitude may lead to a change in interest in science or worse yet, a feeling of being incapable of science learning. This is evidenced by the Harty, Samuel, and Beall (1986) study which found the degree of relationship between attitudes toward science, interests in science, science curiosity, and self-concept of science ability among 228 sixth grade students to be significant ($R = 0.78$ and $R^2 = 0.61$).

The current study examined the relationships between participation in science fairs, the award structure of science fairs, interests in science, and attitudes toward science for elementary school students.

Research Hypotheses

There are two independent variables for this study: participation in and award structure of a science fair. The levels of participation are mandatory or voluntary and the levels of award structure are competitive or noncompetitive. The dependent variables are attitude toward science and interests in science.

H_1: Elementary students who complete a science fair project under a competitive award structure will score lower on attitude and interest than students who participate in a fair with a noncompetitive award structure.

H_2: Elementary students who are required to complete a science fair project will score lower on attitude and interest than students who participate voluntarily.

H_3: There will be an interaction between levels of participation and levels of award structure on attitudes and interest. Specifically, elementary students that voluntarily complete a science project in a fair with a noncompetitive award structure will have higher scores for both attitude and interest than those students that are required to complete a project in a fair with a competitive award structure.

H_4: There will be a greater number of students who voluntarily complete a science project when the award structure is noncompetitive than students who voluntarily complete a science project when the award structure is competitive.

Null Hypotheses

H_{01}: There will be no significant differences between attitude and interest scores of elementary students who complete a science fair project under a competitive award structure and students who participate in a fair with a noncompetitive award structure.

H_{02}: There will be no significant differences between the attitude and interest scores of students who are required to participate in a fair and those who voluntarily participate.

H_{03}: There will be no significant interaction between the levels of participation and levels of award structure on attitudes toward science and interests in science.

H_{04}: There will be no difference in the number of students voluntarily completing a science fair project regardless of the award structure of the fair.

Definitions

Mandatory Participation: The classroom teacher required each student to complete a scientific experiment to be presented in notebook form to the class during a science "fair". Grades from these projects were not used to calculate the students' course average.

Voluntary Participation: A science "fair" was held in the classroom, but students were not required to complete a project for presentation. The students were encouraged by their teacher to voluntarily participate. Grades were not issued for these projects.

Competitive Award Structure: Award ribbons were presented to the two highest ranking science projects. These projects were judged and ranked according to the average scores from two adjudicator sheets.

Noncompetitive fairs: Participation ribbons and coupons were presented to all students who completed a science project and presentation notebook. The projects were judged but not ranked.

RELATED LITERATURE

Most of the literature on science fairs focuses on: attitudes toward science, voluntary versus required student participation, academic competition, and awards. The lack of experimental studies conducted on elementary school science fairs suggests that their influence on students have not been thoroughly examined.

Attitudes Toward Science

Factors that influence attitudes toward science are a major concern because of the ultimate effect attitudes have on science achievement. Secord and Backman (1964) define attitudes in reference to elementary science teaching and learning as "certain regularities of an individual's feelings, thoughts, and predispositions to act towards some aspect of the environment" (p. 97).

The Science Curriculum Improvement Study (SCIIS) found that students' (n = 456) attitudes toward science were enhanced after just one year in an inquiry-oriented, process-approach science class (Kyle, Bonnstetter, & Gadsden, 1988). This approach to science learning is the basis for science fair projects. When students are encouraged to solve the mysteries of science for themselves they begin to take ownership of their learning, and there is a sense of pride that comes with that.

Science teachers play an important role in strengthening the necessary skills that enable students to compete successfully in science fairs (Kutscher, 1990). A survey of North Dakota Science and Engineering Fair (NDSEF) participants (n = 213) showed that 52% of the students gave credit to their science instructors for encouraging them to participate in a fair (Olson, 1985). Another 21% attributed their participation to a combination of the encouragement from their science instructors and parents.

Teachers can have a great affect on the attitudes of their students. They serve as role models in developing positive attitudes toward science. Unfortunately, because of their own lack of confidence with science topics, many elementary teachers view teaching science as "traumatic" (Kyle, Bonnstetter, & Gadsden, 1988). To affect students' attitudes "teachers must act more like coaches than like traditional classroom instructors. Coaches develop talent" (Frankovits, 1990, p. 9).

Studies concerning attitudes toward science indicate that there is a continuing problem implementing research findings in the classroom. Dry and forced subject presentation ultimately affects students' attitudes. Perhaps teachers find more security with the textbook, and are reluctant to experiment with hands-on activities.

Mandatory vs. Voluntary Participation

In the Surrey School District of British Columbia, 67% of middle grade teachers required participation in science fairs (Carlisle & Deeter, 1989). In the United States science fairs are considered extracurricular, yet many teachers require and grade science projects. There were no studies found that recommended mandatory student participation in science fairs. Research does show, however, that 39.5% of the high school sophomore students that were required to participate in a science fair had some success at the NDSEF (Olson, 1985). Another study showed that fifth grade students' interests in science increased when every student was required to submit a science project that was displayed for parents, teachers, and peers (Burtch, 1983).

The NDSEF finalists whose participation was voluntary were also reported as having greater self-motivation to complete their projects. By contrast, if participation was required, the students spent a majority of their time requesting help from a teacher and/or parent (Olson, 1985). When students are mandated to create projects outside the classroom, they tend to see the project as "one more task imposed by the quixotic school authorities" and irrelevant to their science education (Winicur, 1989, p. 27).

Although these findings are inconsistent, some researchers have suggested guidelines for conducting science fairs. Carlisle and Deeter (1989) recommend that for required projects teachers should: (1) justify the project in terms of objectives; (2) give support to the students; (3) integrate a project with class instruction; (4) down-play the competition; and (5) give everyone an award. This approach would assist educators in creating a science-rich environment.

Early involvement in science fairs fosters continued dedication to related activities (Olson, 1985). Fair directors can nurture both short term and long term benefits for student participation. However, the primary goal of the science educator is to foster an environment where students see the inter-relatedness of science and their world. Science experiments generated in laboratories and produced as projects for science fairs do apply to daily living.

Competition

The most controversial aspect of science fair participation is competition (Burtch, 1983; McBride & Silverman, 1988, Scarnati, et al., 1992). Proponents feel that early exposure to a competitive environment prepares students for real-life situations. Opponents of this approach see competition as a "weeding out" process, which is contrary to the focus educators should promote. Carlisle and Deeter (1989) state that "many teachers support the fair as an academic competition that provides challenges and rewards for able students" (p. 25).

In the real world, competition in science is often counter-productive. Globally, scientists work independently on very similar problems without collaborating (NSTA, 1990). Quite often the first time scientists become aware of a duplication of efforts is when their results are published. Ridding our fairs of competition may be the start of encouraging a collegial exchange of knowledge.

Contests influence more than just learning in young students. They also affect self-image. The staff of Chautauqua Junior/Senior High School in New York agreed that a "highly competitive science fair would not significantly contribute to the social and emotional growth" of their students (Scarnati, et al., 1992, p. 39). Very young children believe they will always win contests they enter, and if they do not win, they see themselves as personal failures (McBride & Silverman, 1988). Competition among individuals may be the most effective academic reward structure, yet competition works well only for those with high abilities that most frequently receive rewards. It is usually counterproductive for those students who seldom or never receive rewards (Michaels, 1977).

Competition detracts from the learning experience by promoting isolation between participants (Winicur, 1989; Scarnati, et al, 1992). Large science fairs are usually highly competitive. They encourage and reward excellence, while a large number of non-winners walk away empty-handed. Competition "does nothing for the non-gifted and non-competitive student" (Burtch, 1983, p. 12). The end result divides students into two groups: winners and losers.

Studies show that science fair participants competing against a standard set by an instructor or a school benefit more than those participants that compete against each other (Carlisle & Deeter, 1989; McBride & Silverman, 1988). Competing against standards rewards the effort of participants instead of their worth. This gives students more control over their ability to "win" and encourages judges to reward all ventures. It also provides a platform for constructive criticism, which is commensurate with the primary purpose of the science fair, learning.

Award Structures

The award structure varies greatly among schools that have competitive fairs. The most common are placement awards (1st, 2nd, 3rd place). This system encourages the highest number of participants while producing the least number of winners (McBride & Silverman, 1988). Alternative award systems used in science and engineering fairs are awards by grade level or project category. A few schools recognize only the best project in the fair. Participants in most fairs also compete for special awards sponsored by professional clubs and businesses (Olson, 1985).

The McBride and Silverman (1988) study of judging found that the "most able students" usually received the first prize in competitive fairs that gave only one first prize. This means that less capable students rarely won, even though they may have worked just as hard. These researchers also reported that winners of such awards were usually "not gracious," but rather "boastful," and the losers felt rejected, angry, or jealous.

Research disclosed a variety of alternative award structures. One example came from Carlisle and Deeter (1989) who removed student competition from their district fair upon completion of their research. Students now compete against a set standard and every student receives an award: gold, silver, bronze, or finalist. They note that "students can strive for a high standing with the knowledge that it is attainable" (p. 25).

Teachers at J. B. Nelson Elementary school in Batavia, Illinois created an awards structure that rewards creativity, the quality of the display, and the students' ability to explain their project to a judge (Burtch, 1983). No prizes are given, but rather points are awarded on a scale from one to ten. The final points received are not published, so the competitive nature of the fair is removed.

Summary

Science teachers play a very important role in the lives of young people. They strongly influence students' attitudes toward science by acting as role models. For students to form positive attitudes, as well as learn science, they need to engage in positive experiences it throughout the year. So the question arises: when science teachers involve their students in science fairs, how are they affecting their students' attitudes toward science?

I was unable to find any experimental studies conducted on elementary school science fairs. This leads me to believe that their influence on students has not been thoroughly examined. Because student's abilities vary widely, a look at the award structure and competitive nature of science fairs seems appropriate to ensure all students are encouraged and rewarded for their efforts.

METHODS

Population

The target population for this study was elementary school children in the United States. The accessible population was fifth grade students in Brevard County, Florida.

The 1990 Census reports that Brevard County contains approximately 400,000 residents with a racial breakdown as follows: 89.8% White, 7.9% Black, 1.3% Asian, and less than 1% of other races combined (personal communication, Geographic Research Division of Brevard County, 1993). There were 46 public elementary schools throughout the county serving 34,781 students at the time of this study. (personal communication, Brevard County School Board). There were 4,626 fifth grade students attending public schools during the school year. The race and gender breakdown for these students was: 39.32% white female, 42.54% white male, 6.96% black female, 7.24% black male, 0.52% Asian female, 0.58% Asian male, 1.19% Hispanic female, and 1.64% Hispanic male (Brevard County School Board, Student Services).

Study Sample

The study sample consisted of 216 fifth grade students from two Brevard County elementary schools. The two schools were selected opportunistically based on their principals' willingness to participate. These schools offered a total of nine self-contained fifth grade classes for this study. The students at each school were already placed in the classes.

Each class included exceptional students, those that have tested gifted as well as those students with specific learning disabilities (SLD). The student characteristics presented in Table 1, broken down by race and gender, confirm that the sample can be generalized to the accessible population. Differences between the students due to backgrounds and home-life could not be controlled.

One class from each school was randomly assigned to each of the four research groups:

M/C = mandatory/competitive

M/NC = mandatory/noncompetitive

V/C = voluntary/competitive

V/NC = voluntary/noncompetitive.

Random assignments were made by a drawing. The school with five classes had two V/NC Groups; however, one class was not included in the final data analysis because they were informed of their involvement in a research study and there was mismanagement in administering the post-tests.

Table 1

Breakdown of Study Sample by Race, Gender, and Exceptionality

	Race:	White		Black		Asian		Hispanic		Total
Gender:		F	M	F	M	F	M	F	M	(%)
Normal		68	72	11	10	2	1	4	6	80.6
Exceptional:	Gifted	11	18	1	0	2	0	0	1	15.3
	SLD	2	7	0	0	0	0	0	0	4.2
Total (%)		37.5	44.9	5.6	4.6	1.8	0.5	1.8	3.2	

Instruments

The *Children's Attitudes Toward Science Survey* (Hamrick & Harty, 1987; Harty, Samuel, & Beall, 1986) was used to assess students' attitudes toward science. This instrument consisted of 20 Likert-type items to give a range of scores from 20, representing negative attitudes, to 100, representing positive attitudes. Harty, Andersen, and Enochs (1984) found alpha internal consistency to be 0.78, and split-half internal consistency reliability to be 0.76 when testing 151 fifth grade students. They also found test-retest reliability to be 0.55 ($p < 0.01$) with a three week interval. Harty, Samuel, and Beall (1986) computed an alpha reliability of 0.88 and split-half reliability of 0.89 when they tested 228 sixth-grade students.

The students' interest in science was determined using the *Children's Interests in Science Measure* (Hamrick & Harty, 1987; Harty, Samuel, & Beall, 1986). It also consisted of 20 Likert-type items that students rated on a scale of 5 (fully agree) to 1 (do not agree with at all). The scores range from a low interest in science score of 20 to a high interest score of 100. With 151 fifth grade students, Harty, Andersen, and Enochs (1984) established internal consistency reliabilities of 0.85 for alpha reliability and 0.76 for the split-half reliability method. A test-retest reliability was established with three weeks between administration times, and was found to be 0.72 ($p < 0.01$). Harty, Samuel, & Beall (1986) calculated alpha reliability as 0.87 and split-half reliability as 0.82 for 226 sixth-grade students.

Students were pretested and posttested to determine change of interests in science or attitude toward science. An administration time of 15 minutes was needed for each test. The classroom teacher administered the tests to his/her own class.

Procedure

This study began during the sixth week of the school year to allow the classes time to stabilize. A Gantt chart depicting the flow of the study is provided in Figure 1. Initial contact was made by phone to identify schools with at least four self-contained fifth grade classes. Meetings were then scheduled with school administrators and instructors to provide a brief overview of the research and an outline of this project. When two schools were found, dates for the workshop and research were scheduled.

Weeks:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Teacher Training									
Pretesting									
Student/Parent Notification									
Science Project Preparation									
Science Fair									
Posttesting									
Interviews									

Figure 1. Time flow of research design

Instructor Training

The instructors participated in a four-hour inservice workshop entitled "Science Fairs Can Be A Positive Experience" one week prior to implementation. The workshop was sponsored by the Space Coast Center of Excellence in Science, Mathematics, Computers, and Technology and was facilitated by Diana W. Chester, Assistant Director of the Center and myself. Instructors from one of the schools were unable to attend the workshop at the Center of Excellence, so were trained at their site.

The first hour involved instruction on implementing this research project. The purpose and objectives of the project were explained and each participant was provided with a training packet. The packet included the pretests (color coded for easy identification), a letter of instruction, student worksheets on the scientific method, letters to parents, workshop manuals, and supplemental lists of science projects suitable for primary grades. Questions were answered about the materials or research and examples were shown of completed science project notebooks.

The remaining workshop time involved the teachers in hands-on science activities and a review of the scientific method. Discussion centered on techniques for teaching the scientific method and various ways to develop experiments for elementary students. Participants were provided with two manuals, *Kitchen Chemistry* and *Toying With Fizzics* from which the workshop activities were taken.

The instructors for the competitive groups (A and C) were told to remind their students twice a week about the fair and the medals available for the two top projects. The instructors for the non-competitive groups (B and D) were also told to encourage students twice a week, but to focus on the "fun nature" of the fair, stating that every student participating would receive an award ribbon.

Twice a week the mandatory group instructors (A and B) reminded their students that projects were required. The instructors of the voluntary groups (C and D) encouraged participation by highlighting the experience and the award factor. Projects completed for this study were not used by teachers for calculation of student grades since project conditions varied between classes.

Parent and Student Instructions

A letter was sent home with each student on Monday afternoon of the sixth week explaining the conditions of their class science project. It illustrated that this small-scale fair would expose the students to the science fair concept and prepare them for the school science fair in late March. The letter stressed the opportunity provided for students to apply their science knowledge in a project form.

Parental involvement with the student's project was also addressed in the letter. It stated that encouragement from parents was appreciated, but allowing the student to work on and complete the project on his/her own provided the greatest benefit.

Science Fair Preparation

The instructors administered both the *Children's Attitudes Toward Science Survey* pretest and the *Children's Interests in Science Measure* pretest Monday morning of the sixth week of school. The teachers read the instructions aloud to the students. Students responded in the space provided on each test. Their teacher-assigned code was written in the top right corner of each test. On the following morning, during the time set aside for science in their regular class schedule, each teacher explained the science project as it pertained to that class. The students were instructed to select and complete a science project that interested them. All work was to be done at home as no class time was given for project preparation.

A science project notebook containing information about his or her experiment was to be turned in by each participating student. Examples of two completed project notebooks were shown to the students as guides. The notebooks were to take the place of the science fair backboard and recount the student's project in a scientific format. Their results could be presented using graphs, sketches, photographs, or by written explanation. Backboards or other display equipment were not necessary for these projects.

Students were given six weeks to complete their experiments. Their science project notebooks were to be turned in by Friday of the sixth week of the project.

The Science Fair

The completed science project notebooks were collected and evaluated using the following criteria:

1. Title page - Is it present and neat? (2 points).
2. Question - Is it clear, can it be measured? (5 points).
3. Research - Is it complete, does it pertain to the topic, does it represent a diversity of sources, and include a bibliography? (15 points).
4. Hypothesis - Is it stated clearly, does it answer the question, is it scientifically sound? (10 points).
5. Materials - Are they specifically listed in sufficient detail? (3 points).
6. Procedure - Are they listed in chronological order, logical, and easy to follow? (15 points).
7. Results - Are the observations clear, sequential, and complete? (10 points).
8. Conclusion - Does it answer the question and explain the results logically? (15 points).
9. Scientific Thought - Was the scientific method followed, and is the notebook detailed? Does the student appear to understand the facts? (20 points).
10. Creativity - Is this a distinctive approach to problem solving and is this project original and presented imaginatively? (5 points).

A "Science Project Judging Form" was filled out for each project notebook by two of the panel of judges. The judging panel consisted of two undergraduate students and one graduate student from the Science Education Department at Florida Tech. A total score was obtained for each project by taking the mean scores from the two judging forms. The projects were then ranked so that the highest scores from groups A and C would be first and second place winners.

Each class held their own science project awards ceremony in their classroom during the seventh week of the project. School administrators were invited to attend. The principal of School L participated in the awards ceremony while no administrators attended at School P. Medals were awarded to only the top two winners of groups A and C. These students were asked to come forward and share their project with the class and their medals were draped around their necks. Participation ribbons were awarded to all students in groups B and D, and all of these students were given the opportunity to share their projects with their class.

The teachers administered the posttests measuring attitude toward science and interest in science during the afternoon of the presentation ceremony. These tests were also color coded for easy identification. Students were asked to write their assigned codes in the top right corner of the test.

Treatment Verification

Impromptu observations made during implementation, and student interviews, which took place after administration of the posttests, were used to verify treatment. I interviewed three or four students from each class outside of the classroom to obtain sincere and honest responses. They were each asked questions to promote conversation about their teachers' instructions as well as their interests in science, their attitudes toward science, their self-esteem, and the amount of parental support they received. These interviews also provided qualitative information concerning the effects of science fairs on fifth grade students.

Analysis of Data

Data collected for each of the two dependent variables (attitudes toward science and interests in science) were evaluated separately. Scores from only those students that participated by completing a science project and presenting a notebook were used. Means and standard deviations were calculated for each group. The main statistical tool used in the treatment of data was analysis of covariance (ANCOVA). Interactions between covariates and independent variables were tested for significance. There were no significant interactions when attitudes toward science was the dependent variable and the interaction terms were dropped from the model. The following variable assignments were used in the final analysis of attitudes:

Independent Variables: X_1 = Attitude Pretest

X_2 = Interest Pretest

X_3 = Award Structure

Dependent Variable: Y_1 = Attitude Posttest

For the analysis of the dependent variable interests in science, attitude pretests and the interaction between attitude pretests and award structure were dropped from the model because they were not found to be significant. However, there was a significant interaction between the covariant interest pretest scores and the independent variable award structure. This interaction between the independent variable and the covariant violated the homogeneity of regression assumption of ANCOVA. Instead, an attribute treatment interaction (ATI) analysis was performed using multiple regression techniques (Cohen & Cohen, 1983).

The variable assignments used in the final analysis of the dependent variable, interests in science, were as follows:

Independent Variables: X1 = Interest Pretest

X2 = Award Structure

X3 = X1 * X2

Dependent Variable: Y2 = Interest Posttest

Missing data from participating students consisted of one set of pretest scores and ten sets of posttest scores from both attitudes and interests. Since the missing pretest scores were less than 2% of the sample population, mean pretest scores were entered in their place. The ten students with missing posttests were removed from the study sample leaving a sample size of n = 84.

RESULTS

The results of this study are separated into three sections. The first section includes descriptive statistics associated with the pretest and posttest scores of attitudes toward science and interests in science. Science project scores are also presented in this section. The second section includes inferential statistics analyzing award structure among the mandatory groups. Analysis was not made between levels of participation since there were only five students in the voluntary/competitive group and no students in the voluntary/noncompetitive group that completed projects. The last section contains the results of an aptitude treatment interaction (ATI) analysis of the dependent variable interests in science.

Descriptive Statistics

The means and standard deviations from pretests and posttests of attitudes toward science and interests in science from the participants by group is presented in Table 2. The scores for attitudes toward science decreased in the mandatory/competitive group. However, their interests in science increased under the same conditions. Students who participated in a mandatory/noncompetitive fair displayed an increase in both attitudes and interests. The five students that participated voluntarily in a competitive fair showed a large decrease in attitudes, and yet showed an increase in interests.

Table 2

Participants' Means and Standard Deviations for Attitudes Toward Science and Interests in Science Pretests and Posttests by Group

	Attitude Pre		Attitude Post		Interest Pre		Interest Post	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
M/C	64.3	5.9	63.8	7.3	63.3	11.7	66.3	13.9
M/NC	63.6	6.8	65.4	12.7	69.9	16.0	74.8	23.1
V/C	64.2	2.3	43.2	9.4	75.6	9.6	76.2	4.3

M/C = mandatory/competitive (n = 43)

M/NC = mandatory/noncompetitive (n = 36)

V/C = voluntary/competitive (n = 5)

Five of the six sets of scores measuring attitudes and interests showed larger standard deviations among the posttest scores than the pretest scores. This indicates a wider distribution among the posttest scores as compared to the pretest scores. The distribution changes for the mandatory groups are illustrated in Figures 2, 3, 4, and 5.

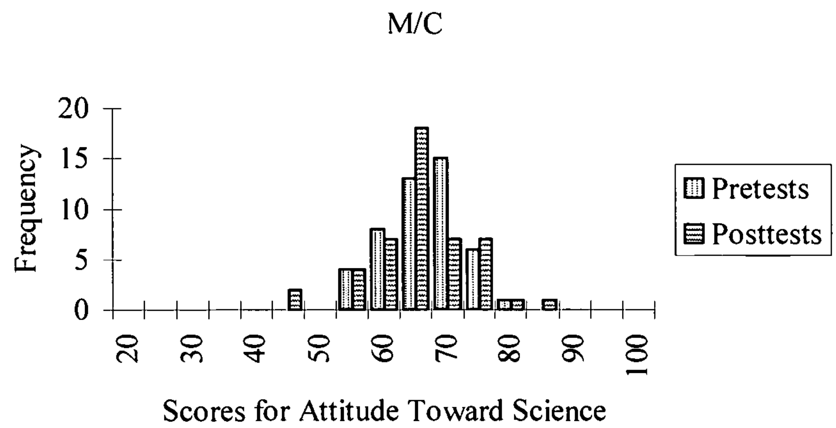

Figure 2 **Mandatory/Competitive Frequency Distributions of Pretest and Posttest Scores of Attitudes Toward Science**

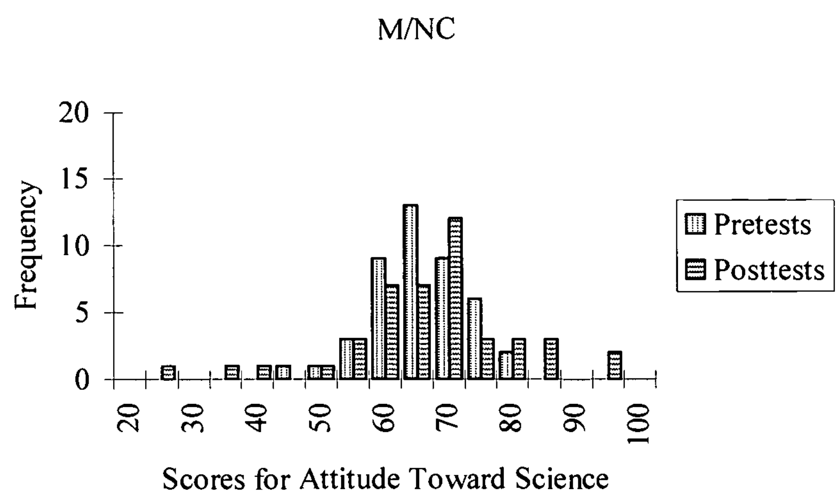

Figure 3 **Mandatory/Noncompetitive Frequency Distributions of Pretest and Posttest Scores of Attitudes Toward Science**

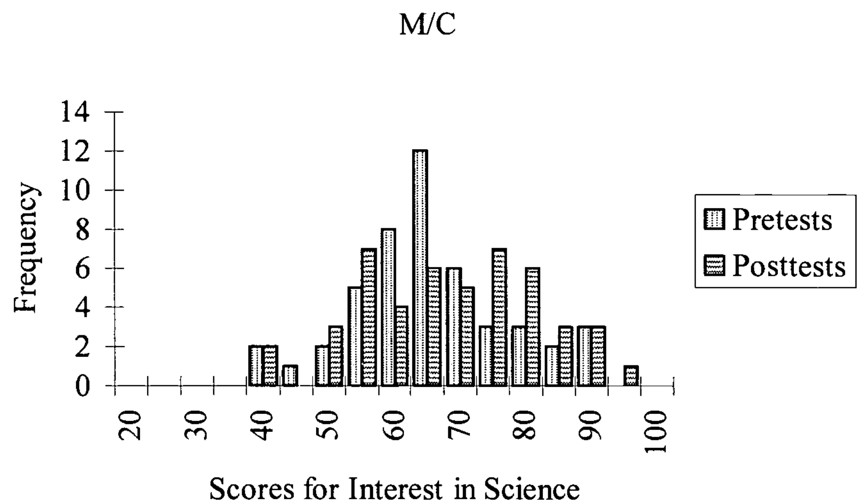

Figure 4 **Mandatory/Competitive Frequency Distributions of Pretest and Posttest Scores of Interests In Science**

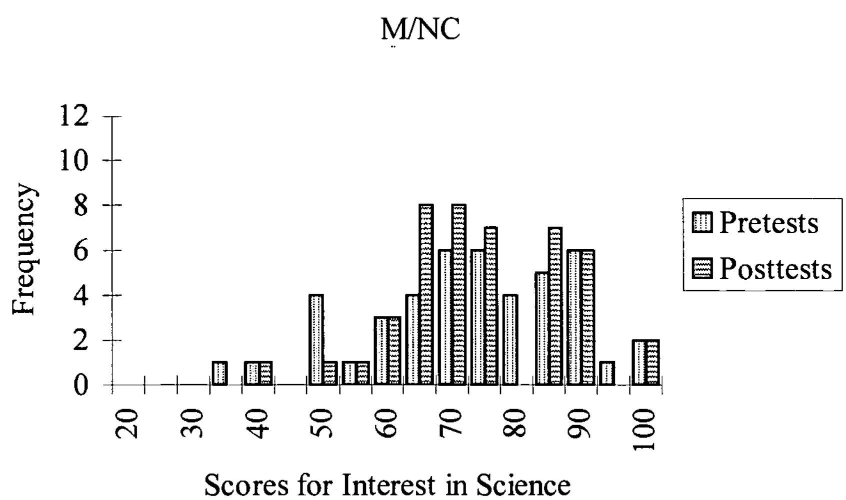

Figure 5 **Mandatory/Noncompetitive Frequency Distributions of Pretest and Posttest Scores of Interests In Science**

Table 3 presents information regarding science projects completed by the students in each group. Of the two mandatory groups, the competitive group produced a higher mean science project score than the noncompetitive group. The number of students who completed a project ranged from a high of 91% in the M/C group to a low of 0% in the V/NC group.

Table 3

Science Project Scores by Group

	Projects (#)	N	Participated (%)	Mean	SD
M/C	43	47	91	53.4	18.8
M/NC	36	44	82	44.6	22.9
V/C	5	49	10	39	16.8
V/NC	0	50	0	NA	NA

It was interesting to note that there was no correlation between science project scores and any of the pretest or posttest scores.

Inferential Statistics

Analysis of Covariance (ANCOVA) was performed on the data from the mandatory groups to determine differences between the levels of award structure ($\alpha = .05$). The data in Table 4 shows that no significant differences were detected between attitudes toward science of those students who participated in a competitive fair and those students who participated in a noncompetitive fair when attitude and interest pretests were used as covariates. However, the data in Table 5 shows that levels of award structure were significantly related to the students' interests in science when interest pretest was used as a covariant. The interaction between award structure and interest pretests was also found to be significant which necessitated the use of an ATI analysis.

Table 4

ANCOVA Summary When Attitudes Toward Science Serve as the Dependent Variable

Source	df	SS	MS	F-Value	P-Value
Attitudes-Pre	1	115.8	115.8	1.3	.260
Interests-Pre	1	747.6	747.6	8.3	.005
Award Structure	1	0.953	0.953	0.011	.919
Residual	75	6736.1	89.8		

Table 5

ANCOVA Summary When Interests In Science Serve as the Dependent Variable

Source	df	SS	MS	F-Value	P-Value
Interests-Pre	1	5008.9	5008.9	45.0	.0001
Award Structure	1	1766.6	1766.6	15.7	.0002
Award*Int-Pre	1	1673.0	1673.0	14.8	.0002
Residual	75	8451.2	112.7		

Aptitude Treatment Interactions

Because an interaction was detected between the covariant interest pretests and the independent variable award structure, the ATI analysis using multiple regression was conducted. Beta coefficients were derived from the ANCOVA and were used in the following equation to plot an ATI:

$$Y_2 = .934(X_1) + 47.786(X_2) + -.691(X_3) + 7.248$$

Dummy coding was used in the equation for the main independent variable award structure, X_2. Competitive award structure was assigned a "0" and noncompetitive award structure was given a "1". Two separate regression equations resulted; one for the competitive group and one for the noncompetitive group.

$$Y_c = .934(X_1) + 47.786(0) + -.691(X_1 * 0) + 7.248$$
$$= .934(X_1) + 7.248$$

$$Y_{nc} = .934(X_1) + 47.786(1) + -.691(X_1 * 1) + 7.248$$
$$= .243(X_1) + 54.734$$

As outlined in Chapter 3, initial aptitudes were entered into the regression equation to plot an ATI (Figure 6). The range of initial aptitudes, X_1, was derived from the actual range of interests in science pretest scores (35 to 96). Low aptitude was given a score of 35; medium aptitude, 65; and high aptitude, 96. Table 6 displays the expected posttest scores on interests in science for each of these three levels of aptitude. Figure 6 clearly shows that elementary students with low initial interests in science would be expected to benefit more from science fairs with a noncompetitive award structure. On the other hand, students who begin with high interests in science would be expected to respond negatively under noncompetitive conditions. These results should be viewed cautiously because the sample was small for an ATI study (Germann (1989).

Table 6

Expected Posttest Scores of Interests Toward Science Based on Students' Initial Interests and Level of Award Structure

		Initial Interest Scores*		
		Low	Medium	High
Expected Post-Interest Scores	M/C	39.9	68.0	96.9
	M/NC	63.5	70.8	78.3

* Low = 35, Medium = 65, High = 96

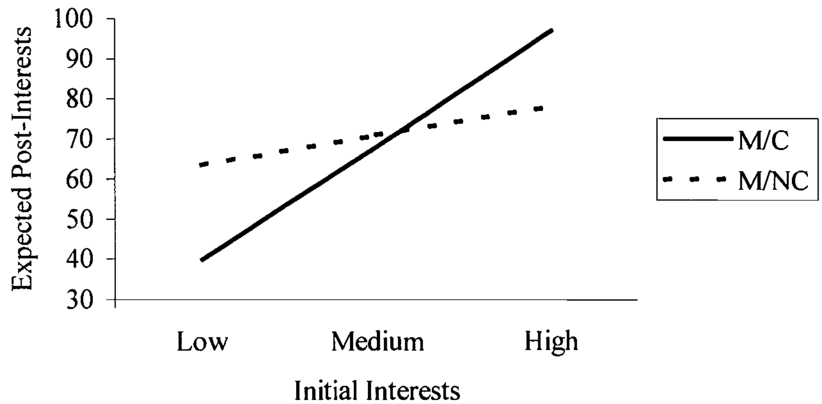

Figure 6 Aptitude Treatment Interaction Between Initial Interests and Post-Interests In Science

DISCUSSION AND CONCLUSIONS

Summary of Principal Findings

This experimental study examined the effects of two levels of participation (mandatory and voluntary) and two levels of award structure (competitive and noncompetitive) on fifth grade students' attitudes toward science and interests in science.

The first hypothesis stated that the award structure of a science fair would not influence elementary students' attitudes toward science nor interests in science. The results of this study supported this hypothesis with regards to students' attitudes. However, students' interests were significantly higher under noncompetitive conditions, therefore this hypothesis was rejected with regards to interests in science.

The second hypothesis, that the level of participation in a science fair would not affect students' attitudes toward science nor interests in science was not statistically analyzed due to the lack of participation among the voluntary groups. Nonetheless, the differences in numbers of participants between the mandatory groups and the voluntary groups leads one to believe that if students are to benefit at all from science fairs, they must be made mandatory.

The third hypothesis stated that there would be no interaction between levels of participation and levels of award structure on attitudes or interests. The results support this hypothesis, as there were no significant interactions found.

The last hypothesis addressed the number of students that would voluntarily complete a science project. There were only five students who participated voluntarily and they were all from the competitive group. No students from the voluntary/noncompetitive group completed a project; therefore, there was insufficient data for inferential testing of this hypothesis.

Discussion

The lack of involvement of the voluntary groups was surprising . Perhaps the teachers' lack of enthusiasm was an issue, or perhaps the thought of repeating a project for the school's science fair in the spring was a deterrent. The students that were interviewed said they "forgot" or "ran out of time" or "couldn't think of a project." Regardless of the reasons for not participating, it appears that for students to benefit from the inquiry-oriented, hands-on approach of science fairs, they must be made mandatory.

Competition may have been a motivating factor in the voluntary science fairs. All five of the students that participated scored above average on their interests in science pretest, and their interests posttest scores closely followed the M/C line plotted in Figure 6. But with so few students participating, this is inconclusive.

Students participating in the mandatory/noncompetitive fairs showed the greatest increase in interests in science scores. These results parallel previously reported results by Burtch (1983). The confirmation received by these students may allow them to feel good about their efforts in science, which may in turn promote greater interests in science. Removing the competitive aspect of academic competition changes the focus from the award to the project.

Harty, Samuel, and Beall (1986) related science ability to interests in science. From that viewpoint, the ATI graph provides teachers with valuable information concerning science fairs in a heterogeneous classroom. It suggests that students with high initial science abilities may be ill-served by participating in a mandatory/noncompetitive fair. This analysis also confirmed the findings of Kutscher (1990); Michaels (1977); Harty, Samuel, & Beall (1986); and Kyle, Bonnstetter, & Gadsden (1988) in reference to competition positively influencing only the high ability students. It appears that high ability students are more competitive and may also be more self-assured so that losing is not as hard on them. Competition may be counterproductive for lower ability students.

Threats to Validity

The non-random selection of students in this study may have been the cause for the initial characteristic differences. An assumption was made that the students were placed in the classes randomly. However, in actuality, the students were placed in classes with an effort to match the classes with each other. It was the goal of the principal to obtain heterogeneous classes, each containing students with a range of abilities, attitudes, and interests. This should have equalized the classes.

Validity threats due to teachers were also of concern. Teachers, past and present, affect students' attitudes and interests toward areas of study. For example, a teacher's enthusiasm portrays to the students the importance he or she places on the subject matter being taught. As role models, teachers set the tone for the class' general attitudes toward the material (Kutscher, 1990). Efforts to control these threats were made through training at the pre-study workshop and frequent reminders to speak enthusiastically when talking about the science fair. Despite these efforts, observations of the nine classes involved in this study revealed a variety of approaches to science and a wide range of enthusiasm between teachers from each school. An attempt to control these differences was made by placing one class from each school into a group.

Posttest scores may also be a reflection of the activities involved within the classroom. This study took place, for the most part, outside of the classroom so students continued their regularly scheduled science classes. The post-attitudes and interests displayed by the students could have been a carry-over from the science topic being covered in the classroom during the time of this study. Since all of the classes were studying oceanography, which is an enticing subject for elementary students, any possible carry-over effects should have been evenly distributed among the students so that comparisons of group means would not be affected.

It was also observed that teachers at one school incorporated a variety of inquiry oriented activities while the teachers from the other school brought in weekly guest lecturers. These different teaching methods could also have affected the students' attitudes and interests in science. An effort to control these differences between schools was made by having all four groups represented in each school. Each group consisted of two classes, one from each school.

Mortality was not perceived as a serious threat. The students who did not complete posttests were evenly distributed throughout the four groups.

The lack of students who voluntarily participated by completing a science experiment and turning in a notebook was also considered a threat. The attitudes and interests of students who actually completed a project could very well be affected differently than those students who did not take part and therefore, had no vested interest. Students who worked hard to turn in a notebook and then subsequently lost during the fair may have developed a negative attitude. On the other hand, students who declined involvement may have felt relieved and possibly confirmed by their choice. This was controlled by analyzing only those students that completed a science experiment and turned in a notebook on time.

Some students brought in their science project notebooks up to a week after the posttests were given, but they were not included as part of this study. All of the students who brought in late notebooks were from the mandatory/noncompetitive group, and they expressed a desire to obtain a participation ribbon and coupon. This suggests there may be benefits to the students by repeating the fair annually.

Although the importance of following the design of this study was stressed, one teacher of the voluntary/noncompetitive group altered the conditions. Students in her class who completed a science project and brought in their notebook by the due date were rewarded with a movie. This extra enticement increased the student participation to 88%, which exceeded the 82% participation of the mandatory/noncompetitive group. These students were not included in this study to avoid implementer bias.

Recommendations for Future Research

The results of this study prompt further questions not specifically addressed by the hypotheses. One question involves the students' academic achievement, or ability, and its effects on attitudes and interests. Comparative achievement scores could not be obtained from both schools involved in this study, so future studies that examine the correlation between achievement and attitudes and interests is called for.

While there are many characteristics that can affect students' performances in a science fair, the ATIs from this study focus only on the students' initial attitudes toward science and interests in science. Perhaps it would have been wise to analyze the students' self-esteem as well.

The ATI results from this study suggest that science fairs, as an enrichment program, perpetuate a form of inequality and should be evaluated further. Determining the aptitudes most responsible for the responses from different award structures would be valuable information.

The long term effects science fairs have on students' attitudes and interests is another question not addressed in this study. Only the initial change in attitudes and interests as a result of one science fair experience was examined. A study that follows students over a number of years, recording various science experiences, would be beneficial.

The initial testing of these fifth grade students showed a wide range of scores for attitudes and interests (52 and 72 points respectively). They arrived in fifth grade with four years of science experiences that have influenced them in some way. A study to determine at what age a science fair might best inspire a student would be interesting.

Future studies might look at differences in attitudes, interests, and science project scores between students who were given class time and teacher assistance while completing a science project and those students who must complete their project outside the classroom. Establishing positive science learning situations for elementary students requires the involvement of many. Teachers help to bring relevance to science education by guiding and coaching students with science projects during class time (Kutscher, 1990). Administrators become involved by offering students positive science fair experiences.

Applications

If the type of science fair a particular student should encounter can be predicted by a prior analysis of some attribute, each student would only have to encounter the type of science fair that was expected to best suit him or her. But for instruction to be responsive to these attribute differences among students, schools would have to offer students a choice as to whether or not they compete for awards and offer at least two different types of science fairs. This scenario is unrealistic, as well as impractical within the public school system. A compromise may be to hold competitive fairs only among the gifted and/or advanced classes while the remaining student body participate in a noncompetitive fair.

The goals of a science fair have always included promoting interests in science (NSTA, 1990). If requiring students to submit a science project that will be entered in a fair with only one winner does not increase interests, obviously a different approach is necessary. This study encourages a re-examination of the award structure of science fairs at the elementary level. Carlisle and Deeter (1989) recommended that students compete only against standards set by the school or the county. Other options might include creating more winning places to produce a greater number of winners; or more special awards so that every student wins something; or even an olympic-type event where each student wins either a gold, silver, or bronze medal.

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