DOCUMENT RESUME

ED 201 493 SE 034 827

AUTHOR	Blosser, Patricia E., Ed.; Mayer, Victor J., Ed.
TITLE	Investigations in Science Education, Vol. 7, No. 2. Expanded Abstracts and Critical Analyses of Recent Research.
INSTITUTION	ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio.; Ohio State Univ., Columbus. Center for Science and Mathematics Education.
PUB DATE	81
NOTE	70p.
AVAILABLE FROM	Information Reference Center (ERIC/IRC), The Ohio State Univ., 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212 (subscription $6.00, $1.75 single copy).
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	*Abstracts; College Science; Elementary School Science; Elementary Secondary Education; Higher Education; *Research; Research Methodology; Science Curriculum; *Science Education; Science Instruction; Secondary School Science; *Student Attitudes; *Teacher Attitudes
IDENTIFIERS	*Science Education Research

ABSTRACT

This issue of "Investigations in Science Education" (ISE) provides analytical abstracts, prepared by science educators, of research reports in the area of student attitudes toward the high school science laboratory, environmental problems, science instructional procedures, and science classes; and teacher attitudes in a preservice institute setting and toward elementary school science curricula. Each abstract includes bibliographical data, research design and procedure, purpose, research rationale, and an abstractor's analysis of the research. (CS)

ED201493

INVESTIGATIONS IN SCIENCE EDUCATION

National Association for Research in Science Teaching

ERIC Clearinghouse for Science, Mathematics
and Environmental Education

Published Quarterly by

The Center for Science and Mathematics Education
College of Education
The Ohio State University
1945 North High Street
Columbus, OH 43210

Subscription Price: $6.00 per year. Single Copy Price: $1.75
Add 50¢ for Canadian mailings and $1.00 for foreign mailings.

SE 034 827

Volume 7, Number 2, 1981

NOTES FROM THE EDITOR

This issue contains analyses of ten articles related to the study of attitudes, a topic of continuing interest to a large number of science education researchers. Adler and Byrd investigated the effects of instructor's attitude on students. Crater surveyed the attitudes of high school students toward nuclear science. Dillon and James studied the attitudes of black students concerning various factors relating to science. Hofstein and his colleagues reported on the development of an instrument to measure the attitudes of high school students toward chemistry and their interest in laboratory work. Quinn provided information concerning the use of value sheets and their influence on the attitudes of high school students about various instructional procedures. Savada looked at attitudes which non-science majors hold about science and technology. Symington and Fensham investigated, among other things, the attitudes of elementary school teachers toward science. Ward attempted to determine if a relationship existed between class size and student attitude toward science. Wooley's study contained an examination of students' attitudes regarding computer-assisted instruction in astronomy. Topics, approaches, and findings vary but the analyses appear to indicate there is still much work to be done in the study of attitudes in a science education context.

Patricia E. Blosser
Editor

Victor J. Mayer
Associate Editor

ATTITUDES

Adler, C. G. and J. W. Byrd. "Instructor Attitude Transfer in a Preservice Institute." Journal of Research in Science Teaching, 13(1): 1-4, 1976.

Descriptors--*Changing Attitudes; *Curriculum; *Educational Research; Physics; *Science Education; Secondary Education; Secondary School Science; Teacher Attitudes; *Teacher Influence

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Glenn Markle, University of Cincinnati.

Purpose

The stated purpose of this study was to determine "to what extent did the instructor's attitude affect the attitude of the participants" during a five-week institute for preservice physics teachers. In addition, the study attempted to determine if a student who initially favored a traditional physics course or a PSSC physics course would develop a more positive attitude towards Project Physics and, if a positive shift in attitude toward Project Physics occurred, would it be distributed across identified subgroups in the institute (i.e., those that liked the institute best, those that liked the institute least, and the best students in the institute)?

Rationale

The principle purposes of the UPSTEP-sponsored institute for preservice physics teachers were to increase the participants' knowledge of high school physics curricula, to improve the skill of developing and presenting demonstrations, and to teach laboratory management skills. Any concurrent attitude change was considered incidental.

Nevertheless, the authors held more positive attitudes toward Project Physics than toward PSSC or the traditional approach to the subject and, even though an attempt was made to present a balanced introduction to the various forms of teaching physics in high school, it was expected that the attitudes of the staff would be communicated to and have some effect upon the participants. This study was conducted to determine if such an effect existed.

Research Design and Procedures

A pretest-posttest design was used to determine the effects of the five-week institute on the attitudes of preservice physics teachers toward Project Physics, the curriculum most favored by the institute instructors. The design for the study was Campbell and Stanley's Design 2, The One Group Pretest-Posttest Design (1):

$$O_1 \; X \; O_2.$$

Participants' attitude towards Project Physics was measured by averaging the ranks assigned to eight objectives for high school physics courses. The objectives were those chosen by the American Institute of Physics in a 1972 study on high school physics teaching. Two of the eight objectives were believed to be strongly associated with Project Physics and one each, with PSSC and traditional physics. The four remaining objectives were not specific to a particular course of study.

The report implies that 15 students were involved in the study but this number is never explicitly stated. The students were assigned to three groups: the five who best liked the institute according to responses on a 20-item questionnaire administered at the end, the five who least liked the institute on the basis of responses to the same questionnaire, and the five who did the best work during the institute based upon their final grade determined by an objective test and the participants' performance in the seminar part of the program.

The treatment consisted of a five-week institute in which the seminar "was taught by an instructor (C.A.) who is admittedly pro-Project Physics."

The "data" were graphically presented by showing the "Objective Average Rating" for each objective before and after the institute. A second table presented the average rank changes in the four key objectives for the entire workshop group, the one-third who liked the institute most, the one-third who liked it least, and the five best students.

Findings

The average ranks assigned to the traditional physics and PSSC physics objectives were lower after the institute than before it. The average ranks of the two Project Physics-related objectives were higher. This pattern was present for members of the workshop as a group and for the three subgroups.

Interpretations

The investigators concluded that the participants "changed their attitudes toward course objectives during the course of the institute. And the change was such that in the end their attitudes roughly coincided with those held by the institute staff."

ABSTRACTOR'S ANALYSIS

The authors of this study attempted to assess the effects of the instructors' attitudes or subsequent changes in participants during a five-week institute. No theoretical basis for the anticipated changes were presented. Although none were stated, the questions posed in the introduction suggested the following hypothesis:

1. During a five-week institute, preservice physics teacher's attitudes toward various physics curricula will shift in the direction of the instructor's attitudes.

The One-Group Pretest-Posttest Design to test the hypothesis was used by Campbell and Stanley "to illustrate several of the confounded extraneous variables that can jeopardize internal validity." They point out that effects other than the experimental treatment might cause a difference between pre and posttest scores not accounted for by the design. In this study, the shift in participant attitudinal scores might have been the result of becoming aware of a different point of view. Many, if not most, preservice physics teachers probably view teaching as the transmitting of facts, concepts, and principles to students. They may never have considered alternative outcomes. The information presented at the institute may have broadened perceptions and enabled them to consider other outcomes which upon reflection, seemed more important.

A second weakness in the design is the effect of testing. Campbell and Stanley (1963) point out that when a signed inventory is employed, the initial administration may be a problem-solving situation in which the respondent attempts to discover the disguised purpose of the test. On the posttest, he knows better how to present himself more acceptably. In the present study, it is not clear if the participants signed the pre and posttests. Nevertheless, a preferred set of responses were likely to have been perceived and may have biased the posttest rankings of objectives.

The test-instrument itself introduces several concerns. Evidence for its validity or reliability is not presented. Given that the data presented were "difference scores," the lack of information concerning reliability of the measures is particularly disturbing.

Finally, inferences concerning attitudinal changes were based upon inspection of the data rather than any statistical treatment. While the number of participants and the nature of the data may have restricted statistical analysis, conclusions which are based upon such data are suspect.

In summary, the present study is weakened by:

1. The lack of a clearly stated hypothesis supported by a theoretical base or previous research;
2. A weak experimental design;
3. The use of an instrument whose validity and reliability was not established;
4. An analysis procedure that was based solely upon the inspection of difference scores; and
5. A lack of generalizability--i.e., it is not clear that the effects, if they exist, would operate in any other setting.

The question addressed by this study, i.e., what is the effect of an instructor's attitudes on the attitudes of his students, is an important concern. Unfortunately, this study failed to provide sufficient evidence to yield an answer.

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Crater, Harold L. "What Opinions Do High School Students Hold About Nuclear Science?" School Science and Mathematics, 77(6): 495-501, 1977.

Descriptors--*Attitudes; *Educational Research; Environmental Education; Nuclear Physics; Pollution; *Science Education; Secondary Education; Secondary School Science; *Student Attitudes; *Student Opinion

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Glenn C. Markle, University of Cincinnati.

Purpose

The stated purpose of this study was to determine if there is a "pattern to the opinions held by today's high-school students toward controversial issues in nuclear science" (p. 496). Also, the study assessed the effects of a Nuclear and Environmental Science program on the attitudes and knowledge of academically talented high school students.

Rationale

Although today's high school students live in a scientific-technological society, many of them hold inaccurate and fanciful ideas about science and scientists. Allen (1959) identified three areas of student misunderstanding:

1. a misunderstanding and ignorance of the nature of science,
2. an unrealistic image of the work of the scientist in American life, and
3. a faulty understanding of the interaction of science and society.

Studies by Mead and Metraux (1957), Allen (1959), and Aiken and Aiken (1966) indicate that students' perceptions of science and scientists have not changed in spite of excellent science curricular materials that confront these areas of misunderstanding.

The contributions of science and technology to the high standard of living in this country have been recognized in the past. However, the application of science-related technology has also been accused of causing many problems facing today's society. The current energy crisis has given rise to advocates for the development of a nuclear power industry as well as groups which vigorously argue against further construction of large power reactors. High school students' perceptions of the nuclear scientist and his work will undoubtedly affect their opinions toward this issue. In the very near future, today's students will be expected to discuss and vote on complex technological issues related to the use of nuclear energy that will directly influence their entire future. Identifying the pattern of opinions currently held by today's high-school students toward nuclear scientists and their work and assessing the effects of an educational program addressing these issues may provide useful information for the developers of high-school science curricula and for high-school science teachers.

Research Design and Procedures

A pretest-posttest design using an experimental and a control group was used to determine the effects of a University of Mississippi summer program in Nuclear and Environmental Science for academically talented high school students. The design for the program evaluation approximates Campbell and Stanley's Design 4, the "Pretest-Posttest Control Group Design" (1963). It differs in that subjects were not randomly assigned to groups. The design takes the form:

O_1	x	O_2	(Experimental)
O_3		O_4	(Control)

The experimental group of 23 students experienced the Nuclear and Environmental Science program while the control group of 27 students experienced an advanced mathematics program offered by the Department of Mathematics at the University of Mississippi. Members of both groups, mostly eleventh graders, had excellent academic records, were particularly interested in science and/or mathematics and were highly recommended by their teachers. About half the participants in each group were residents of Mississippi with the remainder representing many other states including Pennsylvania, Ohio, Indiana, Illinois, Tennessee, and Texas.

The dependent variable for assessing student opinions was the score on a 20-item Likert-type rating scale. Items on the scale were selected "on the basis of their ability to discriminate between students holding favorable and unfavorable attitudes toward nuclear science" (p. 497). The primary intervening variable was the instruction one group of students received in nuclear science.

This treatment consisted of an experimental survey of the properties and applications of radioactivity accompanied by analysis and discussion of controversial issues concerning nuclear science. The text used was David R. Inglis' Nuclear Energy: Its Physics and Social Challenge (1973). Films and pamphlets from the United States Energy Research and Development Administration (now DOE) were used in conjunction with several books and articles critical of nuclear power generation. Throughout the program, the instructor tried to remain scrupulously impartial and the free atmosphere allowed participants to express individual opinions.

Data analysis consisted of a t-test to compare pretest means and posttest means of the two groups on the 20-item attitude survey. In addition to comparing group means on the pretest and posttest, responses to specific items were summarized to indicate student opinions in three areas: nuclear energy, nuclear pollution, and future benefits. Three items related to each area were included with the percentage of students a) agreeing, b) tending to agree, c) neutral, d) tending to disagree, and e) disagreeing.

Findings

There were no statistically significant differences between the experimental and control group attitude scores on either the pretest or the posttest. Student responses to individual items were interpreted as representing a generally uncritical attitude toward nuclear technology.

Interpretations

The investigator interpreted the average attitude score of approximately 53 on a scale of 0-80 as representative of "generally favorable attitudes toward nuclear science at the beginning of the program" among students in the experimental and control groups (p. 497). He was very careful to limit generalizations to academically talented students with an interest in science and/or mathematics.

The results of the t-test were interpreted as indicating no significant effect on student attitudes due to the Nuclear and Environmental Science program.

A nuclear physics subject matter test was administered to students in both groups at the beginning and end of the program. The investigator reported that "the students in the science group appreciably increased their understanding of the principles and applications of nuclear science whereas no similar change occurred in the mathematics group" (pp. 497-498). No related data or statistical comparisons were reported.

Responses to individual items were interpreted as indicating that academically talented students:

1. have a positive attitude toward the use of nuclear energy (p. 499),
2. are not overly concerned about nuclear pollution (p. 499), and
3. are optimistic about the future as it relates to nuclear science (p. 499).

Overall, the investigator concluded that today's academically talented students do not relate to historical events such as nuclear explosions in the atmosphere and radioactive fallout and that they are not actively concerned about current issues of nuclear technology. The attitudes towards nuclear science of these academically talented students was characterized as "uncritical" (p. 500).

ABSTRACTOR'S ANALYSIS

The author did not intend to relate this study to other attitudinal research. His primary purpose, as indicated by the title of the article, was descriptive; he simply wanted to establish the current opinion of academically talented high school students toward nuclear science. The assessment of attitude changes resulting from the Nuclear and Environmental Science course appeared to be a secondary effort. No evidence was presented to indicate that the program was designed to systematically change student attitudes toward nuclear energy. In fact, the totally impartial presentation of both points of view for each issue analyzed is theoretically unlikely to result in appreciable attitudinal change (Bem, 1970).

The validity of generalizing the reported results even to academically talented students with an interest in science and/or mathematics is questionable for at least two reasons. First, the criteria for selecting subjects were specific to the needs and requirements of the summer program at the University of Mississippi. It is not at all clear that the resulting sample was representative of any population. Although the author generalized to academically talented students with an interest in science and/or mathematics, the subjects needed also to have the strong recommendation of a teacher (presumably a science or mathematics teacher), needed to be available for some unspecified time during the summer to take part in the program, and may have had a systematic political bias since approximately half the students were from Mississippi, a relatively conservative state politically. Second, no evidence was presented to support the validity or reliability or the survey scale used to measure student opinions. Although the author claims that the items were "selected on the basis of their ability to discriminate between students holding favorable and unfavorable attitudes," the process used to make this determination was not described. A previous study using the same instrument was referenced, but it contained no description of the developmental process used to construct the scale (Crater, 1972). Neither study reported a reliability coefficient for the scale.

The design for evaluating the attitudinal effects of the nuclear science program was adequate for a single variable study. If the evaluator intended to assess both cognitive and attitudinal changes, a multivariate design should have been used and information about the science content test included in the report. Instead, a single statement asserted that "students in the science group appreciably increased their understanding of the principles and applications of nuclear science whereas no similar change occurred in the mathematics group" (p. 498).

Student opinions toward three specific aspects of nuclear science were inferred from responses to nine items. The rationale for selecting these items was not explicitly stated--the implied criterion was that they somehow measured the same things. It was not clear if these sets of items had been chosen before the data were collected or if the three sets of three items each were chosen after the study in order to support a specific conclusion. The lack of information about the criteria for selecting specific bits of data causes the conclusions to be questionable.

The written report of this study would have been stronger if it had included evidence for the validity and reliability of the attitudinal and content instruments, specific data about the nuclear science content test and an explicit rationale for preselecting specific sets of items to serve as "subtest" within the attitudinal survey. In order to be fair to the author, it should be noted that some of this information may have been excluded to meet the requirements of the publishing journal.

Future research in this area should be directed at determining the attitudes of non-science oriented students toward nuclear energy since they will constitute a majority of the future voters. In addition, strategies for informing these students of the specifics of nuclear technology and the related issues and problems need to be developed.

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Descriptors--*Attitudes; *Blacks; Black Attitudes; Career Choice; *College Students; *Educational Research; Higher Education; Minority Groups; Science Education

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Robert L. Shrigley, The Pennsylvania State University.

Purpose

1. The initial purpose of this study was to design and field-test a four-part instrument testing the attitudes of black American students toward:

   a) Science and society
   b) Science and Blacks
   c) Self-estimates of proficiency
   d) Science as a career

2. Secondly, the science attitudes of Blacks were tested for their relationship to six variables:

   a) Major (science major, science-related, non-science)
   b) Gender differences
   c) Community (rural and urban)
   d) Number of college science courses completed
   e) Number of high school science courses completed
   f) Age

Rationale

1. More black Americans should be involved in the American scientific enterprise.

2. Attitudes toward a career and self-concept are prominant factors in selection of science as a career.

3. Past research of black attitude toward science has involved conventional instruments designed not for Blacks, but the general population. Therefore, one is needed.

4. Knowing the relationship of the six variables to the science attitude of Blacks would be basic to experimental research.

Research Design and Procedure

One hundred eight Likert-type statements were compiled and classified into the four subscategories. Twenty-eight black and four white scientists and science educators served as a jury to judge content validity and the positive-negative classification of each item.

The 108 statements were administered to 80 black students. The data were analyzed as suggested by Edwards (1957), assumed to be the standard Likert analysis. Using the t-value when each statement was compared to the highest 25 percent and the lowest 25 percent of the student scores, 26 of the 108 statements were dropped from the scale.

The revised scale was then administered to 551 black college students in predominantly black colleges in four southern states. The alpha coefficient correlations, a test of internal consistency, on the four subtests were as follows:

Science and Society	.81
Science and Blacks	.67
Self-estimates of Proficiency	.85
Science as a Career	.76

The least squares analysis of variance (Kemp, 1972) was used to test the influences of the six variables on science attitude.

Findings

1. With minor exceptions, the three student subgroups, (a) science major, (b) science-related, and (c) nonscience differed significantly and systematically with the mean score for science major > science-related > nonscience.

2. Females were more positive in their attitude than males toward science and society ($p \leq .01$).

3. Rural subjects were more positive than urban subjects in their attitudes toward science and blacks ($p \leq .05$).

4. There was a positive relationship between the number of high school science courses (but not college science courses) completed and the scores on the four attitude subscales.

5. There were significant correlations among the scores on the four attitude subtests ($p \leq .01$).

ABSTRACTOR'S ANALYSIS

1. The authors are responding to a legitimate need in attitude research.

2. The four categories, (a) science and society, (b) science and blacks, (c) self-estimates of proficiency and (d) science as a career, seem to be valid psychological objects for a science attitude scale for blacks.

3. Submitting the original 108 statements to a jury and analyzing the original data from 80 students by the Likert procedure is a commendable validating process. The authors might have shared with the reader the t-score cutoff by which a statement was dropped from the original scale. They might have also considered the adjusted item-total correlation coefficient as a criterion to judge the validity of an item.

4. The authors might have included all 82 statements in the article.

5. It would have been helpful for the reader to have known which statements were negative and which were positive.

6. The authors gathered data on age of the students, and although the data appeared in the tables, they did not share the rationale for gathering the data nor did they discuss the results.

7. The coefficient alpha on one subscale was marginal (.76) and a coefficient of .67 on Science and Blacks—which seems to be the heart of this attitude scale—is questionable. Crano and Brewer (1973) suggest a minimum coefficient alpha of .80.

8. The finding that enrollment in high school science courses has a relationship to a positive science attitude is confirmed elsewhere (Shrigley, 1974). If persuading more black Americans to enroll in high school courses affects attitude positively, an important principle in attitude theory could become operative here. The persuasibility theory of Hovland et al. (1953) would suggest first of all, that we examine the credibility factor of the persuader. Who could best persuade black high school students to enroll? A science teacher? A black science teacher? A black female science teacher? A counselor? A peer? A model for determining credibility of a persuader has been established for the science educator (Shrigley, 1976). However, there is a basic problem that would need to be resolved. Enrollment in science courses may not be influencing attitude. Black students electing to enroll in more science courses may enter the courses with a highly positive attitude toward science.

9. If the authors' findings that black females have a more positive science attitude than do males were to be a consistent finding, a close analysis of black female attitude might shed some light on how the science attitude of white females, which is consistently lower than males, might be improved.

10. The authors' finding that rural black Americans have a more positive science attitude than urban blacks confirms a similar finding among Trinidadan adults (Abder and Shrigley, 1979). In-depth interviews of rural blacks with a high attitude score might provide some insight into this finding.

11. The significant correlation of the subscales implies that the four components may be operating more as a single scale rather than as four discrete scales. For the researcher interested in developing a single scale and testing a single psychological object, perhaps the attitude of black Americans toward the scientific enterprise, the following is recommended:

    A) Any statements that do not conform to Edward's (1957) 14 criteria for Likert scale construction should be modified or dropped.

    B) One of the purposes of this study was to design a scale for black Americans. Many more of the statements need to make reference to

Blacks. Otherwise the scale does not appear much different from conventional science attitude scales for the general population.

C) Plan to reduce the number of items from 82 to 20-30, a number adequate for establishing reliability and validity, but short enough for respondents to complete in 10-15 minutes.

D) Half of the items on the final scale should be worded negatively and half positively.

E) The four subcomponents make up the original instrument should be proportionately represented in the modified scale.

F) A Likert analysis of the original or new data would provide validity and reliability data. Items not reaching a .30 adjusted item-total correlation coefficient should be modified or dropped. The coefficient alpha of the total instrument should be at least .80.

G) A factor analysis on the data would show the researcher how well the four subcomponents are operating in the total scale.

H) An examination of the frequency of student response to each of the seven categories (from "Completely Agree" to "Completely Disagree") may indicate that a seven-level attitude intensity is not needed. If not, a five-level intensity, "Strongly Agree" to "Strongly Disagree," is suggested.

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Descriptors--Attitudes; *Chemistry; *Educational Research; *Instruction; *Laboratory Procedures; Science Education; Science Experiments; *Secondary School Science; *Student Attitudes

Expanded abstract and analysis prepared especially for I.S.E. by Robert E. Horvat, State University of New York, College at Buffalo.

Purpose

This study reports the development and validation of an instrument to measure high school chemistry students' attitudes and interest regarding laboratory work. The validated instrument is used to probe attitudinal differences on the basis of grade level, major, and sex.

Rationale

The authors reiterate the important role of laboratory in science teaching. To adequately assess such work requires measurement of cognitive, psychomotor and affective outcomes. The present study is an attempt to more adequately deal with affective measures in the science laboratory than has been done previously. It is seen as a step towards developing a more refined instrument and also securing a better understanding of the dimensionality of attitudes towards chemistry laboratory work.

Research Design and Procedure

Sample. Five hundred and five tenth, eleventh and twelfth grade students from 25 classes in 9 Israeli high schools were subjects in the instrument development and validation process. Complete selection criteria for participating students is omitted. However, all students in the sample were taking "Chemistry for High Schools," a new chemistry curriculum strongly oriented toward laboratory work. The eleventh and twelfth graders had elected either a mathematics/physics, biology, or humanities major. Since humanities students do not take chemistry in their final two years of high school, according to the report, I infer no humanities students were included in the sample. (The tenth grade curriculum is undifferentiated.) The students received the attitude inventory one time, in the middle of the 1973-74 school year.

Instrument Development. Eight experienced chemistry teachers constructed 89 Likert-type statements (5 position format). Three broad areas were included: the role of the laboratory as an instructional tool, administrative problems associated with lab work, and students' personal reactions toward their laboratory activities. Another group of six teachers coded each item as representing a positive or negative attitude towards the chemistry laboratory.

This inventory was given to the previously-described sample. The responses were item-analyzed, "carried out in the usual manner," according to the authors. They eliminated 27 items to produce a final, 62 item inventory.

These 62 items (listed in an Appendix, along with item means for each) were then factor-analyzed to produce subscales. The oblique-rotated factor matrix produced eight retained factors, accounting for 51 percent of the total variance. Items loading at .30 or higher on each factor were included on that subscale. Nine items repeat on different subscales, because these items loaded on two separate factors. Three of the 62 items did not load heavily on any factor and were apparently discarded. In subsequent analyses, only the eight subscales were discussed.

"Meaning" for each subscale emerged from inspecting the individual items. For example, Factor I "appears to indicate that students consider laboratory work as specifically part of the chemistry learning experience. Factor II can be called "the 'amount' of practical work factor..." (p. 403) and so forth.

Reliability estimates provided for each subscale (containing anywhere from 4 to 16 items) are Cronbach's alpha and the Spearman-Brown split-half estimate. The total test reliability (probably 62 items) is .95 with Cronbach's alpha, and .86 using the Spearman-Brown estimate. Three subscales, each with four items, has reliabilities under .70 (Spearman-Brown).

With suitable reliability determined for the subscales and the total inventory, the researchers then reanalyzed their sample data, using scores on the identified factors as the dependent variables of grade (10, 11, 12), sex, and major (biology, or math/physics). One way ANOVAs were reported for grade level vs. subscale score with post hoc comparisons made using the conservative Scheffé test. T-tests were used to compare subscale scores vs. sex.

Findings

Examining the mean score on each subscale indicates students in the sample generally had a positive attitude toward chemistry laboratory. Only on one scale (Factor II) did the mean score fall below the "indifferent" range--students feel they get too much chemistry laboratory work.

Significant F values on the one way ANOVAs (subscale score vs. grade level) were obtained for Factors II (amount of lab work), Factor V (personal attitude toward laboratory work) and Factor VII (immediate and future benefits of lab work). In each case, the grade 12 students' sub-scale scores were significantly lower than their tenth or eleventh grade counterparts.

While the tenth grade students in the sample were very heterogeneous, as compared with the students in grades 11 and 12, only on scale VII did a significant difference occur between these grades. Here, eleventh graders were more positive toward the benefits of lab work than were tenth graders--or twelfth graders!

The authors also report no significant differences on "attitude towards the chemistry laboratory" between math/physics majors and biology majors. No data are included to support this finding.

Finally, no significant differences were found when the mean ratings on each subscale were arranged by sex of the respondents. However, the authors then include seven specific items from the various scales which did show a statistically significant difference between girls' and boys' attitudes, as determined by t-tests. In these items, girls had a more favorable science laboratory attitude than boys.

Interpretations

1. Perhaps, due to increasing age and sophistication, chemistry students in grade 12 find lab work less stimulating than in previous grades. This supports the opinion of many teachers that the role of lab work in teaching high school chemistry should be more limited for 12th grade students.
2. While a previous study by Walberg (1967) indicated girls had a less positive attitude toward physics lab work, no such difference was evident here for chemistry lab instruction. Thus, in chemistry, "the laboratory method is as appropriate for girls as it is for boys." (p. 409)
3. Interest in and attitude towards high school chemistry laboratory work is not one-dimensional, as it has been assumed to be for science interest.

ABSTRACTOR'S ANALYSIS

This study is one of a number of attitude instrument validation studies reported over the years. It follows the usual mode of applying the Likert format. The instrument is developed, a sample group takes the "test," and conclusions are drawn. While there appears to be no lack of attitude scales in existence, I feel there is a lack of refinement of these initial instruments into something possessing more global utility.

Given, for the moment, the need for more attitude assessment devices, what are some important procedures to be included in developing such an instrument? First, there is nothing inherently faulty with summated rating scales, such as the Likert format used here. In fact, research indicates Likert scales usually yield the same results as the more laboriously constructed equal-appearing interval (Thurstone) scale. But the item construction phase must be carefully planned and carried out.

Each item must possess content validity, assessed by experts in the field to be measured, as was done here. The readability and clarity of each item is often enhanced by pilot-testing all items or groups of items. Then an inventory can be field-tested, and necessary modifications made from information on the statistical "performance" of individual items.

Once this is done, however, the task is not completed. Ebel (1961) stresses that scale statistics are specific to the particular sample of individuals tested. Improvements in overall scale statistics by dropping items may be lost in subsequent administration to different samples. Thus, cross-validation of new scales is very important. As Fraser (1977) notes, most science education research reports scales (as here) without any cross-validation to other samples. Thus, the reader is unsure of how these instruments will ultimately perform with related sample populations.

A second important type of validity for attitude instruments is discriminant or construct validity. Each scale should measure a unique construct not measured by any other scale. Obviously this concept is important because of the scientific principle of parsimony, and the practical constraints of test-taking time. A factor analysis does provide clusters of items for separate scales. But, in the present study, the inclusion of nine items on more than one scale leaves the uniqueness of each construct open to question. Multiple pilot testing, and correlations of scale scores with each other on the multiple pilot tests, would provide valuable information on construct validity, and also (it is hoped) cross-validate the instrument.

Of course, reliability measures are also critical to an attitude instrument. If the internal consistency of the scale is low, you have no instrument at all. Cronbach alpha estimates of internal consistency, which is equal to the average of all possible Spearman-Brown split-half reliabilities (Cronbach, 1951), is adequate for this assessment.

These brief and necessarily incomplete comments on attitude inventory development set the ground work for some general comments on the Hofstein, et al. article. (For a complete, "how to" approach for inventory development, see Edwards (1957).) The article, as written, is relatively clear. It presents items that may be quite useful for laboratory attitude assessment. However, there are several important omissions, perhaps due to journal space limitations:

1. What criteria were used to select the final 62 items from the 89 in the original inventory? This is critical information. Without it, elimination of potential selection bias cannot be presumed.

2. How was the sample population selected? Were any random procedures used? Without this information, the reader cannot generalize sample results to any identifiable population. It should be noted the present study was not an experimental study, but rather descriptive or survey research. However, such results--even if obtained with non-random procedures--can be generalized upon replication with other groups. For a discussion of this issue, see Peaker (1968).

3. A brief discussion of "no significant difference" for science laboratory attitude on the part of physics/math majors and biology majors has NO supporting data analysis.

4. Several important bits of statistical information are not included. For example, the degrees of freedom for the F statistic in the one way ANOVAs are not stated, although they could be calculated from information provided. However, including the degrees of freedom allows the reader to easily judge if the proper experimental unit was used in the analysis. Also, standard deviations or standard errors for each individual inventory item are omitted in Appendix I, although means are provided.

5. Several other questions are left unanswered after careful reading of the report:
   a. How did the three "broad areas" originally sampled by the test items fit into the eight factors finally obtained?
   b. If the entire inventory has an acceptable reliability as reported, why was a total scale score not included in the statistical analyses? If this was a desire to avoid "lumping apples and oranges," it should be explicity stated in the article.
   c. How was the factor interpretation performed? By one person or group consensus?

A second area of potential improvement in the report centers on statistical analyses. I suggest that a factorial ANOVA analysis (three levels of grade vs. two levels of sex vs. two levels of major) for the various dependent scale scores might yield more valuable information than the series of one way ANOVAs and t-tests actually performed. Such a factorial analysis would provide information on interactions between the independent variables, which conceivably might shed some light on results.

Another statistical issue involves the inappropriate inclusion of Table VI. This table provides individual attitude items which have significant mean score differences between boys and girls. However, the preceding Table V indicates NO statistically significant differences on any subscale for boys vs. girls. This technically inappropriate procedure is analagous to "plowing around" in a data set, making Scheffé comparisons, after the overall F statistic for that data set was not significant.

After reading many research reports in the literature, I'd like to interject two more troublesome issues into this discussion. First, many researchers have pointed out the distinction which exists between statistical significance and <u>practical</u> significance. In the current study, for example, twelfth graders score 1.76 points below eleventh graders on factor II, amount of lab work, which <u>is</u> statistically significant. But what is the practical significance of this less than five percent differance on a ten item attitude scale (potential 40 point range) for this group of 352 students? It is well known that large sample sizes will increase the likelihood that small scale score differences are statistically significant. If these differences mean anything in the real world, the researcher must somehow convey that to the reader. It is not enough to pump data through a computer, circle scales that turn out to be statistically significant on the printout, and proceed to discuss and rationalize their <u>practical</u> significance. (It should be mentioned that Hofstein, <u>et al</u>. have done some of this critical interpretation of practical significance implicitly.)

A second troublesome issue directly involves some of the study's results. If twelfth graders in the sample did exhibit less positive attitudes towards chemistry laboratory after two and one-half years of it (as compared with grades 10 and 11), can we be complacent about the job we are doing as chemistry teachers? I think not.

As for the assumed unidimensionality of science interest and attitudes toward school science learning, which the authors state (p. 409), much recent literature views this more on a multi-dimensional framework. For example, Klopfer (1971) identifies six affective aim categories in an "attitude toward science": manifestation of favorable attitudes toward science and scientists, acceptance of scientific inquiry as a way of thought, adoption of "scientific attitudes," enjoyment of science learning experiences, development of interests in science and science-related activities, and development of interest in pursuing a career in science.

In conclusion, I strongly urge more attitude assessment research be conducted as "follow-up work." We need not all reinvent the wheel, so to speak. Perhaps some of us can make a wheel, borrowed from a colleague, work a little better. Also, in the area of assessing science laboratory outcomes, far more emphasis should be placed on psychomotor assessment--which of the three broad domains appears to have been the most neglected. A good discussion of this issue is given by Doran (1978).

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Quinn, R. E. "Using Value Sheets to Modify Attitudes Toward Environmental Problems." Journal of Research in Science Teaching, 13(1): 65-69, 1976.

Descriptors--*Attitudes; *Changing Attitudes; Educational Research; Environmental Education; *Environmental Influences; Science Education; *Secondary Education; Secondary School Science; *Values

Expanded abstract and analysis prepared especially for I.S.E. by Gerald H. Krockover, Purdue University.

Purpose

The purpose of Quinn's study was "to determine whether value sheets cause high school students to change their expression of selected environmental attitudes to more nearly agree with expressions of those attitudes which have been judged to be consistent with maintaining a quality ecological environment" (pp. 65-66).

Rationale

No rationale for this study was presented. However, it is assumed that the goal of the study was to encourage the subjects to develop a positive attitude (value) toward their environment.

Research Design and Procedure

Four tenth-grade classes in each of five separate schools participated in this study. One teacher was involved in each of the five schools. Classes were randomly selected for treatment. Twenty value sheets were presented to each experimental group at a rate of two per week for ten weeks.

A single classification and a double classification analysis of variance was done using the pretests and posttests of classes one and two to determine if the responses given by the pretested treatment group changed as a result of their use of value sheets. A single classification analysis of variance was performed on all items of all four posttests to also analyze the above problem and to determine if the responses given by the unpretested treatment group changed as a result of their use of the value sheets. The posttest observations were also set up on a double classification analysis of variance, taking the pretests as another treatment factor.

Findings

Both the experimental and control group mean scores changed significantly on five items; only the experimental group mean score changed significantly on five other items; and only the control group mean score changed significantly on four other items.

The double classification analysis of variance using the pretests and posttests of the experimental and control groups resulted only in significant differences by trials.

All four posttest mean scores were analyzed together to determine the effect of the pretest on learning. The probability that all four means were equal fell below the 0.05 level on four questions.

A double classification analysis of variance was also conducted using the pretested and untested, and the experimental and control groups. The results indicated that the pretests were a significant learning experience on five items; the value sheets caused significant change on three items; and the interaction effects between pretests and value sheets were significant on four items at the 0.05 level.

Interpretations

The pretest was a significant learning experience for the experimental group and the control group in 10 out of the 32 items on the attitude survey. The value sheets did not change the attitudes of the students in the experimental groups as they were measured by the attitude survey instrument used.

ABSTRACTOR'S ANALYSIS

This study provides an excellent example of exploiting data to its fullest through the use of statistical analyses, Fortunately, the results did not really change no matter what data analysis was used. Many questions can be asked about this study, for example:

1. Why was a sample of tenth graders selected for the study? Why wasn't the number of students participating in the study reported?

2. Why weren't reliability and validity reported for the survey instrument?

3. Quinn states that, "twenty value sheets were presented to each experimental group at the rate of two per week for ten weeks" (p. 66). Why was this method selected? Who wrote the value sheets? Were they tested before they were used in the study? Why were two value sheets used per week? Why did the study only last ten weeks instead of twelve, twenty, etc.?

4. How was the teacher variable taken into account? Four different teachers could certainly confound the variables.

5. Total instructional time was twenty minutes per week for ten weeks. Could this explain the lack of any substantive results?

6. How was the level of significance selected for this study and why wasn't it justified?

7. Why does the conclusion consist of only two sentences which indicate that no results were obtained? Is this an indication of the

contribution of studies of this type to the science education literature?

In conclusion, Quinn makes five recommendations at the end of the article, none of which indicate that the shortcomings of this study may be due to the way it was designed, developed, conducted, implemented, and the statistics used. Future studies should concentrate on using valid and reliable instruments. Furthermore, care must be taken to adequately identify the characteristics of the population used, a justification of the statistical design and a realistic time period for the conduct of a study. This study illustrates that research cannot be conducted for twenty minutes per week for ten weeks. The most efficient handling of studies of this type is for the journal editorial boards to reject them.

Santiesteban, A. Joseph. "Attitudes of High School Students Toward Science Instructional Procedures." Journal of Research in Science Teaching 13(2): 171-175, 1976.

Descriptors--Attitudes; *Educational Research; Instruction; Science Education; Secondary Education; *Secondary School Science; *Sex Differences; *Student Attitudes; *Teaching Procedures

Expanded abstract and analysis prepared especially for I.S.E. by Robert J. Vanden Branden, Drake University.

Purpose

The primary purpose of the study is to investigate the attitudes of high school students toward various science instructional processes and procedures. The attitude variables examined deal with the structure and function of the laboratory, teacher questioning behavior, textbooks, library reports and independent projects, testing, grading, types of instruction, and a number of other categories. A secondary purpose is to determine if male and female students responded similarly to the attitude variables.

Rationale

The secondary science curricula and science teacher-training programs place emphasis on various teacher-student roles that may or may not be perceived favorably by the students. Science teacher training emphasizes focusing teacher behaviors toward inquiry-oriented instruction. As part of this inquiry-oriented instruction the teacher asks open-ended questions, encourages students to explore alternative explanations, and stresses the use of laboratories designed to encourage the student to behave scientifically. Yet, some students, indoctrinated by spoon-feeding approaches to instruction, may have strong negative attitudes toward inquiry-oriented instruction. Other students may enjoy textbook-centered instruction and may consider this the appropriate or best instructional method.

Procedure

Test construction. A large number of items were generated that sampled student attitude variables. Items were submitted to a panel of judges, including two science educators and a measurement expert, to determine the content validity and accuracy of each statement. Ambiguous and repetitive items were eliminated. Sixty items, using a seven-point summative scale, were randomly compiled into a test booklet.

Sample. Three hundred thirty-one students enrolled in tenth, eleventh and twelfth grades from four high schools in Alachua County, Florida, were selected as test subjects. Students were enrolled in courses such as IIS biology, BSCS Blue, BSCS Green, Chem Study chemistry, physics, human physiology, and general biology. Two of the high schools were suburban while the remaining two were located in rural areas. The test sample was purposefully selected for its heterogeneity since it was of interest to investigate the attitudes of various types of students. Forty-three subjects were eliminated before analysis because they failed to respond properly to the questionnaire. Of the remaining subjects 150 were females and 138 were males.

Findings

Factor analyses using varimax rotations were performed for each sex with squared multiple R's as communality estimates. The principle axes factor matrices accounted for 74.66 percent of the total score variance for the female and 75.52 percent for males. Fifteen factors were extracted and rotated for the females, and 14 for the males. Reliabilities for the test items, estimated as not less than the square roots of the communalities (Guertin and Bailey, 1970) ranged from .74 to .95 for the females and .73 to .93 for the males. Ten factors were labeled for the females and eight factors for the males. Factors and their factor loadings are reported in Tables I and II.

Factor I, labeled "Oral Reports-Science Projects," indicates that females place much importance on the giving of oral reports and participation in science projects. Factor I for the males, labeled "Small Groups-Task Performance," suggests that males consider working in small groups and the performance of particular tasks to be desirable. Factor II for females is labeled "Specific Instructions," while Factor III is "Set Induction." It appears that females desire structure in the form of specific instructions and would like to have verbal advance organizers. Factor II for males, labeled "Learning Effectiveness," places emphasis on means of making learning from textbooks, audiovisual materials, and labs more effective and interesting, while Factor III is concerned with the need for math skills. Analysis of the remaining factors indicates that there are wide discrepancies between the attitudes of males and females to identical items. Although some factors have similar labels, their sum of squared factor loadings are quite different. Labels as well as the numerical values indicate that these factors are not identical.

Interpretations

It is difficult and a bit treacherous to attempt to delineate implications from this study to science instruction. Students in this sample have indicated an auxiliary role for the science teacher. There is a strong indication that science teachers should teach math and reading skills. Many of the texts used in secondary science classrooms are difficult to read and incorporate complex mathematical concepts and the request for assistance from the science teacher is warranted. Structured laboratories and classroom procedures are indicated to produce greater learning and to be greatly desired by students. This may be a reflection of haphazard planning where the purpose of the instruction and procedures to be followed are unclear. Both males and females stressed positive attitudes toward small-group work while females highly valued projects and oral reports. Both small-group work and projects are common instructional procedures, simple to implement and generally enjoyed by the students in this study. Males appear to be concerned with methods of making science instruction more effective through the use of audiovisual materials, textbook pictures, and laboratory experiences.

Total factor structure for males is substantially different than for females. This suggests that the sexes perceive the importance or desirability of certain instructional procedures very differently. Although the attitude measure employed in this study can be considered a course measurement device, it is realistic to assume that differences in the perception of the importance, relevance or interest of instructional procedures vary as a function of sex. The results of this study agree with the previous study by Guertin and Jourard (1962) and indicated that pooling both sexes in a factor analysis and then performing an analysis of variance to determine differential response to factors by sex is not practical.

In future studies of student attitudes toward science instructional procedures, analyses using race, age, and achievement should be performed. Analyses of this type coupled with the growing body of aptitude-treatment-interaction data will be of assistance in the development of science instruction relating to both individual and group differences. By recognizing both cognitive and affective individual and group differences and designing materials and procedures to meet those differences, learning in the science classroom and laboratory will be facilitated.

ABSTRACTOR'S ANALYSIS

The determination of the attitudes of high school students toward methods (implementation) of instruction should be of vital concern to educators who are interested in curriculum and instructional improvement. As each of us is influenced by his/her subject matter background and interest, it is appropriate to address the study of student attitudes to a specific discipline.

This study included very limited references to attitudinal studies of secondary science students. Two of the references were to modern factor analysis and another 25 percent of the references were to attitudes of elementary students toward science.

It is assumed that the construction of the test that sampled student attitude variables conformed to some guidelines of construction because a panel of judges was used to determine content validity.

Because tables were included in the article, one for females and one for males, which stated factors and factor analyses, the reader might infer what the attitude test items might be.

The sample number of 288 high school students enrolled in seven different science classes was adequate, probably because of complexity of variables examined.

I do not understand the rationale of the statement "The test sample was purposefully selected for its heterogeneity since it was of interest to investigate the attitudes of various types of students." How the sample was selected is another concern as the procedure might have an effect on the results.

My definition of an attitude is the predisposition of an individual to respond to a specific stimulus object, symbol, concept, procedure etc. The attitude includes cognitive, emotional and action tendency components. The article would have been strengthened by including more specific descriptions of the specific attitudes (factors?) being evaluated even if a very different definition was used.

A 60-item attitude test was used to evaluate student attitudes toward structure and function of the laboratory, teacher questioning behavior, textbooks, library reports, independent projects, testing, grading, types of instruction and a number of other categories in IIS biology, BSCS Blue, BSCS Green, Chem Study, physics, human physiology, and general biology. This represents an overwhelming number and variety of variables especially when "a number of other categories" is included in the list.

Some assumptions stated in the introduction and interpretations might be challenged although most remarks are not judgmental and seem appropriate. While science teacher training should include an emphasis toward inquiry-oriented instruction, the statement "Science teacher training emphasizes focusing teacher behaviors toward inquiry-oriented instruction" is overstated and might be difficult to substantiate.

The first statement in the interpretations section indicates that the author is honest. I fully agree with him because many of the relationships to which he refers are difficult to find in the tables and are not to be found in the text of the article.

The interpretation of the findings related to gender is interesting but poses a number of problems for the reader who has not seen the test items. Certainly the following statement is presumptuous--"Although the attitude measure employed in this study can be considered a course measurement device," (what does this mean?) "it is realistic to assume that differences in the perception of the importance, relevance or interest of instructional procedures vary as a function of sex."--Why? Not all studies related to attitudes of students (and teachers) would agree with this. As an example, my dissertation produced results which indicated that the attitudes of preservice male and female teachers, when placed in an hypothetical classroom situation, were not significantly different. While my paper was only indirectly related to his study, it indicates, to me, that his generalization may be shaky.

The research report was interesting and it may provoke additional research. The paper was well written, but very brief.

The purpose of the study was met and evaluated. The results were in table form. The interpretations of the primary purpose and the result statement related to the secondary purpose might be justified if the report were enlarged to include the test items (or samples) and a description of the seven-point summative scale and its interpretation.

The results were interesting. Because almost all classes contain male and female students and because all students have unique needs, wants--attitudes (whether or not the variance is a function of sex), the importance of the results to all teachers is that a variety of methods is better than a single method. It strengthens the notion that a teacher (of science or other subjects) should possess a repertoire of methods of instruction and methods of evaluation. It alludes to the need for the teacher to plan and organize the course and class sessions using his/her repertoire of methods to assist each student to achieve the variety of student objectives.

An instrument, such as the one used in this study, might well be employed to determine the needs of the students in each class, so that the appropriate instructional procedures are implemented.

Savada, D. "Attitudes Toward Science of Nonscience Major Undergraduates: Comparison with the General Public and Effect of a Science Course." Journal of Research in Science Teaching, 13(1): 79-84, 1976.

Descriptors--*College Science; Community Attitudes; Educational Research; Higher Education; *Public Opinion; *Science Education; *Scientific Attitudes; Student Attitudes

Expanded abstract and analysis prepared especially for I.S.E. by Marvin Bratt, The Ohio State University.

Purpose

The purpose of this study was twofold. The first question addressed was How do the attitudes towards science and technology of non-science major college students compare with most of the general public? The second question was Do the attitudes of students change after a science course?

Rationale

In 1967 The Commission for Undergraduate Education in the Biological Sciences (CUEBS) noted that many students took only science courses that were required of them and that these students often ranked poorly in such classes. Of primary concern was the observation that most students were enrolled in biology courses during the freshman year and that such courses were labelled "flunk-out" courses. With this in mind, the author assumed that college students would be intellectually brighter and better informed and therefore should have "stronger" opinions on science and its social impact. He also assumed that science major undergraduates should have more positive attitudes than non-major undergraduates.

He related the study of the first question to studies by the National Science Board (1973) and S. Whitney (1959). The study of the second question was related to studies by Johnson, Ryan and Shroeder (1974), Kempa and Dube (1974), Kennedy (1973), and Simmons and Esler (1972).

Research Design and Procedure

Information gathered concerning the national sample reported here was gathered as a survey by the Opinion Research Corporation (1973). Data gathered for the purpose of comparison was done on a pre-test treatment - post-test design. There were no controls designated; however the national sample data are provided. The sample consisted of intact groups (classes) enrolled at three colleges in California. Sixty-five subjects, 30 males and 35 females, were involved in the study.

The treatment was described as the "Principles of Natural Science" course which was three hours of lecture and one hour of laboratory work for 15 weeks. The course was divided equally among a physicist, a chemist, a cell biologist and an ecologist and focused on "origin and evolution."

The instrument used for data collection was the survey questionnaire designed by Opinion Research Corporation (1973). The survey questionnaire contained nine items. No validity or reliability data were reported. This survey was completed by all subjects on the first and last days of the course. Results were reported as percentages. Statistical analyses were calculated using a non-random difference statistic (Walpole, 1974).

Findings

Among the findings of interest, a majority of the sample suggested that science and technology had changed life both for better and worse. Reactions to science after the course increased across satisfaction or hope but decreased over excitement or wonder. There was an increase across fear or alarm. Rankings of nine occupations changed very little after treatment; scientist moved from rank 4 to rank 3. When asked if science and technology did more harm than good, 60 percent reported more good while after treatment, only 28 percent reported more good. These persons apparently moved into the group which reported "about the same."

When asked whether science and technology was the cause of problems, a slightly larger percentage suggested "some" or "most" at the end of the treatment. Science and technology was blamed for changing things too fast (48 percent to 68 percent) after treatment. After completing the course, an overwhelming majority (71 percent) responded to increased societal control over science and technology as compared to 49 percent on the pre-test. When asked to rank priorities as to government spending for science and technology, the greatest change in ranks was for developing faster and safer public transportation (from seventh to second).

Interpretations

From these data, Savada concluded that, prior to the course, students had more negative opinions of science and technology than did the general public. He suggests that the students were sufficiently disturbed about the bad aspects and rapid rate of change to demand increased social control of science and technology. He concluded that students felt more negative towards science and technology after treatment than before. The postulation was made that the mass media could have influenced the students more than the general population. He claimed that mass media could be responsible for shaping attitudes of students and that the course reinforced these attitudes.

ABSTRACTOR'S ANALYSIS

A statement by Renner, et al. (1976) says it best, "Most of this research is directed toward science as a discipline, school subject, scientists or instructional problems. The subjects are usually students or their teachers." There have been relatively few studies reporting attitudes of the general public towards science. On the whole, the general public's attitude toward science seems to be fairly positive, consistent and stable according to the data reported here. There is a discrepancy, however, when these data are compared to the students enrolled in the science courses. These data seem to be consistent with other data on college students who seem to view science and science education somewhat more negatively. There do not seem to be additions to the conceptual or methodological techniques currently in use in this research area. Percentages are compared between the four groups of administrations.

The validity could be suspect in several ways. Is it possible or perhaps questionable to generalize from an instrument such as this survey? Does the general public see the scientific endeavor as a solution to societies' problems? Eighty-one percent of the population (general public) stated that science and/or technology will eventually solve problems in pollution, disease, drug abuse and crime. Spending tax money to support various areas certainly does not seem to reflect the voting records of our politicians. Perhaps more powerful statistics could have been applied to these data which would lead to other conclusions. A serious question could be raised concerning the sample chosen to compare with the national sample. It is questionable whether "non-science" majors would have stronger or more positive attitudes towards science. It would have been a stronger study if students were randomly assigned from a college population, at least to provide some control over negative attitudes expressed by "non-science" majors.

Studies on attitude change after coursework, institute participation or following workshops are frequent in recent science education literature. In the main, these studies are done with teachers or pre-service teachers (see Piper and Moore, 1977). Little research has focused on changing attitudes or teaching strategies among college professors. This, perhaps, is the key to the somewhat negative (or less positive) attitudes towards science among college students. Current strategies used in science education have focused on developing science processes as well as technology and recent information and knowledge developed by the scientific community. Such courses have demonstrated substantial success in improving the attitudes of teachers and students towards science and science teaching. One could question the approach used in the course reported in this study. The instructors were professional scientists; a biologist, a chemist, a physicist and an ecologist. The material covered dealt with the origin of the universe, atomic particles and astronomy. Renner et al. (1971) suggest that a substantial proportion of college freshmen are not intellectually capable of understanding such complex scientific theories. It is entirely possible that the subjects in this study reacted negatively towards the science course because they did not fully comprehend the meaning of the material.

While there are several researchers who disagree with theories of intellectual development, the data cannot be overlooked as a possible confounding variable. Papers presented at the annual convention of the National Association for Research in Science Teaching (1979) illuminate the disagreements in theory but also provide substantial direction for continued research in this area. Little doubt remains that the formation and development of attitudes towards science is directly linked to the type and style of instruction encountered in the high school and college years. The link between concept formation and understanding and attitude formation is crucial to the understanding of and interpretation of results such as these reported in this study.

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Symington, David J. and Peter J. Fensham. "Elementary School Teachers' Closed-Mindedness, Attitudes Toward Science, and Congruence with a New Curriculum." Journal of Research in Science Teaching, 13(5): 441-447, 1976.

Descriptors--*Curriculum Development; Dogmatism; Elementary Education; *Elementary School Science; *Educational Research; *Process Education; Science Education; *Science Teachers; Science Programs; *Teacher Attitudes.

Expanded abstract and analysis prepared especially for I.S.E. by Harold H. Jaus, Purdue University.

Purpose

The purpose of this investigation was to determine the relationship between the dogmatism of teachers and two intervening variables in the context of a recently introduced innovative science course for elementary school children. The intervening variables in question were (1) congruence with course expectation for classroom behavior, and (2) attitudes toward science. The researchers hypothesized that the more dogmatic elementary teachers will express less congruence with the behaviors expected by the innovative course and have less positive attitudes toward science than their more open-minded colleagues.

Rationale

Previous studies have indicated that closed-minded (dogmatic) teachers are generally resistant to curriculum change or innovation. This relationship, however, may not be a simple one. For example, the structure of the new program is likely to be a source of intervening variables, i.e., structured programs (S-APA) versus unstructured programs (Nuffield Primary Science). Second, the manner of the introduction of the new program in the schools may be a significant variable since it has been suggested that closed-minded teachers are more likely to accept changes which carry the approval of external educational authority figures. Third, it may be that elementary teachers have attitudes toward science which will color their responses to the new programs and intervene between dogmatism and that response. An underlying assumption suggested by the investigators was: A closed-minded teacher may very well accept a science curriculum change if the change is viewed as highly structured, approved by educational authorities, and if the teacher viewed science as authoritative and associated with established patterns. The authors cite research that closed-minded teachers are more traditional in their classroom behavior and in their views of "ideal" pupils, e.g., working infrequently with small groups, giving more information, giving more directions, and viewing "ideal" pupils as obedient, quiet, reserved, and readily accepted the judgment of authorities (Bird, 1971; Cohen, 1971).

Research Design and Procedure

This correlation study involved 72 teachers (36 male, 36 female) of grades five and six in 24 schools located in the suburbs of Melbourne, Australia. These subjects were the teachers of the recently introduced "innovative" science course. First year teachers of the science course and teachers who had undergone inservice education in science were excluded from the study. The data were collected two years after the introduction of the science course.

The science course taught by the teachers in the study was presumably a science course designed for fifth and sixth graders. The course was "not only concerned with the introduction of science as topics of study" but, also, "specified patterns of classroom organization and teacher behavior" (similar to those of Nuffield Primary Science). According to the authors, these patterns represented for the teachers in the study "a marked departure from many established transactions of the elementary school classroom."

The instrument used to measure congruence with course expectation was developed by Symington (1974). In its final form the measure consisted of nine items, each containing a description of a class situation and five alternative forms of behavior which a teacher could adopt to meet the situation. The teacher ranked the alternatives from most to least suitable and a comparison of the teacher's rankings with an "official" ranking produced a score. Ten elementary science experts generated the "official" rankings by determining the closest behavior expected by the science course planners to the least like expected behavior. A slightly modified Schwirian's Science Support Scale (Tri-S) (1968) was used to measure the teachers' attitudes toward science. The Tri-S is a Likert-type scale using items based on a five-fold value system: rationality, utilitarianism, universalism, individualism, and a belief in progress. The reliability of this measure has a reported value of 0.87.

Open and closed-mindedness was measured using a modified Rokeach instrument developed by Ray (1970). Ray's instrument is made up of positive items from Rokeach's scale and new negative items. Validity was determined by the "criterion groups" approach with obtained reliability values on students (0.91 and 0.81) and adults (0.78).

A two-way, least-squares analysis of variance was used with dogmatism score and years since initial college training as independent variables and congruence as the dependent variable. The same analysis was used with dogmatism score, years since initial college training, and attitudes toward science scores. Correlation coefficients were obtained for dogmatism scores and attitudes toward science scores, and dogmatism scores and the Tri-S five sub-scale scores.

Findings

Both hypotheses were supported by the data. Teachers' congruence with the dogmatism scores provided an F ratio of 4.95 ($p < .05$). Teachers' attitudes toward science scores and dogmatism scores provided an F ratio of 9.75 ($p < .01$). The value of the correlation coefficient between dogmatism and attitudes toward science was -0.51 and remained as a partial coefficient of -0.46 when the effect of years since initial college training was removed. All but one (belief in progress) of the Tri-S sub-scale score with dogmatism score correlations were significant at the 0.05 level using a two-tailed test. These correlation values ranged from -0.19 to -0.45. There was no evidence to suggest that the time since the teachers' initial college training interacts with either congruence or attitudes toward science.

Interpretations

Based on the results of their study the researchers contend that "teachers' dogmatism was related to both their beliefs about teachers in classrooms and the teacher's attitude toward science." The inverse relation obtained between congruence and dogmatism was of particular significance in that the highly authoritarian tradition in which the innovation of the course occurred may have been expected to lead teachers of high dogmatism concurring with it. However, the authors infer that "radically" different teacher behavior requirements of the course overrode the course's authoritarian introduction and thus became a dominant intervening variable.

It is suggested by the authors that dogmatic teachers ought to be provided with a more realistic understanding of science in the hope that they may respond to teaching innovative science courses rather differently.

ABSTRACTOR'S ANALYSIS

This study provides additional support concerning the contention that closed-minded teachers have significantly less favorable attitudes toward science and teaching "new" science programs than their more open-minded colleagues. In a review of the literature before 1972, the abstractor found seven studies not mentioned by the authors showing that closed-minded teachers also had less favorable attitudes toward teaching "new" science programs than more open-minded teachers. Some criticisms and suggestions for improving the article follow.

It would have been informative if data from a group of fifth and sixth grade teachers not involved in teaching the "new" science course were obtained and reported. Or, if this were not possible, a pretest and a post-test, rather than only a post-test, had been administered to the teachers of the "new" science course. Such data would allow causal relationships to be made. For example, perhaps the nature of the science course in question influences teachers' dogmatism, congruence (attitudes toward teaching science), and attitudes toward science. Data from a control group or a pretest would also permit more support to the authors' contention that dogmatic teachers have less favorable attitudes toward science and congruence with intentions of the science course.

The authors state that the teachers involved in the study were all teaching the new science course but no mention is made concerning how these teachers became involved, i.e., were they forced to teach the course or did they choose to do so? (It is assumed they were forced to do so.) Being forced to teach a new course might influence even the most open-minded teachers' attitudes about the teaching behaviors expected of the course and its subject matter. Pretesting or use of a control group would support or reject the above contention. Also of interest would have been information concerning instrument score differences between the male and female teachers (36 male, 36 female). Perhaps the sex of the teacher is an intervening variable.

Although the researchers found a significant difference between teachers' congruence and dogmatism scores using analysis of variance, they did not report the correlation coefficient between congruence and dogmatism. Since this was a correlation study, such information seems necessary for the reader to see the magnitude of the correlation. A reader does not get a "feel" for a correlation by ANOVA results alone.

Also helpful to the reader would have been (1) the inclusion of mean and range values of the teachers' scores on the instruments used, (2) example items from the congruence measure, (3) data or references to support the claim that the teachers involved in the study "had weak backgrounds in science," (4) the inclusion of more information concerning the administration and scoring of the instruments used, the nature of the "new" science course, the reliability of the instrument measuring congruence, and (5) some indication as to how well the dogmatic teachers actually taught the new science course and their actual feelings toward teaching the course. It may be that the more dogmatic teachers taught the course as it was intended and did indeed like teaching the course. Based on the article, none of the instruments used directly addressed themselves to these last two points.

It appears important to point out that many of the weaknesses and suggestions offered by this abstractor are not the problem of the authors. Authors who submit articles for publication are dependent upon the journal reviewers for revision suggestions. When such revision suggestions are not forthcoming, authors have little to go on for revision purposes.

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Descriptors--Attitudes; Attitude Tests; *Class Size; Educational Research; *Grouping (Instructional Purposes); Science Education; Secondary Education; *Secondary School Science; *Scientific Attitudes

Expanded abstract and analysis prepared especially for I.S.E. by Robert L. Shrigley, The Pennsylvania State University.

Purpose

The purpose for the study was to examine the relationship between class size and student attitude toward science.

Rationale

Although not spelled out early in the report, but alluded to in the discussion, the rationale for the proposed class size-attitude relationship was based on the assumption that smaller instructional units contribute to (1) maintenance of personal identity, (2) teacher-student rapport, and (3) better opportunity for student participation. The reader can further infer that those three small class characteristics in science instruction affect student attitudes in a positive direction.

Research Design and Procedure

The sample was drawn from high school biology, physics, and chemistry classes from 12 states in three regions of the United States that made up the federally-funded Minnesota Research and Evaluation Project (MREP).

All schools were stratified by population with each strata systematically sampled and one teacher and one of his/her classes randomly selected. Furthermore, a random third of the students in each class was sampled for attitude and achievement data.

So that the variables of teacher attitude toward science and student achievement might not mask a class size-attitude relationship, the former two variables were held constant through the use of a partial correlation statistical technique.

Hypothesizing that the attitude concept has two components (intellectual and emotional), three attitude measures (intellectual, emotional, total) for both students and teachers were investigated. As a means of testing attitude homogeneity, student and teacher emotional-intellectual components were correlated resulting in the correlation coefficient of .58 for student attitudes and .51 for teacher attitudes. Those correlation coefficients were considered sufficiently low to assume that intellectual and emotional attitudes were distinguishably different concepts. Therefore, there seemed to be justification to test each attitude concept.

The class was used as the basic experimental unit. The value of student attitudes (emotional, intellectual, and total) and student achievement were class means. Class size and teacher attitude scores were used directly as reported.

The author used Moore and Sutman's (1970) Science Attitude Inventory (SAI), a Likert-type attitude scale with a test-retest reliability correlation coefficient of 0.93. SAI has two components, one measuring emotional and the other measuring intellectual attitudes. The composite of the two subscores was the total attitude test score.

Student achievement was measured by the test of Achievement in Science, a 45-item multiple choice test comprised of items drawn from the National Assessment Test for Science. The KR20 reliability calculated from the MREP sample was 0.87.

Findings

With student achievement and teacher attitude (emotional, intellectual, and total) held constant, the hypothesis that smaller instructional units have a significant positive correlation to student emotional, intellectual, and total science attitudes was rejected at the 0.01 level. Therefore, class size seems not to be directly related to student attitude toward science.

Ancillary to the main thrust of the study, the author tested relationships between other variables, an action unaccompanied by hypotheses. Significant beyond the 0.01 level were the partial correlations between student achievement and

1) class size,
2) student emotional attitude score,
3) student intellectual attitude score, and
4) student total attitude score.

Interpretations

Three major observations were made by the author:

1) Positive attitudes seem not to be directly related to smaller instructional units in the secondary school sciences.
2) Either the attitude concepts is not readily divisible into emotional and intellectual components, or the methods of this study were too crude to detect it.
3) Two pairs of factors seem to be related:
   (1) class size-achievement
   (2) attitude-achievement.

Although the study failed to reveal a direct relationship between class size and attitude, the author suggests that the two variables are related indirectly. That is, if class size affects achievement and achievement affects attitude, then, class size affects attitude.

Using the route of logic from class size to attitude through achievement, the author offers the following implications:

1) Because our skills in defining, measuring, and devising instructional schemes are far better in the cognitive than the affective domains, advancement in affective domain may best be promoted by fostering achievement in the cognitive areas.

2) Conversely, affective-directed strategies should aid cognition.

3) If class size influences cognition, it may also influence affective goals.

ABSTRACTOR'S ANALYSIS

Science attitude is worthy of high priority in educational research, and the author's statement chiding educators to develop effective research strategies in the affective domain regardless of their feelings toward affective goals in education is commendable.

To assume with the author that the concept of attitude is multi-dimensional is well documented in the literature of the social psychologist. So his decision to test both the emotional and intellectual components of attitude is in line with Triandis (1971) who suggests that attitude is more than a single concept; it has not only an affective and cognitive component, but a behavior one, too. Fishbein and Ajzen (1975) suggest four dimensions: belief, attitude, intention, and behavior. Using Moore and Sutman's attitude scale, with both emotional and intellectual components, was in line with the author's objectives.

The author exercised foresight in holding constant student achievement and teacher science attitude, two variables that could have masked the relationship of the two variables under study: class size and attitude.

Relating class size and attitude, the author uses: 1) maintenance of a personal identity, 2) teacher-student rapport, and 3) the students' opportunity to participate, but he failed to provide a theoretical underpinning for those three components. Why should they be related to attitude?

In quest of theoretical support, the author might have examined the literature of the social psychologist where models for attitude research have been developed since the 1940's. Several approaches to attitude modification are described in detail by several authors including Zimbardo, et al., (1977), Wrightsman, (1977), Kiesler, et al., (1969), and Triandis, (1971).

The author might have drawn some support for active participation of students had he examined Kurt Lewin's group dynamics theory. In the days of food shortages in World War II, Lewin tested group discussion and lecture as a means of persuading housewives to serve kidneys, sweetbreads and heart, beef cuts not commonly served in the 1940's. Far more housewives attending discussion groups served the unusual meats than those attending lectures (Triandis, 1971). Therefore, we might assume that participation influences attitude more than do lectures.

Triandis spells out the differences. Lectures are passive; they are cognitive with no personal commitment required. Discussions are active; verbal statements made by group members before the group can be a form of commitment to a point of view. Group norms can change before your eyes.

Without a more precise definition of the author's other two components, maintenance of personal identity and teacher-student rapport, drawing theoretical support for them becomes more difficult.

Even if we could assume that the author's three characteristics of class size have an adequate theoretical base, to further infer that those characteristics function differently due to class size is quite an inferential leap. Student participation, personal identification and teacher-student rapport might be the function of the individual teacher's philosophical outlook.

And class size may not have been fully tested in this study. With a mean enrollment of 20.52 and a standard deviation of 8.11, the range of the author's class sizes may not have been enough for the variable, class size, to function.

The author infers that, although class size is not directly related to attitude, it may be indirectly related via achievement. But as acknowledged by the author, the class size-student achievement relationship found in the study is questionable. The study involved intact classes. Thus students were not randomly assigned to various sized classes. Therefore, schools which systematically produce high achievers could be those financially able to support smaller classes.

And with class size-achievement now in question, the author's logical syllogism that class size affects attitude via achievement is also weakened. This, in turn, affects the author's suggestion that we might best improve attitude through cognition. That we can better define, measure and design instructional strategies in the cognitive than the affective domain is probably true. But instead of furthering attitude through the cognitive domain, science educators should first attack the problem of science attitude through an analysis of the theoretical models of attitude modification found in the literature of the social psychologist cited earlier in this analysis.

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Descriptors--*Achievement; *Astronomy; *Attitudes; College Science; *College Students; *Computer Assisted Instruction; Educational Research; Higher Education; Instruction; Science Education

Expanded abstract and analysis prepared especially for I.S.E. by Ronald D. Simpson, North Carolina State University.

Purpose

The purpose of this study was twofold: 1) to introduce college students to selected astronomical and mathematical concepts in an introductory astronomy course by way of three types of computer-assisted instruction (CAI), and 2) to investigate the effects of sex and type of CAI on improvement of mathematics ability, transfer of learning, and attitude toward CAI.

Rationale

The investigator introduced this study by citing a study by Wall (1973) in which research in astronomy education between 1922 and 1972 was reviewed. Wooley agreed with Wall "...that research is needed to determine the effects of student(s) variables (sex, I.Q., etc.) and of different instructional strategies, such as computer-assisted instruction (CAI), on student achievement and attitudes."

The investigator also discussed a concern held by many astronomy educators: the amount of mathematics that is needed by students for successful completion of an introductory course in astronomy. In a prior study, Wooley developed an instrument to measure mathematics ability, ranging from arithmetical operations through the solution and application of algebraic expressions.

Another area of concern discussed by the investigator in this study is the effect of feedback, or reinforcement, on learning via the CAI method. He cites work of Brown (1967) and Gilman (1969) where several options for feedback are listed. Other studies such as those by Swets (1962), Klaus (1965), Holland (1965), and Bryan and Rigney (1965) are mentioned by the investigator. From his review of the literature, it appears that there is considerable debate as to the net effect of feedback on student learning via CAI.

The investigator also discussed two other variables of concern in CAI: student attitudes and sex. Several studies have shown that undergraduate students possess attitudes toward CAI that are at least as positive as those toward traditional kinds of instruction. Wooley suggests that there may be sex differences involved relative to attitudes and achievement via CAI, but he does not cite specific studies to confirm or reject this notion.

In summary, the general aim of this study is an attempt to consider student gender, mathematics background, mode of reinforcement (during CAI), and student attitude in relation to achievement in introductory astronomy when CAI is used as the primary instructional strategy.

Research Design and Procedure

The subjects in this study included 68 males and 26 females enrolled in an introductory astronomy course at Eastern Michigan University during the winter semester of 1975. The 94 students were enrolled in two sections (23 and 71) and both were taught by the investigator.

The investigator reports that his design can be classified as a pretest-posttest, control group design (Campbell and Stanley, 1965). Within each of the two sections, students were randomly assigned to one of the three CAI groups. Pre- and posttest measures of mathematics ability were administered. Course achievement and student attitude toward CAI was also measured at appropriate times throughout the course.

Each of the 18 CAI modules used in this study consisted of a Fortran IV computer program with which students interacted via a teletype terminal linked to a time-sharing computer. Each module included necessary directions to students that served to perform important administrative functions.

The nature of the CAI treatments used in this study can best be described by quoting the following section written by the author:

> Three types of CAI were developed, each type consisting of a series of six modules. An experimental treatment consisted of either Type I or Type II CAI. Each treatment was intended to improve a student's ability to cope with the math encountered in the course. Both Type I and Type II CAI presented Ss with a series of numerical, beam-balance problems designed to elicit the discovery of the torque principle and to provide practice in applying and extending this principle. In addition, Ss were asked a series of questions covering the related area of direct and inverse relationships.
>
> The two treatments differed in the type of feedback received. Type I CAI provided Ss with knowledge of results, knowledge of correct response, and response contingent feedback. Type II CAI supplied Ss with only knowledge of results feedback. Type I might therefore be called guided discovery CAI and Type II, discovery CAI.
>
> Type III CAI asked Ss to respond to questions based on information presented by the modules. The information dealt with orbital motion and the sun's diurnal motion. Since no mathematical material or manipulations were involved, Ss receiving Type III CAI were taken as the control group for investigating improvement in math ability. Type III CAI always provided Ss with a combination of knowledge of results and knowledge of correct response feedback.

The pre- and posttests of mathematical ability were parallel instruments designed by the investigator to measure achievement ranging from arithmetical operations through solution and application of algebraic expressions. Two "transfer exams" required students to solve numerical problems related to mathematical relationships in light and telescope formulas (Transfer Exam A) and in black-body radiation laws and cosmology (Transfer Exam B). The author did not elaborate specifically on how the "transfer exams" were used in this course and in this investigation.

The CAI attitude instrument was a measure of student experience in such areas as: time spent, difficulty of material, relevance of questions and feedback, mechanical problems, and continuation of program. The instrument was modified by the investigator based on an earlier form developed by Brown (1967).

Findings

Since students from Group II scored higher in math ability than the other groups on the pretest, a one-way analysis of covariance was run using the pretest as the covariate. The results showed no significant differences at the .05 level of probability between Groups I and II for any of the post-treatment measures. This suggests that no one type of feedback produced improvement in math ability, transfer of learning, or attitude toward CAI as measured by the instruments used in this study.

Alternatively, both Groups I and II scored significantly higher than Group III, the control group, on the math posttest. Thus, both the guided discovery method of Type I and discovery method of Type II produced improvement in math ability as measured by the posttest.

When sex was considered, females scored lower than males on all measures, and significantly lower ($p < 0.01$) on the math posttest and on the CAI attitude instrument. Females in this study appeared to benefit less from CAI than males. The major findings of this study are shown in Table II as constructed by the author.

TABLE II

F-VALUES AND MEANS FROM ONE-WAY ANALYSIS OF VARIANCE WITH BREAKDOWN BY GROUP

Variable	Group I			Group II			Group III			F-Value
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	
Pretest	34	62.06	19.81	33	70.30	16.77	33	65.67	20.44	1.57
Posttest	32	71.56	29.19	31	79.03	17.39	33	61.21	24.97	4.31*
Exam A	32	67.91	16.63	31	74.29	14.80	32	71.88	12.95	1.49
Exam B	31	63.29	16.11	31	67.29	14.31	32	65.69	12.91	0.60
CAI Attitude	31	5.52	27.23	31	9.55	23.66	31	17.39	20.03	1.99

*$0.01 < p < 0.05$.

Interpretations

Gilman (1969) found that students receiving feedback guiding them to the correct response performed better than those who were forced to discover the correct answer. This investigation does not support this claim. This study does support, however, Gilman's findings that students' attitudes toward CAI are independent of the type of feedback they receive. Also, females appear to benefit less and have a less positive attitude toward CAI than do males, no matter what type of feedback is used. The author in this study states that responses to items on the CAI attitude instrument suggest that part of the negative attitude expressed by females is related to what they perceive as the mechanical and impersonal nature of CAI.

Wooley concludes this report by stating "the findings of this study suggest that CAI can be effective in producing problem-specific learning regardless of the type of feedback used. If transfer of learning is one of the desired goals of instruction, more attention should be given to the principles of transfer than to the nature of feedback. In addition, an attempt should be made to make CAI more compatible with the needs of female Ss, especially where this is an important factor. How this can be accomplished is not entirely clear; however, the use of reliable visual display terminals and computer graphics techniques might prove more appealing and effective to female Ss."

ABSTRACTOR'S ANALYSIS

This investigator has done an excellent job in relating the findings of this study to prior published studies. When compared with other investigations, it was shown here that variation in feedback did not produce significant differences in math achievement as one might have suspected, particularly in light of what Gilman (1969) found. Replication studies like this one are recommended by most educational researchers. Another case in point is the apparent influence of gender on achievement and attitude as related to CAI.

This study offers additional evidence that sex differences do exist when it comes to mathematics achievement and to attitude toward computers. While no new conceptual or methodological models emerge from this study, the reported results do help to clarify some important relationships that have been questioned and researched by other individuals in the past. In an applied sense, the results contribute to our knowledge of astronomy education and to how this can be facilitated by computer-assisted instruction.

This study is well-written and easy to follow. Given the constraints faced by the investigator, the research design and statistical procedures used appear to be appropriate. The results were well displayed and the findings and conclusions were communicated openly and to the point. The review of literature was pertinent and the major variables dealt with in the study emerged in a clear and sequential manner throughout the report.

Upon reading this research report, I do not find anything seriously wrong. It is, of course, the purpose of these analyses to offer suggestions for improvement and to, hence, stimulate useful dialogue. In this spirit, I have two general concerns that I will discuss in hopes that further studies of this kind might be improved.

The first area of concern deals with the topic of *validity*. Terms such as "math ability," "transfer of learning," "astronomy achievement," and "attitude toward CAI" were described and measured in terms of tests or instruments that were not shared with the reader. While reliability estimates were reported (and they were reasonable), no operational definitions were forwarded and no case for validity was developed. For a study like this to be solid, one needs to have assurance that the variables being assessed are being properly defined and accurately measured by instruments that possess construct, content, and predictive validity. While these types of validity are hard to ascertain in a single study, it is important to at least acknowledge this and to offer some evidence to the reader that the instruments being used are reasonably good ones. In the case of the various achievement measures that were used here, the reader has no data other than internal consistency estimates to convince him or her that the tests were valid ones. As far as the attitude instrument is concerned, the reader is left almost completely in the dark. Also, the scores presented in Tables I and II are not explained in any way. CAI attitude mean scores presented in the two tables were confusing to me since those in Table II seemed unusually low when compared to those reported in Table I. Group I and Group II means appeared noticeably lower than the mean for Group III, yet the F-value did not suggest that there was any significant difference. In short, the attitude scores were very confusing and were, for the most part, meaningless as far as knowing what it was they were supposed to represent.

A second area of concern is a weakness often seen in doctoral dissertations: *the considerations of too many unrelated variables at one time.* This study attempts to deal with "type of CAI," "modes of feedback," "math ability," "transfer of learning," "astronomy achievement," "math background," "attitude toward CAI," and "sex." Ideally, this is probably too many variables to attempt to understand well in a single study, particularly when they are not carefully developed together. Also, these variables represent several different classes of variables (background, cognitive, affective, antecedent, transactional, outcome, etc.) and they were not presented in a tight, conceptual framework or model showing possible interrelationships. In a design like this, one often ends up knowing a little bit about everything but not too much about anything.

The two areas of criticism mentioned here were covered for constructive purposes. Indeed, most research studies in education (including my own) fail to measure up to the two criteria I have imposed here. In closing, I would suggest that 1) by working extremely hard to develop validity and 2) by dealing with variables cast parsimoniously within a tighter theoretical framework, most educational research would be improved.

I think this study represents an insightful and useful approach to two very relevant areas in education--the use of CAI and the importance of quantitative skills in science achievement. I trust that this study and this analysis will serve as an impetus for further investigations along this line.

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