DOCUMENT RESUME

ED 404 109 SE 054 091

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TITLE The Role of Cognitive Dissonance on the Science Attitudes of Middle School Students.
PUB DATE 94
NOTE 33p.; Some pages may not reproduce well.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Classroom Research; *Cognitive Dissonance; Intermediate Grades; Junior High Schools; *Middle Schools; Science Education; Student Attitudes; *Writing Assignments
IDENTIFIERS *Attitudes Toward Science; *Middle School Students

ABSTRACT

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THE ROLE of COGNITIVE DISSONANCE on the SCIENCE ATTITUDES of MIDDLE SCHOOL STUDENTS

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Abstract

Based on the tenets of Leon Festinger's theory of cognitive dissonance, five preconditions for dissonance arousal were operationalized in a counterattitudinal essay writing task. The five preconditions were: perceived choice, irrevocable commitment, minimum incentive, perceived responsibility for consequences, and foreseeability of negative consequences of behavior. The sample was 141 middle school students enrolled in grades 6, 7, and 8. Subjects were asked to write essays on the theme "Why I like learning science," with the expectation that the essays would be publicly displayed and read by their peers. It was predicted that dissonance arousal following the essay writing task would be reduced by a positive attitude change in the direction of the counterattitudinal advocacy. The effect of grade level, gender, and three treatment levels on attitude change were assessed. Data were collected with the Middle School Science Attitude Scale and analyzed with the 3x2x3 ANCOVA; the pretest was treated as the covariate. A significant three-way interaction of grade level, gender, and treatment level on science attitude scores was found.

INTRODUCTION

The volume of attitude research published since the 1960's suggests that generating new knowledge in the affective domain is important to science educators. Yet reviewers assign us poor marks on the outcomes of our attitude research (Peterson and Carlson, 1979; Schibeci, 1984). We argue that past efforts have generated an amorphous block of single-shot studies that fail to form any theme or theory. Such a scheme deprives researchers the option to systematically design new studies atop the reflection and creativity of past generations of scholars.

At the same time, science educators are heirs to a legacy of theoretical frameworks already forged by fellow scientists working in the field of social psychology. A precedent of science educators staking their claim was set by a community of scholars who generated a decade of attitude research based on Hovland's learning theory model (Shrigley and Koballa, 1991).

PURPOSE OF THE REPORT

Herein we propose that science educators stake another claim, this time based on Festinger's (1957) cognitive dissonance theory. In this report our objectives are as follows:

1. Outline the six prerequisites to cognitive dissonance, the precursor to attitude change, as forged by three decades of research in social psychology based on Festinger's theory.

2. Report on a study designed atop the six prerequisites where the effect of writing pro-science essays on the science attitudes of adolescents was tested.

3. Analyze the study's research design in light of the findings and recommend revisions that could strengthen subsequent research in science education based on the Festinger model.

COGNITIVE DISSONANCE: WHAT IS IT?

A single, simple definition of dissonance has alluded attitude researchers for three decades. Elser (1986) advances a two-pronged definition that has evolved from two psychological bases: cognition and motivation. Festinger (1957) defined dissonance as an inconsistency between two or more cognitions; i.e., thoughts, beliefs or attitudes, e.g., "I smoke; smoking is harmful to my health". Here dissonance obviously has a cognitive base.

A motivational explanation asserts that dissonance is a feeling of discomfort aroused by circumstances that we would prefer to avoid, e.g., a longstanding NRA member who represents a district whose voters have tilted in the direction of gun control legislation.

Dissonance is commonly compared to such physiological drives as hunger and thirst. Dissonance can be sensed during consequential moments in life, e.g., when we make decisions; when new information seems contrary to current knowledge; or, when our behaviors seem not to match our attitudes.

Decision-making. After rendering a decision we may experience that sinking feeling that accompanies the nagging

thought that we may have made the wrong choice. This mild form of tension is especially evident if two choices manifest similar qualities. Consequently, we seek a means to reduce the dissonance.

To illustrate, we may experience some doubt following the purchase of a new car. Since we know very well that the car cannot be returned, we are prone to persuade ourselves that our choice of cars was fitting. For example, we may candidly compare the merits of our choice with the limitations of the other cars that we considered and rejected. If our neighbors concur with our arguments and admire our choice of automobiles, such opinions may reduce our dissonance. (Sears, et al., 1988)

Discrepant events. Science teachers have long realized the driving force of discrepant investigations, e.g., demonstrating that an ice cube will float in one clear liquid and sink in another. Students with a naive understanding of density commonly assume that both solutions are water, or that one ice cube is somehow heavier than the other. Seeing an ice cube sink in "water" is contrary to their prior experiences. Not privy to the knowledge that the second liquid is alcohol, a substance less dense than water, students express surprise, and may even experience an uneasy feeling (i.e., dissonance), by the unexpected behavior of the "sinking" ice cube. As a result, students commonly employ rapt attention and readily accept the challenge to make sense out of what they are seeing (Shrigley,1987;1991). Friedl (1991) aptly describes such student behavior thusly:

"Generally, there will be an inner feeling of 'wanting to know'".(p.3)

Attitude-behavior mismatch. The source of dissonance that interests attitude researchers, especially those employing Festinger's theory, is attitude-discrepant behavior. Examples of a mismatch in attitude and behavior are as follows: the pacifist who volunteers for combat duty; the biology teacher who joins a church that requires its members to embrace creationism; an anti-science student who is challenged to regard science from another point of view by writing a pro-science essay.

Under the conditions described later in this report, Festinger's theory predicts that the discrepancy between attitude and behavior of the pacifist, the biology teacher, and the science student, will arouse cognitive dissonance. To reduce dissonance, they can choose to alter their attitude so that it better matches their behavior. The pacifist may set aside dovish thinking and report for front line duty, or he/she may report for combat duty as a medic rather than a rifleman. The biology teacher may choose to embrace theistic evolution, and the student may choose to pursue more positive attributes of science instruction.

HISTORICAL PERSPECTIVE

When Festinger, a cognitivist, garnered evidence that minimum rewards fomented more change in attitudes than high rewards, one might have predicted that his theory would be controversial. Aronson (1980, p. 10) recalls that "...early dissonance experiments sounded a clarion call to

cognitively-oriented social psychologists, proclaiming in the most striking manner that human beings think, they do not always behave in a mechanistic manner". [Italics are Aronson's].

In a review of Festinger's (1957) book, Solomon Asch (1958), an early critic of the theory, commended Festinger for creating a theoretical tool that would bring coherence into a sprawling area of attitude research. Chapanis and Chapanis (1964) rendered major criticisms of the theory in a review of the first five years of dissonance research. Denying the existence of dissonance, Bem (1970) even advanced alternate interpretations of earlier research findings along the lines of radical behaviorism. However, the postulates of cognitive dissonance theory continued to serve as the theoretical rationale for hundreds of studies.

Festinger's theory has enjoyed a longer period of staying power than a dozen or more approaches to attitude change analyzed in the reviews of Insko (1967) and Kiesler et al. (1969). Its longevity is due, in part, to the scrutiny of researchers who have continued to test its tenets across three decades.

Cooper and Fazio's (1984) "A New Look at Cognitive Dissonance" reforms the theory by defining an additional source of dissonance. Evidence suggests that dissonance is more likely aroused in subjects from discomforting circumstances that they would prefer to avoid rather than Festinger's proposed ill-fitting cognitions. Elser (1986) tempers their claim by reminding the reader that dissonance

arousal draws upon two psychological bases: motivation and cognition. Both seem theoretically viable without lessening the reality of dissonance as a precursor to attitude change.

Cooper and Fazio (1984) also disclose several prerequisites that must be in place before the arousal of dissonance in subjects can be predicted to occur. Those prerequisites serve as the theoretical rationale for the study reported herein.

DISSONANCE IN THE LIFE OF ADOLESCENTS

Involving adolescents in cognitive dissonance as a result of writing a counterattitudinal essay may be novel, but it is hardly without precedent within the mores of our society and the practices of science teachers.

Parents and teachers have long challenged young people to walk in the shoes of another before rendering a judgment about other people or their viewpoints. Wrestling with social or environmental concerns, e.g., the animal rights activists' criticism of confining wild animals, such as Shamu, the killer whale, to an aquarium, can thrust adolescents into the role of seeking merit in a point of view alien to their own--much like students who choose to act out or formally debate viewpoints opposite their own. Such open-minded and tolerant attitudes are considered virtues in an open and free society, but they can generate moments of discomfort for those involved.

Moving even closer to science teaching, probing a problem from all sides in search of solutions , e.g., middle school students who set out to remedy food waste in the

school cafeteria (see Tinker, 1987), can steer students onto untraveled highways, and at times, uneasy routes of critical thinking as they gather and weigh the impact of alternate solutions on a community. As illustrated earlier, such decision-making exercises can arouse dissonance.

Finally, discrepant science investigations invite students to come to grips with the unexpected. Here a counterintuitive experience drives students in search of new knowledge that will resolve the perceived inconsistency and thereby lower cognitive dissonance. It may be significant that Thompson (1989) looks not to Festinger's theory to explain the behavior of students confronted by a discrepancy, but Piaget's (1970) theory of equilibration.

The two theories have common roots. Disequilibrium, the attribute of Piaget's theory defined by Abraham and Renner (1986) as the learner's desire for cognitive consistency during the learning process, resembles Festinger's cognitive dissonance. Furthermore, the authors describe how disequilibrium, and related Piagetian concepts, serve as a theoretical rational for the learning cycle, a highly researched, three-phased teaching strategy employed by informed middle school science teachers.

In summary, moments of dissonance (or disequilibrium) sensed by students during the learning process may be an important source of motivational energy available to innovative science teachers.

THEORETICAL RATIONALE

Science educators commonly persuade elementary teachers to adopt a more positive attitude toward science. This process is expected to generate more positive science behaviors in teachers. Here the change process is an attitude-to-behavior orientation and persuasion is employed by outside experts.

Festinger's theory is a behavior-to-attitude model. To illustrate the point, Brehm and Cohen (1962) challenged Yale University students unhappy with police actions on campus to write pro-police essays. Finding themselves behaving positively toward police by writing a favorable essay, the subjects' attitude toward the police became more positive. Thus, attitude followed behavior and the change process was self-persuasion. Myers (1987, p.45) contrasts the two directions to attitude change. He asserts that "We are likely not only to think ourselves into action, but also to act ourselves into a way of thinking."

Two student scenarios. In the study reported herein, middle school students were asked to write pro-science essays. Positive subjects were expected to air their current feelings toward science; they would not experience dissonance and their science attitude was predicted to remain stable.

However, negative students who composed pro-science essays were expected to experience dissonance. These subjects were expected to reduce dissonance by bringing

their science attitude more in line with their positively-written essay.

SIX PREREQUISITES AND DESIGN OF THE STUDY

The dissonance literature of the last three decades, and especially the more recent summaries of Cooper and Fazio (1984), Elser (1986), and Sears et al. (1988), serve as the linchpin for this study. The tenets of cognitive dissonance theory center around the prerequisites or preconditions to dissonance arousal. A search of science education literature identified only one study based on Festinger's theory. Steiner's (1980) work, based on two prerequisites to dissonance arousal, challenged ninth graders to videotape a message for their peers extolling the merit of enrolling in science courses.

The investigators of this study have derived six prerequisites to dissonance arousal from recent reviews of the attitude literature. By systematically manipulating the six prerequisites within a treatment where students negative toward science compose counterattitudinal (pro-science) essays, dissonance can be predicted--thus setting the stage for attitude change.

1. Dissonance perceived by subjects. Cognitive dissonance can be aroused by enlisting subjects to publicly advocate a position counter to what they are known to hold. Kelman (1953) demonstrated that a counterattitudinal advocacy is effective in changing the attitudes of middle school students, the age-level of subjects involved in this study. He found that seventh graders who wrote an essay

supporting a Tarzan comic book that they initially disfavored, resulted in more favorable attitudes toward the book. Cooper and Worchel (1974), West and Wicklund (1980), and Scher and Cooper (1989) confirm the premise that dissonance can be reduced by an attitude change. In this study, the theory predicts that subjects with a negative science attitude should become more positive by writing an essay promoting science instruction.

2. Minimum incentive. Providing a minimum incentive to engage in a counterattitudinal act insures that a subject has insufficient justification to participate in the behavior for reward. Thus, Festinger's theory predicts that providing subjects minimum incentives for participation will raise the probability of attitude change. Kelman's (1953) study tested this premise. Subjects were promised one of the following: a definite reward; a low probability of reward; and no reward. Subjects promised a low probability of reward composed better quality essays; they also manifested the highest attitude change.

Subjects who realize a low incentive, and therefore an insufficient justification for participating in an act contrary to their espoused attitude, but do so anyway, experience dissonance arousal. The significance of minimum incentive in arousing dissonance and subsequent attitude change was tested and documented by Festinger and Carlsmith (1959), Brehm and Cohen (1962), and Linder et al. (1967).

Committed to writing the essay, subjects in this study were encouraged to perform well. The subjects were informed

that the essays would not be scored. Considered a standard language arts assignment, students were granted credit for having completed the essay. Tailored in this way, the design was expected to hold student incentive at a minimum level.

3. Commitment irrevocable. An irrevocable commitment implies that decisive action has been taken by a subject to engage in a counterattitudinal, and therefore, dissonance-arousing behavior. West and Wicklund (1980) maintain that "the decision serves as the starting point for dissonance analysis because the cognition of having chosen is highly resistant to change" (p.71). Evidence for reducing postdecision dissonance by enhancing the chosen alternative (in our study, the pro-science essay) has been demonstrated by Brehm (1956), Knox and Inkster (1968), Younger et al. (1977), West and Wicklund (1980), and Rosenfeld et al. (1986).

After disclosing the directions for the essay writing task, the subjects in our experimental treatment group signed their names next to their chosen topics, thereby committing themselves to complete the task. The signatures connoted irrevocable commitment. Also, all subjects carried through on the commitment to write the essay of their choice.

4. The perception of personal responsibility. Cooper and Fazio (1984) stress the importance of the subject assuming personal responsibility for the consequences of counterattitudinal behavior. To operationalize this precondition to dissonance, subjects were expected to sign

their names to the completed essays. Thus, anyone reading the essay would attribute the contents to the author. Also, two announcements on the public address system invited the student body to read the essays posted on the school's hallway bulletin board.

Cooper and Fazio (1984) report that the two mechanisms employed by subjects in an effort to deny personal responsibility for counterattitudinal behavior are coercion and unforeseeability. Accounting for those preconditions in this study are described below.

5. Choice perceived. There are at least two reasons to avoid coercion in dissonance research. First, coercion of subjects is unethical. Secondly, dissonance theory predicts that coerced subjects will not accept personal responsibility for counterattitudinal behavior; neither will coerced subjects sense dissonance. Studies demonstrating the importance of perceived choice in arousing dissonance were reported by Brehm and Cohen (1962), Aronson and Carlsmith (1963), and Zimbardo et al. (1965).

The treatment group in this study could choose an essay theme from a list of 14 topics related to science instruction gleaned from a survey of 1,855 middle and secondary school students who identified their top reasons for liking science class (Lazarowitz et al. 1985). To further elevate choice, subjects were granted the option to write on any science topic related to the theme, "Why I like science".

Participating in the essay writing exercise was implicitly mandatory. It could be argued that students have little choice but to study language arts (or science) in the middle school; state departments of education mandate it. However, composing the pro-science essay served as an ongoing language arts lesson for the week. We assumed that offering such a broad list of essay options would be perceived by the subjects to be adequate.

6. Dissonance foreseeable. Had the students proceeded into the counterattitudinal behavior blindly and without knowledge of the conditions that might lead to dissonance and any accompanying consequences, Festinger's theory predicts that the subject would not accept personal responsibility for the content of the essay.

The subjects in our study should not have been caught unawares. They were forewarned that they would be writing a pro-science essay. Furthermore, the directions indicated they would choose the topic, sign the essay, and the possibility existed that the essays would be posted in the hallway or published in the school newspaper. Teachers or peers aware of their lack of fondness for science could be puzzled by the contents of the essays.

THE STUDY AND RESEARCH QUESTIONS

The purpose of this study was to test whether a counterattitudinal essay writing treatment based on a current interpretation of dissonance theory would render more positive science attitudes among middle school students

who are negative toward science instruction. The following research questions were investigated:

RQ1 Will students who compose counterattitudinal essays generate more positive attitudes toward science?

RQ2 Will the public display of students' counterattitudinal essays generate a more positive attitude change than merely writing the counterattitudinal essays?

RQ3 Will the effects of engaging students in a counterattitudinal essay writing task differ by grade level?

RQ4 Will the effects of engaging students in a counterattitudinal essay writing task differ by gender?

Sample

The research sample consisted of 141 students in grades 6, 7, and 8 who attended a Pennsylvania middle school. The sample was primarily Caucasian, of average ability, and represented a cross-section from many socio-economic groups. All subjects received 40 minutes of science instruction daily in a departmentalized setting.

For this study, six intact classroom groups were selected from eight homogeneous clusters of 6th, 7th, and 8th grade students. Enrollment ranged from 23 to 27 students in each classroom group. Two sections of students from both grade six and eight were randomly chosen to participate in the study. In grade seven, only two sections of students were available; therefore, both were included.

From the two experimental groups at each grade level, one was randomly selected as a treatment group and the other

served as a control group. A flip of the coin determined the assignment of the groups to treatments.

Instrumentation

Prior to and following the treatment, the Middle School Science Attitude Scale (Misiti, et al., 1991) assessed subjects' attitude toward classroom science. Described more fully elsewhere are the tests for validity undergone by the instrument. Special attention was devoted to the instrument's content and construct validity. Two different samples of middle school students responded to the 23 statements and a Likert analysis of these data generated coefficient alpha r-values of 0.96 and 0.92; adjusted item-total correlations r-values ranging from 0.42 to 0.85; and, estimated average interitem correlations of 0.48 and 0.33.

The coefficient alpha and item-total correlation r-values suggest that the 23-item scale is a reliable instrument. The positive interitem correlations suggest that the items are intercorrelated and working together to measure a single underlying variable--assumed in this case to be science attitudes of middle school students.

Methodology

Pretests were administered to the subjects' by the regular science teacher nine weeks prior to the treatment. In an attempt to disguise a connection between the essay writing assignment and science attitude study, the treatment was conducted by the subjects' language arts teachers during regularly scheduled language arts classes. Subjects in the

treatment groups were asked to write persuasive essays and they were informed that the essays might be displayed on a school bulletin board or published in the school newsletter. Subjects in the control groups practiced letter writing to a fictitious company requesting information.

Upon completion of the essays, half were selected randomly and displayed on a large bulletin board in the school hallway where the essays were visible to anyone passing by. One week following the public display of the essays, the Middle School Science Attitude Scale (Misiti, et al., 1991) was administered again to all subjects.

Data Analysis

To investigate RQ1, the subjects' posttest science attitude scores were submitted to a one-way analysis of variance (ANOVA) to test the effect of the counterattitudinal essay writing treatment on attitude change (see Table 1).

The posttest mean science attitude scores for the sample disclosed no significant difference between the experimental and the control group (see Table 2). These data fail to support the premise that engaging middle school students in a counterattitudinal essay writing task will improve their science attitudes.

To assess the effects of grade level, gender, and treatment conditions (RQ2, RQ3, RQ4), and any interactions of these variables on attitude scores, the posttest science attitude scores were submitted to a 3x2x3 analysis of covariance (ANCOVA). Pretest science attitude scores served

as a covariate to control for any effect they would have on the posttest science attitude scores. The 3x2x3 factorial design included three grade levels (6,7,8), two gender levels, and three treatment levels (essay written, essay written and displayed, no essay).

The ANCOVA analysis (see Table 3) revealed a significant three-way interaction of grade level, gender, and treatment levels ($F=2.734$; $df=4, 122$; $p=.032$). The three-way interaction suggests that the effects of the three variables working together may be responsible for the mean score differences among the groups (see Table 4). For the purposes of this discussion, however, it is assumed that the treatment failed to generate the predicted results.

DISCUSSION AND RECOMMENDATIONS

The final section of this report serves as a review and critical analysis of the findings and a reinterpretation of the study's procedures in light of those findings. Six questions, one representing each prerequisite to dissonance arousal, are asked of the empirical data generated by the study, a content analysis of the student essays, and a reexamination of the literature, especially Cooper and Fazio's (1984) discerning review, "A New Look at Dissonance Theory' and Elser's (1986) analysis.

1.Dissonance perceived. Did the subjects perceive cognitive dissonance?

In this study, we assumed that students who wrote counterattitudinal essays would experience dissonance and

the consequences that might accompany it. Here dissonance is defined as a sense of tension or uneasiness brought about by ill-fitting cognitions (e.g., "I don't like science all that much; I wrote good things about science") or circumstances one would prefer to avoid (e.g., "My teacher or my friends may think I really like science class because of what I wrote in my essay"). In this study, Festinger's theory predicts that subjects writing counterattitudinal essays could reduce dissonance by adjusting their science attitude to better match the substance of their pro-science essays.

No direct evidence was sought to assess whether or not subjects experienced dissonance. The empirical results of this study, however, suggest that the treatment failed to trigger dissonance in some of the students. Here students were encouraged to choose essays from a broad range of topics related to science instruction. Or they could choose a science topic outside the list of suggestions but related to the topic, "Why I like science".

Evidence embodied within the substance of the essays suggests that the procedure prompted some students to choose topics that existed at the outer fringe or even outside the scene of science instruction. In other words, they might have sought out more positive topics that would be less prone to arouse dissonance.

For example, a content analysis of the essays disclosed that 79% of the sixth grade males composed essays about a science teacher who was friendly and engaging in and outside the classroom. This subset of subjects, some commonly

observed to have had a less than favorable attitude toward science, appear to have written about a likable person who happened to teach a subject not to their liking. In this case, dissonance theory would predict that a subject with a negative attitude toward science could write a pro-teacher essay and experience no dissonance. And therefore, no attitude change toward science instruction would be forthcoming.

In retrospect, restricting subjects' choices to Lazarowitz's list of 14 science topics might have reduced or eliminated essay choices at the edge of or outside the basic theme of science instruction. In this case, one could speculate that if more subjects would have written essays central to the theme, dissonance arousal would have been heightened and attitude change would have been elevated.

Another choice, "Make a list of 10 things that you enjoy in science class", might have been more successful in nudging subjects to write a counterattitudinal essay. Even those students who are less than positive toward science often enjoy some features of science instruction; across this sampling, experimenting was commonly cited as a favorite. After listing one or two positive features, the subjects might be willing to reappraise and adjust their attitude by extending their list of positive attributes of science instruction.

Modeling more closely the procedures designed by dissonance researchers, who have worked primarily with adult subjects, we might have asked subjects to write an essay

supporting a longer daily science instruction period or more instructional periods per week. Such a procedure could have directed subjects to write essays more central to the theme of science instruction. On the other hand, it could have required organization and communication skills beyond the abilities of some middle school students.

2. Minimum incentive. Did the subjects consider their reward for writing the essay a low level incentive?

That a minimum incentive is more likely to arouse dissonance than a high reward remains a central tenet within Festinger's theory. In this study middle school students satisfied a language arts assignment by writing the essay. It was not scored. We have no evidence that students, especially those writing the counterattitudinal essays, realized a reward so great that dissonance would be avoided.

3. Commitment irrevocable. Was the commitment to write an essay on the student's chosen topic irrevocable?

If a subject can revoke or "take back" the substance of their counterattitudinal essay, such an action short-circuits the arousal of dissonance. Here students signed their names alongside their chosen topics on a master list. Records reveal that all subjects carried through on the writing commitment. They signed their names to the essay. This evidence suggests that the subjects must have considered their commitment irrevocable.

4. Personal responsibility. Did the subjects accept personal responsibility for the substance or content in their counterattitudinal essays?

Cooper and Fazio's (1984) review and analysis of the cognitive dissonance literature identifies personal responsibility as the critical antecedent to dissonance arousal. Here subjects could avoid dissonance by denying personal responsibility for writing an essay that did not fully match their feelings about science. The mechanisms employed to deny personal responsibility, according to the reviewers, are coercion and unforeseeability. Answering the above question requires that we explore the impact of those two variables on dissonance arousal in this study.

5. Choice perceived. Did the subjects perceive that they were granted a choice in writing the essay; or did they feel coerced?

Students who could not perceive some options could justify composing an essay as little more than practice in spelling, punctuation, and sentence structure. In this case, they would feel little responsibility for the counterattitudinal substance within the essay--much like the subjects in the study's control group who practiced letter writing.

As reported earlier, the subjects exercised the options granted them--and more. It is doubtful that they felt coercion in the research design as executed in this study. However, if in future studies based on this theory the choice of options is limited as recommended above, eliminating a feeling of coercion must be addressed in the research design.

The prerequisite of perceived choice raises the following questions: How broad must the options be for middle school students to perceive that they were granted a choice of participating in the study? Must they be granted the choice of refusing to write an essay? Perhaps, but the essay writing exercise was considered an ongoing composition assignment on the part of school officials. Therefore, it may be safe to assume that students would sense no coercion when their choices were limited to the general theme of "Why I like science".

There are a host of options that could be offered middle school students that might satisfy the prerequisite of perceived choice: a) limiting essay topics to Lazarowitz's 14 reasons why students like science; b) making a case for more hours of science instruction per week in an essay should be considered; c) the option of message media might satisfy the subjects' perception of choice (i.e., essay, audiotape, videotape).

6. Dissonance foreseeable? Were the consequences of counterattitudinal essay-writing, and the possibility of dissonance, foreseeable to subjects?

Had the students proceeded into the treatment without knowledge of the consequences, Festinger's theory predicts that the subject would not accept personal responsibility for the content of the essay. In such a case, no dissonance would be expected.

Here again, no direct evidence was sought from subjects to answer the question, but the procedures spelled out the

conditions for the study. It was assumed that subjects would sense the dissonance that might accompany the writing and posting of counterattitudinal essays.

FINAL RECOMMENDATIONS

Attitude research in science education could be advanced by designing studies based on theoretical rationales adapted from models developed and refined by social psychologists. Steiner's (1980) work introduced researchers in science education to Festinger's theory of cognitive dissonance; this study advanced that mission one more step. The analysis of the literature renders six prerequisites to dissonance arousal, the antecedents to attitude change under Festinger's approach. This study has been designed atop the six preconditions for dissonance arousal; the research procedures have been analyzed and amended. We recommend that revised strategies embodied within this review serve as a template to initiate a network of studies leading to knowledge that will enhance positive science attitudes of students and teachers--a fitting objective at a time when there is a national concern about the flight of students from science courses.

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Table 1

ANOVA Summary Table of Posttest Science Attitude Scores

Effect	SS	df	MS	F	Probability
Groups	20.98	1	20.98	.03258	.8345
Error	894292.31	139	643.83		

Table 2

Posttest Means and Standard Deviations for Experimental Groups

Group	N	Mean	SD
Essay writing	73	67.70	25.52
Control	68	68.47	25.22
Total	141	68.07	25.29

Table 3

ANCOVA Summary Table of Grade Level, Gender, Treatment, and Interactions, on Posttest Science Attitude Scores

Effect	SS	df	MS	F	Probability
Pretest	20424.68	1	20424.68	81.181	.0000
A-Grade	1650.64	2	825.32	3.280	.0397
B-Gender	206.87	1	206.88	0.822	.3696
C-Treatments	11.21	2	5.60	0.022	.9660
A x B	1240.72	2	620.36	2.466	.0871
A x C	396.83	4	99.21	0.394	.8140
B x C	463.87	2	231.94	0.922	.4029
A x B x C	2751.04	4	687.76	2.734	.0315*
Error	30694.50	122	251.59		

* $p < .05$

Table 4

Posttest Mean Science Attitude Scores by Grade Level, Gender, and Treatment, Adjusted for Pretest Scores

	Male			Female		
Grade	EP	EO	NE	EP	EO	NE
	Adjusted Mean Science Attitude Score					
6	77.09	75.07	76.33	73.10	63.85	61.14
7	71.73	62.37	56.61	48.28	60.86	69.87
8	66.52	61.54	68.54	68.28	78.15	68.15

Key:Treatment Levels
EP Essay written and published
EO Essay written only
NE No essay

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