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ABSTRACT

Males are more likely than females to aspire to and attain careers in science. This pattern might be attributed to differences in the appeal of school science to boys and girls. In this study, 114 middle school students in grades 7 and 8 carried out versions of science experiments that differed in their motivational appeal. Findings showed that boys were more attentive to aspects of science experiments that elicit perceptions of control, whereas girls were more attentive to social aspects. Further, attempts to enhance the interest value of science experiments were found to be more effective for girls than boys. Motivational enhancement of science experiments was found to affect subsequent choices to participate in science experiments. An appendix discusses modifications to the experiment procedure. (Contains 2 tables, 3 figures, and 12 references.) (Author/SLD)

RESEARCH REPORT

GENDER DIFFERENCES IN SCIENCE INTEREST

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Running head: GENDER DIFFERENCES IN SCIENCE INTEREST

Abstract

Males are more likely than females to aspire to and attain careers in science. This pattern might be attributed to differences in the appeal of school science to boys and girls. In this study, middle school students carried out versions of science experiments that differed in their motivational appeal. Findings showed that boys were more attentive to aspects of science experiments that elicit perceptions of control, whereas girls were more attentive to social aspects. Further, attempts to enhance the interest value of science experiments were found to be more effective for girls than for boys. Motivational enhancement of science experiments was found to affect subsequent choices to participate in science experiments.

Gender Differences in Science Interest

Introduction

In the U. S., there are marked differences between the proportions of men and women who work as scientists. Women compose about 48 percent of all professional workers, but only 25 percent of all scientists. The underrepresentation of women is most severe in the physical sciences and engineering, where in 1983 women composed 10 percent and 3 percent of workers in those fields, respectively (National Science Board, 1985).

Differences in science-related career aspirations surface before students reach college: Among SAT examinees planning to obtain advanced placement in physics, 72 percent were males and 28 percent were females (College Board, 1987). Of those examinees planning to major in the physical sciences, only 30 percent were females, and of those intending to major in engineering, 16 percent were females.

The reasons for differences in scientific attainment and aspiration are undoubtedly complex and interactive. One hypothesis is that males, as a result of many forces, are more likely to develop positive attitudes toward science, and that these positive attitudes lead them to choose scientific careers. Some evidence to support this view was found by the National Assessment of Educational Progress (1986) in their 1985-86 science assessment. When eleventh graders were asked, "When you have science in school, do you like it?," 61 percent of boys answered yes, as opposed to 52 percent of girls. Attitudes toward science might influence decisions such as how many science courses to take in high school, whether to choose a science major, and whether to pursue a scientific career.

The present study, focusing on middle school science, addressed three questions about the importance of interest in science: (1) Do males and females differ in the aspects of science experiments they find interesting? (2) Do interest-related enhancements to science experiments play a more important role for one gender than the other? and (3) Do attitudes toward science affect the decisions that students make about involvement with science?

A Model of Interest in Science

In this study, the interest value of science experiments was manipulated by making modifications to the procedures of junior high school (seventh and eighth grade) physical science experiments. A model of interest in learning guided the motivational enhancement and degradation of the experiments. Three dimensions of the interest appeal of science experiments were discerned from the literature on interest and intrinsic motivation: (a) cognitive appeal, (b) mastery appeal, and (c) social appeal.

Cognitive appeal describes environments that present novel, vivid, or discrepant stimuli. The effect of these stimuli may be to promote a sense of curiosity, fascination, or fantasy. More generally, the environment engenders what Piaget called "cognitive disequilibrium," which occurs when new information cannot be incorporated into existing cognitive structures. If the new information is discrepant with what is already known, the perceiver is motivated to reduce the discrepancy. This process, called accommodation, is said to advance mental development (Gottfried, 1983). Since cognitive appeal does not necessarily involve feelings of achievement or social involvement, it is separable from the other two components of the model.

Mastery appeal arises from the ability to deal (.ectively with one's environments or to direct oneself in them. It has been suggested that, beyond survival needs, a person's primary interest is to change his or her environment (deCharms, 1976). Mastery appeal manifests itself in self-determination, in a propensity to formulate and carry out plans. Environments or tasks have mastery appeal when they engender a sense of control.

Social appeal describes situations that foster cooperation with others toward some common objective, and reflects Bruner's (1966) notion of reciprocity. It is not imitation of others, but fitting oneself into an enterprise where relationships among participants are important, as are the attitudes of participants toward their common goals.

Many theorists have tried to decompose interest and intrinsic motivation; some commonly cited categories fall fairly neatly into the proposed components of cognitive, mastery, and social appeal. Bruner (1966), for example, hypothesized that the will to learn was stimulated by three factors: curiosity, a desire to display competence, and reciprocity, the satisfaction gained by cooperative efforts toward reaching common goals. Malone and

Lepper (1987) have proposed fantasy, challenge, and cooperation (among others) as examples of intrinsic motivators. Interest dimensions described by other theorists and researchers, and the relationships of those constructs to the proposed dimensions, are displayed in Table 1.

Insert Table 1 About Here

In a separate study not reported here, the model received some empirical confirmation (Martinez, 1987). Middle school students responded to the question "What makes science experiments interesting?" by listing characteristics of enjoyable experiments. After a content analysis, these characteristics were reduced to a set of twelve. The twelve characteristics were sorted by another group of students into disjoint clusters according to whether they made science experiments interesting in the same way. The clusters were subject to a statistical technique known as latent partition analysis (Wiley, 1967). The analysis confirmed that the characteristics fell into three distinct clusters that corresponded closely to the components of the proposed model.

The purpose of the present study was to seek empirical evidence of the usefulness of the model in enhancing the interest value of science experiments. Further, the study was intended to uncover individual differences in the effects of enhancements, and the relative importance of each of the components of the model.

Method

Sample

Subjects were 114 seventh and eighth grade students from intact science classes in public middle schools. The subjects ranged in age from 12 to 14. Although no formal assessment of socioeconomic status was made, students from these classes appeared to come from middle- and lower-middle class backgrounds.

Materials

Procedures from four science experiments were adapted from Physical Science[1] (Carter, Bajema, Heck, & Lucero, 1987), a textbook for middle school students. Pilot work indicated that two of the experiments, on acceleration and light, were quite popular among students, while the other two, on pendulums and density, were less popular. The ratings of popularity were gathered by asking students to rate the appeal of the experiments after they carried them out. The distinction between popular and unpopular experiments was used for data analysis.

Two of the experiments, on accleration and pendulums, were presented in two versions: original and enhanced in interest value. The other two experiments, on light and density, were presented in original, interest-enhanced, and interest-degraded forms. Modifications were guided by the model of interest described above such that enhancement and degradations were made along all three lines of appeal (cognitive, mastery, and social). The modifications were not manipulated independently on each component because pilot work indicated that enhancements on one dimension alone were insufficiently powerful to create a detectable effect.

As an example of an enhancement for cognitive appeal, the following fantasy introduced the experiment on density:

> Imagine You and your partner have been hired by NASA to design part of a space station. But first you have to decide which materials to use. There are several possibilities, including wood and steel. To find out which is the best, you and your partner must find out their densities.

Other modifications were intended to enhance or degrade mastery appeal and social appeal of the experiments. A complete account of the nature of the interest modifications is given in Appendix 1.

Procedure

The study took place in two phases with two separate groups of students. In the first phase, science experiments were used in their original and enhanced forms. In the second phase, students used experiments in their original, enhanced, and degraded forms. In all experiments, students chose the partners they wished to work with and these pairs were randomly assigned to treatment conditions. The time allotted for each experiment was about 1.5 hours and extended over three class periods for two experiments. This was sufficient time for all pairs of students to complete two experiments.

Upon completing the experiments, students were given a questionnaire designed to assess their interest in each experiment. The questionnaire had four scales: overall appeal, cognitive appeal, mastery appeal, and social appeal. Each scale had six statements to which students responded strongly agree, agree, unsure, disagree, or strongly disagree on a Likert-type scale. The maximum score on each of the four scales was 24.

Finally, students were told to choose an additional experiment on the same subject as one they had completed. For example, if students completed an experiment on light and one on density, they were told to choose whether to do a follow-up experiment on light or one on density. The students never actually performed the additional experiment, but the signup data were used as quasi-behavioral measures of the effect of interest enhancements on subsequent choice regarding science participation (see Maehr, 1976).

Results

The design was a 2 x 2 x 2 MANOVA, with factors of interest enhancement, the gender of the subject, and popularity of the experiment (popular or unpopular) in its original form. Dependent variables were the cognitive, mastery, social, and overall appeal of the experiments.

Main Effects: Treatments

A MANOVA was carried out with the dependent variables of self-reported cognitive, mastery, social, and overall appeal. Enhancements were found to have a positive effect on overall appeal of the unpopular experiments ($F(16, 176)=5.40$, $p<.01$), but not on popular ones. That is, motivational enhancements were effective only in procedures that were less interesting in their unmodified state.

Main Effects: Gender

Across treatment conditions, boys and girls differed in their ratings of the motivational appeal of the experiments. These differences were significant on two dependent variables: mastery appeal and social appeal. Table 2 shows that, across treatment conditions, girls rated all four experiments more socially

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Insert Table 2 About Here

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appealing than did boys. They responded to statements such as "This experiment helped us work as a team" and "My partner and I helped each other more than usual" with greater affirmation than did boys; these differences were statistically significant in three of four experiments (Figure 1).

Insert Figure 1 About Here

Another consistent finding was that boys rated the experiments higher in mastery appeal than did girls (Figure 2). Boys responded to statements such as "I knew exactly what to do during the experiment" and "I felt confident during the experiment" with greater affirmation than did girls. These differences were statistically significant in the density and light experiments.

Insert Figure 2 About Here

Gender x Treatment Interaction

In general, girls were more responsive to motivational enhancements than were boys (Figure 3). The interactions between gender and interest enhancement were strongest in the unpopular experiments, in which gender x treatment interactions were significant in overall appeal ($F(2, 95)=4.40$, $p<.05$) and cognitive appeal ($F(2, 95)=3.37$, $p<.05$). That is, the motivational enhancements on the unpopular experiments were significantly more appealing for girls than for boys. Boys actually reported that enhanced versions were more appealing than original versions, but this difference was not statistically significant.

Insert Figure 3 About Here

Further evidence that girls responded more strongly to interest enhancements was that simple main effects were statistically significant on overall and cognitive appeal on the unpopular experiments, and mastery appeal on the popular experiments. The lower ratings given by girls may have provided more opportunity for enhancements to affect self-reported ratings of interest.

Signups for Future Experiments

After students completed the experiments, they were asked to sign up for an additional experiment, described merely as being similar to one of the two they had just completed. Interest enhancements positively affected signup frequencies. Students were more likely to sign up for an additional experiment of the kind that they carried out in enhanced form. The differences were statistically significant in Phase 1 of the study (Chi square (2, n=37)=3.93, p<.05), but not in Phase 2.

Summary of Results

The following generalizations summarize the data:

1. Boys and girls differed in the self-reported intrinsic interest of the experiment procedures. Girls rated the experiments higher in social appeal and boys rated the experiments higher in mastery appeal.

2. Gender x treatment interactions indicated that girls were generally more responsive to motivational enhancements than were boys.

3. There was some evidence that interest enhancements can positively influence choices about which experiments to carry out in the future.

Discussion

Science teachers often have considerable choice in the selection and modification of experiments their students carry out. This study shows that tnese choices can influence students' attitudes toward science experiments. Moreover, students differ in what they find interesting in a science experiment. In this study, boys were more likely to be interested in gaining a sense of control over the experiment. Overall, girls reported lower perceptions of mastery, a finding paralleled in many studies (Dweck, 1986). Girls were more interested in the social aspects of the experiments, and perhaps more important, were generally more sensitive to interest enhancements, as indicated by the simple main effects. Signup data also gave partial confirmation to the notion that interest can influence future choices about which science activities to engage in.

This experiment provided some evidence that attitudes toward science can be shaped by choice and modification of curricular materials. Over several years of schooling, the cumulative experience of science may very well contribute to decisions about whether to enroll in high school physics, or whether to choose a scientific career. When a teacher modifies an experiment to enhance its interest value, those modifications may produce great benefit, especially for girls, and increased interest may encourage the formation of positive attitudes toward science. But if experiments are chosen or explained haphazardly, or if little attention is given to the motivational appeal of the experiments, girls may be placed at a disadvantage. Teachers and curriculum developers would benefit from a clear concept of what makes science interesting. This knowledge can have immediate value and important long-term consequences.

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Footnote

1. Adapted from Physical Science: A problem-solving approach, Revised Edition by Joseph L. Carter and others, © Copyright, 1979, by Ginn and Company. Used by permission of Silver, Burdett, & Ginn.

Table 1

Dimensions of Interest

Theorist	Component of Proposed Model		
	Cognitive Appeal	Mastery Appeal	Social Appeal
Dewey (1902)	Instinct of Investigation Instinct of Art	Instinct of Making	The Social Instinct
Bruner (1966)	Curiosity	Competence	Reciprocity
Maslow (1970)	Cognitive	Esteem	Attachment
Harter (1980)	Curiosity Interest	Challenge	
Malone & Lepper (1987)	Fantasy Curiosity	Challenge Control	Cooperation Competition Recognition

Table 2

MANOVA and Univariate Statistics for the Combined Data Set: Factor=Gender

Variable	Gender: Males (n=46) M	SD	Females (n=55) M	SD	Significance Test
					F(8,88)
All Variables					4.44, p<.01
		Unpopular Experiments			
					F (1,95)
Overall Appeal	13.48	4.28	12.71	5.97	0.93, n.s.
Cognitive Appeal	12.70	4.36	11.82	5.71	0.98, n.s.
Mastery Appeal	14.67	3.99	11.31	6.07	11.44, p<.01
Social Appeal	14.35	6.34	18.31	4.75	11.24, p<.01
		Popular Experiments			
					F (1,58)
Overall Appeal	13.89	4.82	13.31	5.61	0.29, n.s
Cognitive Appeal	12.98	4.55	13.09	5.77	0.04, n.s.
Mastery Appeal	14.89	4.43	12.69	6.12	3.29, n.s.
Social Appeal	14.65	6.37	19.27	3.32	20.26, p<.01.

Note: The unpopular experiments are the pendulum and density experiments.
The popular experiments are the acceleration and light experiments.

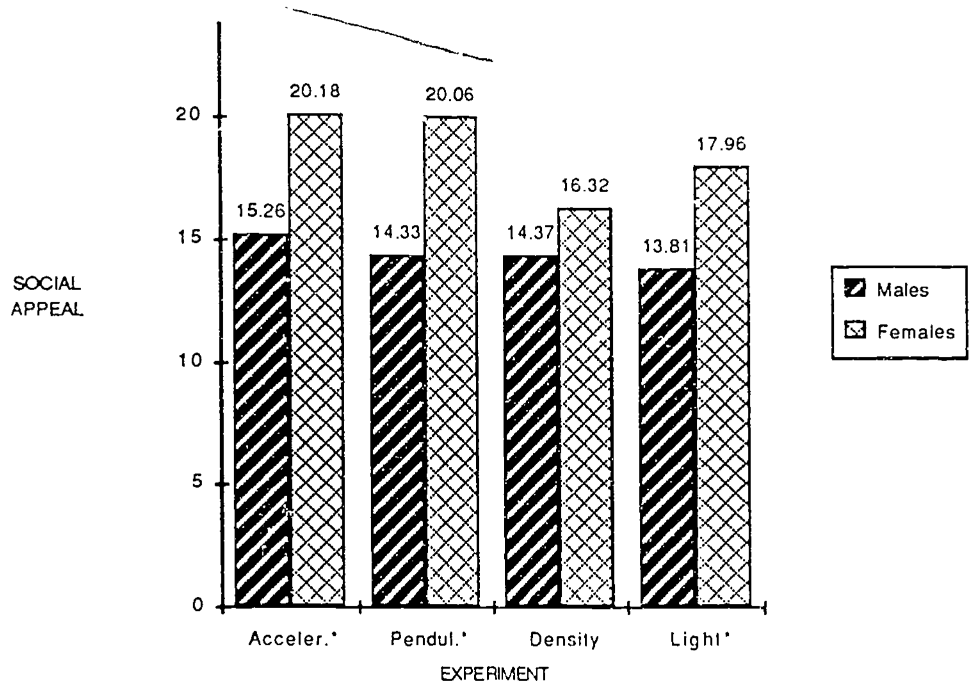

Figure 1: Differences in Social Appeal Across Experiments, by Gender
* gender difference significant; $p<.05$

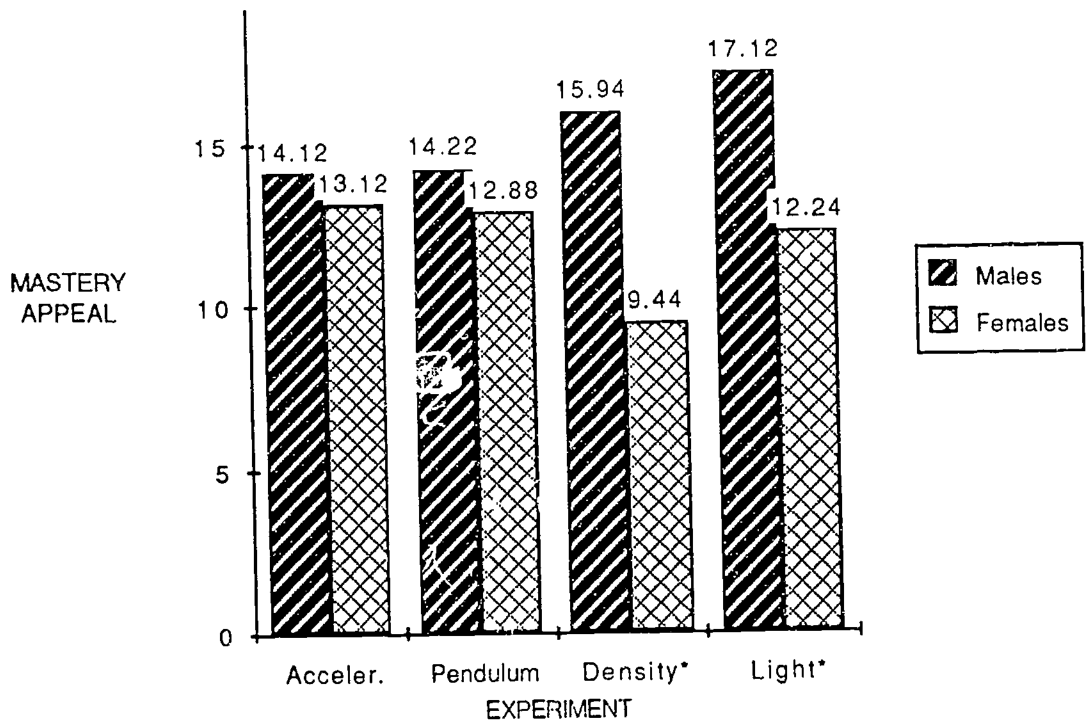

Figure 2: Differences in Mastery Appeal Across Experiments, by Gender
* gender difference significant; p<.05

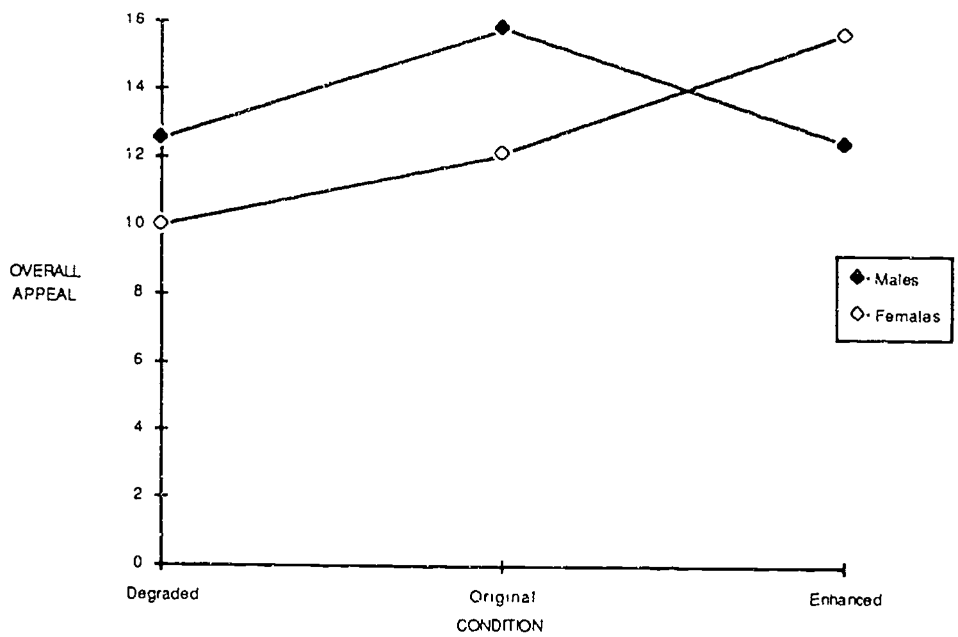

Figure 3: Gender x Condition Interaction (p=.01). Combined Data Set: Unpopular Experiments (pendulums and density).
Simple main effect for females (p<.01).

Appendix

Modifications to Experiment Procedures

Degradations

Cognitive Appeal

Increase in the number of trials used on each section

One font used in text protocol

Mastery Appeal

Sections of text layout less distinct than in original version

Explanations lengthened

Questions increased in number and difficulty

Social Appeal

Communication between partners was discouraged

Enhancements

Cognitive Appeal

Introduction of a fantasy related to the topic of study

Unusual type fonts

Words suggesting inquiry, such as "discover"

Casting of the experimental outcomes as mysterious and puzzle-like

Reduction in the number of trials used on each section

Unusual colors of paper

Mastery Appeal

Suggestion of challenge using phrases such as "if you can . . ."

Reformulation of the procedure to make layout simpler

Substitution of specific wording for ambiguous wording

Use of examples for calculations

Social Appeal

Persons references, such as "You"

Posing of questions requesting discussion, joint answers, and sharing of experiences relevant to the exercise

Assignment of a role to each partner (e.g. "releaser" and "timer")
