DOCUMENT RESUME

ED 243 672 SE 044 403

AUTHOR Czerniak, Charlene; Chiarelott, Leigh
TITLE Science Anxiety: An Investigation of Science Achievement, Sex and Grade Level Factors.
PUB DATE Apr 84
NOTE 59p.; Paper presented at the Annual Meeting of the American Educational Research Association (68th, New Orleans, LA, April 23-27, 1984).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150) -- Tests/Evaluation Instruments (160)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Academic Achievement; Anxiety; *Elementary School Science; *Instructional Program Divisions; Intermediate Grades; Junior High Schools; Questionnaires; Science Education; *Secondary School Science; *Sex Differences; Student Attitudes; Teacher Attitudes
IDENTIFIERS *Science Anxiety; Science Education Research

ABSTRACT

This study reviews literature on science anxiety related to such variables as sex, intellectual capacity, achievement, and attitudes. To measure science anxiety, a questionnaire (included in an appendix) was developed, pilot-tested on students in grades 5 and 7 in the Bowling Green (Ohio) School District, and administered in final form to 532 fourth, sixth, eighth, and ninth grade students. ANOVA, MANOVA, and ANCOVA statistical analyses were done on the data. Among the major findings are the following: (1) feelings (particularly anxiety) toward science and science-related topics are significantly sex-related; (2) females at grade 4 already display more anxiety toward science than do males; (3) for this study, science anxiety did not increase with grade level; (4) since only 30 percent of fourth and sixth grade teachers compared to 100 percent of junior high school teachers rated science as first choice when asked to rate preferences for five different subject areas, it is speculated that teachers' attitudes may affect feelings toward science; and (5) significant differenes on science achievement in relation to science anxiety were found, with high levels of science anxiety correlating with low science achievement scores. (Author/JN)

# Science Anxiety: An Investigation of Science Achievement, Sex and Grade Level Factors

Charlene Czerniak
Bowling Green (OH) City Schools

Leigh Chiarelott
Bowling Green State University



Paper presented to the Annual Meeting of the American Educational Research Association, New Orleans, April, 1984

ABSTRACT

Science Anxiety: An Investigation of Science Achievement, Sex and Grade Level Factors

Charlene Czerniak & Leigh Chiarelott

This study reviews the literature on science anxiety related to factors such as sex, intellectual capacity, achievement, attitudes, etc. To measure science anxiety, an instrument was developed by the researchers, pilot tested on students in grades five and seven in the Bowling Green (OH) School District, and administered in final form to 532 fourth, sixth, eighth and ninth graders. ANOVA, MANOVA, and ANCOVA statistical analyses were done on the data. Among the major findings were the following: (1) feelings, particularly anxiety, toward science and science-related topics, are significantly sex-related; (2) females at grade four already display more anxiety toward science than do males; (3) for this study, science anxiety did not increase with grade level; (4) since only 30 per cent of fourth and sixth grade teachers rated science as first choice when asked to rate preferences for teaching five different subject areas while 100 per cent of junior high teachers rated science as their first choice, one might speculate that teachers' attitudes affect feelings toward science; and (5) significant differences on science achievement in relation to science anxiety were seen with high levels of science anxiety correlating with low science achievement scores.

LC4/20/a
mjh

## Introduction

The recent surge of interest in science education, reminiscent of a similar surge in the late 1950's, has raised important issues as to why American students have turned away from the study of science in elementary and secondary schools. Concerns have been raised regarding declining enrollments in upper level (chemistry and physics) science courses, particularly among women, the decline of interest in pursuing science-related careers, the reluctance, and sometimes even fear, individuals express when faced with science-related problems, and finally, and perhaps most important from a national priority standpoint, the decline in science-related standardized test scores.

Related research in the area of math anxiety has provided some revealing data that point to a similar phenomenon in the study of science. Given the concerns expressed above, and the research on math anxiety, it is conceivable that a link exists between science anxiety and such factors as sex, grade level, and achievement. Thus, this study will describe an effort to research this phenomenon (science anxiety) and determine its association with the factors enumerated above. This will be accomplished in two ways: (1) through a review of research and related literature on science anxiety; and (2) through an original study on the relationship of science anxiety to sex, grade level and achievement among fourth, sixth, eighth and ninth graders. The second part of the study will include the development of an instrument to measure science anxiety among intermediate and middle grade students (see Appendix A).

The Phenomenon of Science Anxiety

Generally, anxiety and fear, as feelings, are difficult to distinguish from each other. Fear usually has to do with real, physical threats to one's self, while anxiety usually has to do with one's sense of security. The things that cause anxiety are often fears that are only imagined (Knarnes, 1980). However, anxiety real or imagined, can be a debilitating state for an individual. Anxiety tends to interfere with thinking, learning, and normal functioning.

Mallow (1981) in his book, Science Anxiety: Fear of Science and How to Overcome It, discussed science anxiety quite thoroughly. He stated that when we speak of "science anxiety," we mean the general fear or aversion by students and society toward science concepts, scientists, and science-related activities as a whole.

Research has suggested that science anxiety does exist in many students as well as in society in general. Science anxiety was believed to cause many individuals numerous problems in learning science. Mallow (1981) claimed that science anxiety was reflected in a variety of ways, both physical and psychological. Physically, students had sweaty palms, upset stomachs, headaches, and rashes. Psychologically, students displayed tension and nervousness by tapping feet, chewing nails, becoming distracted, pulling at hair, etc.

Researchers have explained that people, because of anxiety and repeated bad experiences, find confrontation with science a distasteful experience. They tend to become frustrated, avoid science, deny competence in science, and finally, dislike and avoid anything scientific. In fact, Mallow (1981) suggested that a

widespread consequence of math and science avoidance is the widespread avoidance of anything quantitative.

Mallow (1981) concluded that anxiety toward science was being reflected by dropping enrollments in science classes in the United States. Once in classes, students displayed fear of science labs, lectures, and tests. Students hesitated to ask questions, seemed to fear participation in lab settings, and froze on tests. Many students reported feeling dumb and unable to comprehend science. Mallow (1981) reported that science anxiety was also being reflected in lower achievement scores.

The existence of science anxiety in some individuals seems to be fairly well-established. Of greater interest, however, is the high incidence of science anxiety among females, especially of high school and college age. Science anxiety clinics set up at various institutions have reported that the proportion of female applicants is considerably higher than that of males. At Loyola University of Chicago, for example, two-thirds of the applicants to a science anxiety clinic were women.

The relationships between sex and achievement, intellectual capacity and attitudes toward science are important to this study in order to view the emergence of science anxiety in context. In the second part of the study, the existence of science anxiety among younger students is examined in light of sex, grade level and achievement. Whether sex appears as a common characteristic at these age levels will be critical to the conclusions drawn regarding science anxiety.

Science Anxiety and Achievement

Using studies of mean scores of boys and girls on science tests such as the International Association for the Evaluation of Educational Achievement (IEA) surveys, Comber and Keeves (1973) reported sex differences in science achievement in nineteen different countries, three different age groups, and four different areas of science. They also have shown that boys did better than girls in nearly all areas and that sex differences were larger for older (pre-college) students than for younger (ten-year-old) students.

Two large surveys on science achievement in the United States have reinforced conclusions that boys' achievement was higher than girls'. The difference was, again, greater as one increased in grade level. The National Assessment of Educational Progress (1975) and Shaycoft, et al, (1963) showed these sex differences were also more obvious in physical science than biological science. These two studies did not take into account, however, that fewer girls were likely to enroll in science. They looked only at scores between boys and girls who were in science courses. Comber and Keeves (1973) showed that in almost all countries, the sex difference was highest in physics, smallest in biology, with chemistry falling somewhere in the middle.

A few studies have presented data on high achievers in science. Kelly (1978) summarized studies that showed the higher the achievement considered, the greater the discrepancy between sexes. Studies of high achievement in science in the United States have also revealed marked sex differences (Hansen and Neujahr, 1974; Keating and Stanley, 1972).

Achievement scores for science in early grades were reportedly similar. However, by high school, boys significantly outscored girls (Aiken, 1971; Fennema, 1979; Sells, 1978). It was found that women were less likely to continue science education to the college level. On the average, girls did as well as, or slightly better than, boys in primary grades, but girls began to fall behind boys in adolescent years (Sadker and Sadker, 1974). A review edited by Thorsten Husen in 1974 analyzed Swedish students by grade level and also revealed increasing sex differences in science achievement with increasing grade levels (Kelly, 1978).

It has been suggested that the mathematical requirements of science were a factor for girls' dislike of and difficulty with science (Kelly, 1978). Fennema (1974) suggested the same reasons for low mathematical achievement - its association with science. Kelly (1978) reviewed studies that suggested girls disliked math because of its science association and girls disliked science because of its mathematical association. Therefore, no valid correlations could be made; both subjects were blamed for anxiety because of their relationship with the other.

Many researchers have attempted to explain the sex-related differences in school achievement, and numerous reasons have been suggested. The most complete review of research on sex differences is probably Maccoby and Jacklin's (1974) book, The Psychology of Sex Differences. These two authors reviewed 1,600 studies published between 1966 and 1973 to try to distinguish between factual and mythical reasons for sex differences in school achievement. The authors concluded that many reasons for sex differences were simply

assumed - often as a result of selective reporting. They did find that, on the average, girls have greater verbal ability than boys, and boys tend to have greater numerical and spatial abilities than girls. Girls were also usually less aggressive than boys. However, on other points, the authors did not reach firm conclusions.

Science Anxiety, Intellectual Capacity and Achievement

Since sex differences in science achievement have been shown, it has sometimes been suggested that boys may have a greater intellectual capacity for science. Boys generally did better than girls on tests such as numerical, mechanical, and problem solving. However, studies found numerical ability was not related to science achievement, and tests of mechanical ability were strongly dependent upon previous mechanical experiences (Kelly, 1978). Girls' performance on problem solving tests seemed to depend upon the type and content of the problems (Milton, 1958; Strassberg-Rosenberg and Donlon, 1975). Since such conflicting studies existed, valid conclusions could not be made regarding these two areas.

Girls did tend to score higher on verbal tests (Maccoby and Jacklin, 1974) and manual dexterity (Oetzel, 1966). However, these abilities were not convincingly demonstrated to be connected with science achievement (Kelly, 1978).

Men did score higher on tests of spatial ability (Maccoby and Jacklin, 1974). The fact that scientists, especially physical scientists, often need to possess the ability to manipulate objects in their minds is a reasonable assumption for the need to possess spatial ability. Physical scientists have been shown to often have greater

spatial ability than artists, social scientists, or even biological scientists (Child and Smithers, 1971; Hudson, 1966; Roe, 1953).

Throughout school, boys did better on spatial tests which suggested boys were more analytical. Girls tended to be more "global," more influenced by all elements together. Thus, girls' cognitive abilities seem to have developed differently, and they entered adolescence with a style of thinking less appropriate to scientific work (Rossi, 1965; Renner, 1976).

Witkin (1973) concentrated on analytical thinking as opposed to global thinking, and the relationship between field dependence, subject choice, and sex. He discovered that men were more analytical than women. This was also confirmed by Maccoby and Jacklin (1974) and Oetzel (1966). These authors also confirmed that scientists were more analytical than artists. Maccoby and Jacklin (1974), however, found that a spatial component was present in most commonly used analytical tests, and that sex differences in analytical thinking may be entirely accounted for by this component.

Many studies, as summarized by Maccoby (1970) suggested that child rearing practices may affect I.Q. Girls, with less overtly affectionate and less nurturant mothers in pre-school years tended to reject the female sex-role. Masculine sex-role identification was associated with problem solving ability. Children with high verbal ability tended to have mothers who helped them with tasks, were intrusive, demanding and protective. Children with high spatial or numerical abilities tended to work independently of their mothers and worked with physical things rather than people. Carlsmith (1964) found boys with fathers absent during early childhood became more

verbal. Furthermore, girls who became scientists, often associated with their fathers.

The origin of sex differences in spatial ability is not clearly understood. Some researchers suggested a genetic link (Sherman, 1977). Studies, however, by DeFries, et al, (1976) did not show a genetic correlation. Sherman (1977) reviewed biological theories of sex differences in cognitive functions and concluded that the suggested sex linked genetic basis to spatial ability has been disproved. Evidence from comparisons of hormonal levels were also lacking, but were still being researched further.

Kelly (1978) stated,

> Nevertheless, deficience in spatial ability cannot completely account for girls' poor performance in physical science. Even if spatial ability and science achievement were perfectly correlated, a sex difference of 0.4 of a standard deviation in spatial ability could not account for a sex difference of 0.6 of a standard deviation in physics achievement. But of course spatial ability and science achievement are not perfectly correlated. From the observed correlations of .6 to .7, sex differences of 0.2 to 0.3 of a standard deviation in physics achievement might be predicted, but that still leaves a substantial unexplained residue. (p. 9)

Standardized tests have shown girls performed better than boys in languages, while boys performed better than girls in science subjects (Kelly, 1978). It was also found that, "Girls and boys gained similar grades in science examinations but that girls attempting science subjects were a more selected group, with higher verbal ability scores than the boys attempting science subjects." (p. 11) Kelly thus concluded, "The sex difference in performance relative to verbal ability was consistently in favor of boys in chemistry, variable in biology, and consistently in favor of girls in languages." (p. 11) Walberg (1969) has shown similar results in the United States among

students taking optional physics courses. It was discovered that girls did better on I.Q. tests, but boys did better on physics achievement tests.

Some researchers have suggested that the possible success of girls in biological science was due to the way it was taught. Biological science has traditionally been taught by more verbal means than physical science, and it seems to depend less upon spatial ability - a bias which would tend to match with girls' socially developed, as opposed to sex-linked, abilities (Kelly, 1978).

Intellectual differences have often been classified by cognitive thinking styles. Hudson (1966) expressed differences between scientists and artists in terms of convergent thinking. Scientists seemed to be more convergent thinkers and artists seemed to be more divergent thinkers. A major flaw in this work, however, is that it was first done on boys and this distinction has not clearly been demonstrated for girls (Cropley and Field, 1968; Field and Cropley, 1969; Hudson, 1968). Maccoby and Jacklin (1974) and Oetzel (1966) found that whether girls were more convergent than boys, or vice versa, seemed to depend entirely upon the type of test used.

Lovell (1974) and Mealings (1963) have suggested a connection between science achievement and reaching Piaget's formal operations stage of concept development. Field and Cropley (1969) linked concept development to sex differences in science achievement. Studies in England found that the Nuffield "O" syllabi for chemistry had a conceptual level higher than most students that age could understand. They found that girls in particular resented the course and experienced acute anxiety. The girls were also more discouraged by

failure in the course (Kelly, 1978). Other writers have found no connection between stage of concept development and science achievement (Lawson, 1976; Maccoby and Jacklin, 1974).

Science Anxiety and Attitudes Toward Science

Different studies have suggested students' attitudes affect achievement. Research on attitudes have consistently shown females to have less favorable attitudes toward science than males. Girls particularly disliked physics and chemistry, while biology was favored somewhat (Gardner, 1975; Kelly, 1978).

Studies have shown, however, primary age children, both male and female, liked science and math. Attitudes about science and math, as well as achievement, in lower grades were about the same (Ernest, 1975). By adolescence, girls had begun to dislike both subjects. By high school, girls felt incompetent in science and mathematics and thought boys did better. A study of 506 students showed that in grades nine through twelve, 32 per cent believed boys did better than girls in math, while only 8 per cent felt girls did better (Ernest, 1975).

Furthermore, studies found that when surveying boys' and girls' attitudes on masculine and feminine careers and subjects, science was overwhelmingly considered a male category. Biology was slightly similar - whereas, math, physics, and engineering were highly masculine (Kelly, 1978).

Biology was considered nurturative and concerned with people - medicine served as an example. Kelly (1978) and Rossi (1965) found girls did not reject science careers in medicine because they seemed unfeminine, while they did reject science careers in engineering for

the same reason. Girls seemed to perceive science careers as too demanding and often feared hostility by male colleagues (Rossi, 1965).

Physics was consistently considered by students to be a difficult subject. Kelly (1978) suggested the reason was that the subject was of high conceptual level, or it was graded more strictly than other subjects. Bridgham (1972) studied the effects of grading practices on physics enrollments and suggested that physics enrollments by girls would rise 80 per cent if the grading procedures and severity were the same as with other subjects.

In addition, Ahlgren and Walberg (1973) found that girls worried about the social problems science was capable of causing. They worried that science could be abused and felt science neglected human implications. These feelings were thought to have been factors that may have caused females to avoid and dislike science.

Studies by Hansen and Neujahr (1974) showed that even girls gifted in science were less interested in it than boys - and less likely to go into science careers. Therefore, in summary, interests in and attitudes toward science have been demonstrated to affect choices of science courses, and ultimately, occupational decisions.

The literature, in general, seems to indicate that sex is an important variable in science anxiety. The relationship between sex and intellectual capacity is less clear and drawing conclusions correlating these factors with science anxiety would be questionable. The link between sex and the factors of achievement, science anxiety and attitudes toward science appears to be stronger, and it could be concluded that some correlation does exist among these factors. The literature also seems to indicate that science anxiety increases with

grade level and would do so in a statistically consistent fashion (i.e., would show continuous ascendancy when plotted on a graph). However, as will be shown in the following section, important gaps still exist in this literature.

Problem

Ample evidence has shown that mathematics and science anxiety exist, but fewer studies have been conducted exclusively on anxiety toward science. Research that has been conducted came about because of awareness of success of math anxiety clinics and because of recognition of the need to reduce science anxiety as well. Therefore, a need to investigate science anxiety alone exists. In spite of the many studies that have been conducted related to science anxiety, several factors still stand out and lack thorough investigation. It would seem that a more careful examination of those factors is necessary in order to get a more precise picture of the effects of science anxiety.

Research has indicated that anxiety toward science and math developed somewhere between primary grades and high school, but few studies examined students in the grades where the changes seemed to take place. Therefore, more research is needed to examine science anxiety in students between primary grades and high school.

Studies demonstrated that females were more anxious toward science and math in high school and college. More research is needed to determine if the same is true of females at elementary and junior high age levels.

Finally, since science achievement by boys was shown to be greater than by girls in high school, an apparent need to examine

whether or not anxiety exhibited toward science at younger age levels is related to achievement in science clearly exists. Research should also attempt to determine whether or not achievement in science is sex-related at younger age levels.

The present study focused specifically on science anxiety to determine levels of anxiety from grades four through nine in relationship to grade level, sex, and science achievement. This study was designed to investigate and determine to what degree anxiety toward science exists at intermediate and junior high age levels (grades four, six, eight, and nine).

Sample

The sample for this study was drawn from fourth, sixth, eighth, and ninth graders in the Bowling Green School District, Bowling Green, Ohio. The subjects in this study represented students from a single school system which may not be representative of all school populations. In addition, the sample was not random. Due to several laws regulating research involving minors, the sample consisted of volunteers with parental consent. Therefore, caution is recommended in generalizing the findings to other populations. The sample of students with parental consent was 532. The sample included 119 fourth graders (65 male and 54 female), 129 sixth graders (52 male and 77 female), 182 eighth graders (80 male and 102 female), and 102 ninth graders (47 male and 55 female). This sample represented approximately half the true population of grades four, six, eight, and nine.

Instrumentation

An existing instrument which was related to the objectives of this study could not be found by the researchers. The first step employed, therefore, was to design a questionnaire to rate science anxiety in students from grades four through nine.

Statements for the Science Anxiety Questionnaire were designed to assess students' levels of anxiety toward science and science-related topics. The forty statements were empirically selected to test four areas: 1) testing situations, 2) laboratory/experiment situations, 3) classroom/lecture situations, and 4) science-related situations.

Twelve Likert-type questions were devised for each sub-topic where students were to respond by placing themselves on an attitude continuum for each statement, ranging from "very calm" to "fairly calm" to "neutral" to "a little nervous" to "very nervous." Each category was given a corresponding weight of 1, 2, 3, 4, or 5. The words "very calm," "fairly calm," "neutral," "a little nervous," and "very nervous" were chosen because it was felt that these words represented the opposite ends of a continuum on anxiety, since anxiety can be described as nervousness.

The readability of the questionnaire was determined by the Fry Readability Formula (1976). As a result of the formula, the questionnaire was found to have a readability level of 6.4.

To determine content and face validity, a total of seven persons was utilized to evaluate and screen the original instrument. The questionnaire was examined by a teacher of each grade level to be involved in this study and examined by three professors of education at Bowling Green State University. Each person was asked to examine

the content of the questionnaire and to comment on any ambiguities or difficulties they might notice.

From the validation procedures, several modifications were made and the resulting forty-eight item science anxiety questionnaire was piloted on grades five and seven on a total of fifty students.

Modifications were made based on the perceptions of these teachers, and eight questions were eliminated due to difficulty in concept level for intermediate and junior high age students.

To determine reliability, the internal consistency of the science anxiety questionnaire was found using the Cronbach Coefficient Alpha Formula. This formula was used on the intended forty items and the original forty-eight items. Based on a possible value of 1.00, the resulting reliability coefficients were between 0.925 and 0.958, depending upon grade level and sex of students. Table I displays the internal consistency scores by sex and grade level obtained on the questionnaire. Other reliability tests were not employed because the pilot sample consisted only of fifty students. A factor analysis was then computed for the forty items. The factor analysis procedure used included principal component factoring followed by a varimax rotation. In this procedure, only those factors with eigenvalues exceeding one were retained. Six factors were retained by this mineigen criterion. The eigenvalue, % of variance explained, and % of variance explained by rotated factor pattern are presented in Table II. Table III displays the mean of each factor and the correlation coefficients for each factor. Only factors one through four were used since these factors accounted for most of the variance among items. The rotation factor matrix was used to determine the degree to which each of the

forty items loaded on each factor. Only those items having a loading value at or above .38 were considered.

This process resulted in identifying fourteen items for factor one, nine items for factor two, eight items for factor three, nine items for factor four, two items for factor five, and two items for factor six. Because of the small number of items in factors five and six, they were collapsed into the four other factors on the basis of similar item content. An examination of the content of the fourteen items for factor one indicated the common characteristic that they contained was direct, physical application of scientific principles, factor two indicated the characteristic was testing, factor three indicated performance in front of others while doing things related to science, and factor four indicated general application of scientific principles.

The Comprehensive Test of Basic Skills (CTBS) (CTB/McGraw-Hill, 1982) was the instrument used in this study to compare science anxiety with science achievement. The CTBS is a series of norm-referenced, criterion-referenced, objectives-based tests for K-12. The instrument was designed to measure achievement in basic skills commonly found in school curricula.

Hypotheses

To achieve the objectives of this study, the research design was organized to test the following major null hypotheses:

1) For overall science anxiety, as measured by the four factor dimensions, there is no significant difference in level of science anxiety shown between males and females.

2) For overall science anxiety, as measured by the four factor dimensions, there is no significant difference between grade levels.

3) For overall science anxiety, as measured by the four factor dimensions, there is no significant relationship between science anxiety and science achievement.

In addition, the following minor null hypotheses were formulated:

1a) There is no significant difference in level of science anxiety on the variable, testing, shown between males and females.

1b) There is no significant difference in level of science anxiety on the variable, direct application of scientific principles, shown between males and females.

1c) There is no significant difference in level of science anxiety on the variable, general application of scientific principles, shown between males and females.

1d) There is no significant difference in level of science anxiety on the variable, performance in front of others, shown between males and females.

2a) There is no significant difference in science anxiety on the variable, testing, between grade levels.

2b) There is no significant difference in science anxiety on the variable, direct application of scientific principles, between grade levels.

2c) There is no significant difference in science anxiety on the variable, general application of scientific principles, between grade levels.

2d) There is no significant difference in science anxiety on the variable, performance in front of others, between grade levels.

Hypotheses Testing

To test the eleven null hypotheses, a multivariate analysis of variance, an analysis of variance, the Scheffe method for pair-wise comparisons, and a correlation analysis were utilized. In order to examine science anxiety more closely, an analysis of covariance was used to adjust science anxiety means to science achievement.

The multivariate analysis of variance was utilized to determine differences in overall science anxiety among the variables sex, grade level, and sex interacted with grade level.

An analysis of variance was used to analyze each variable (testing, direct application of scientific principles, general application of scientific principles, and performance in front of others) for differences by sex and by grade level.

The Scheffe method of analysis is a statistical method for pair-wise comparisons when cell sizes are not equal. Since neither grade level nor sex samples were equal, the Scheffe statistical method was used to compare science anxiety means by grade level and sex. The Scheffe test was performed after each of the ANOVA's with significant F ratios.

A correlation analysis was used to determine whether, and to what degree, a relationship existed between science anxiety and science achievement. Since differences on science achievement could affect science anxiety, an analysis of covariance was computed to adjust science anxiety means to national and local percentiles. This procedure provided a closer examination of each variable in relation to science achievement. Differences for all tests were determined significant if the probability level was $< .05$.

Hypothesis One--Science Anxiety and Sex of the Student

For overall science anxiety, as measured by the four factor dimensions, there is no significant difference in level of science anxiety shown between males and females.

Findings

A MANOVA was computed for science anxiety to determine differences in means for sex/grade, sex, and grade level. Table IV displays MANOVA results for these factors. Hypothesis one was rejected because the probability level was less than the type I error of .05. It was concluded that differences in science anxiety did exist between sexes.

Further analysis of each variable (testing, direct application of scientific principles, general application of scientific principles, and performance in front of others) using an analysis of variance (ANOVA) revealed differences in means for sexes existed on all factors but one, the general application of scientific principles. Results of the ANOVA for each factor are displayed in Table V.

At the univariate level, the variable, direct application of scientific principles, was significant for sex interacted with grade level. Since, however, there was no significant interaction between sex and grade level at the multivariate level, the standard procedure is not to consider the interaction at the univariate level. Therefore, sex interacted with grade level was not taken into consideration in subsequent statistical analyses.

Hypothesis one (a) Testing by sex

This hypothesis was rejected because the probability level was less than the type I error of .05.

Hypothesis one (b) Direct application of scientific principles by sex

This hypothesis was rejected because the probability level was less than the type I error of .05.

Hypothesis one (c) General application of scientific principles by sex

This hypothesis was not rejected because the probability level was greater than the type I error of .05.

Hypothesis one (d) Performance in front of others by sex

This hypothesis was rejected because the probability level was less than the type I error of .05.

It was concluded that differences in means between sexes did exist. The Scheffe method for pair-wise comparisons was then used to compare science anxiety means and to determine which group had higher means. Results of the Scheffe for overall differences in science anxiety means by sex are shown in Table VI. Females were shown to display more overall science anxiety than males.

The Scheffe method for pair-wise comparisons was also used for each variable to compare science anxiety means and to determine which group had higher means. The level of significance used was .05. Results of the Scheffe test for each variable are displayed in Table VII.

In conclusion, the MANOVA showed differences on overall science anxiety existed for sexes. Therefore, the first hypothesis was rejected because the probability level was less than the type I error of .05. Further analysis of each of the four variables using an analysis of variance (ANOVA) showed differences on anxiety for sex on all factors but one, general application of scientific principles. Hypothesis one (a), one (b), and one (d) were rejected because the

probability level was less than the type I error of .05. Hypothesis one (c) was not rejected because the probability level was greater than the type I error of .05. It was concluded that differences in science anxiety means between sexes did exist on all factors but one, the general application of scientific principles. The subsequent Scheffe tests displayed that females exhibited more anxiety than males for overall science anxiety and for all variables but one, the general application of scientific principles.

Hypothesis two - Science Anxiety and Grade Level

> For overall science anxiety, as measured by the four factor dimensions, there is no significant difference between grade levels.

Findings

The MANOVA test showed that differences in overall science anxiety for grade levels did exist. (See Table IV.) Therefore, hypothesis two was rejected because the probability level was less than the type I error of .05.

Further analysis of each variable (testing, direct application of scientific principles, general application of scientific principles, and performance in front of others) using an analysis of variance (ANOVA) revealed differences in means for grade levels on all variables. (See Table V.) Therefore, hypothesis two (a) Testing by grade level, hypothesis two (b) Direct application of scientific principles by grade level, hypothesis two (c) General application of scientific principles by grade level, and hypothesis two (d) Performance in front of others by grade level were all rejected because the probability level was less than the type I error of .05. It was concluded that differences in science anxiety means between

grade levels did exist on overall science anxiety and on all variables. Therefore, the Scheffe test, using an alpha level of significance of .05, demonstrated that science anxiety did not increase by grade level as suggested in the literature. Instead, the Scheffe test (see Table VIII) showed that the fourth grade was more anxious toward science than the eighth grade for overall science anxiety.

The Scheffe method for pair-wise comparisons was also used for each variable to compare science anxiety means and to determine which group had higher means. The level of significance used was alpha .05. Results of the Scheffe test for each variable are displayed in Table IX.

The Scheffe test for grade level differences on each of the four variables indicated that the fourth grade was more anxious toward science on two variables (testing and direct application of scientific principles) than the eighth grade. No other grade level differences were indicated, and science anxiety was not shown to increase by grade level as suggested in the literature.

In conclusion, the MANOVA revealed that differences on science anxiety did exist for grade levels. Therefore, hypothesis two was rejected. Further analysis of each variable using an ANOVA demonstrated that grade level differences existed on all variables. Therefore, hypotheses two (a) through two (d) were rejected. Subsequent Scheffe tests were computed to compare science anxiety means and to determine which grades had higher means. The Scheffe tests revealed that the fourth grade was more anxious than the eighth grade for overall science anxiety, and the fourth grade was more

anxious than the eighth grade on two variables, testing and direct application of scientific principles.

Hypothesis three - Science Anxiety and Science Achievement

> For overall science anxiety, as measured by the four factor dimensions, there is no significant relationship between science anxiety and science achievement.

Findings

A correlation coefficient was computed for total science anxiety and science achievement (national and local percentile scores) on the CTBS. The correlation analysis revealed a significant relationship between science anxiety and science achievement. Means, standard deviations, probability values, and correlation coefficients for achievement are displayed in Table X.

Hypothesis three was rejected because the probability level was less than the type I error of .05. It was concluded that an inverse relationship existed between science anxiety means and science achievement scores; high levels of science anxiety correlated with low science achievement scores.

When a significant relationship was found between science anxiety and science achievement, an analysis of covariance (ANCOVA) was computed for the variables, national and local percentile, with the variables, sex/grade, sex, and grade. (See Table XI.) This analysis of covariance adjusted science anxiety means to national and local percentile scores. This provided a closer examination of sex and grade level differences.

The analysis of covariance revealed differences for the covariates, national and local percentile. National and local percentile differences were significant for the factor, testing;

national percentile differences were significant for the factor, performance in front of others. However, the factors, direct application of scientific principles and general application of scientific principles, did not display differences.

The analysis of covariance did reveal significant differences for sex on all factors but one, the general application of scientific principles, and it revealed significant differences for grade level on all four factors. Table XII displays results for sexes when means were adjusted to national and local percentiles. It was concluded that differences in science anxiety between sexes existed for all variables but one, the general application of scientific principles. These results matched results for non-adjusted means.

Table XIII displays P values for each variable by grade level when means were adjusted for achievement, and Table XIV displays the adjusted science anxiety means for each grade level.

When science anxiety means were adjusted to national and local percentile scores, more differences were observed on science anxiety between grade levels. However, instead of increasing by grade level as indicated in the literature, anxiety generally decreased as grade level increased. (See Figures 1-4 for a display of the increases in anxiety on each variable.) For three variables, testing, direct application of scientific principles, and performance in front of others, the fourth grade was found to be the most anxious followed by the sixth, ninth, and eighth grades. For one variable, general application of scientific principles, anxiety decreased as grade level increased. Therefore, science anxiety generally decreased as grade level increased, but on three out of four variables, the ninth grade

was more anxious than the eighth grade; and on all variables, the fourth grade was the most anxious.

Survey of Teachers

In addition to cooperating in this study by administering science anxiety questionnaires, the twenty-four teachers also cooperated by filling out a short questionnaire. The short questionnaire asked two things of the teachers: 1) to estimate the number of students in their classes who did not take the science anxiety questionnaire that they felt may be anxious about science, and 2) to rate their preference (from 1-5) for teaching science in relation to four other subject areas (math, social studies, language arts, and reading). Table XV displays results of the first question and Table XVI displays results of the second question.

Conclusions

Statistical analysis of the data collected for this study suggest the following conclusions:

1) Feelings, particularly anxiety, toward science and science-related topics, are significantly sex-related. Differences on anxiety toward science exist with females being more anxious than males. This is in accord with previously conducted research that dates as far back as the early 1950's. In spite of feminist movements and general changes in attitudes about sex-roles since the 1950's, one might speculate that female attitudes toward science have not changed greatly.

2) Females at grade four already display more anxiety toward science than do males. It would, therefore, appear that the sex-related differences started at an earlier age than that of

students in fourth grade. Kohlberg (1966) suggested that sex-typed behavior started in preschool and continued to be shaped more intensely during the elementary school years. He suggests that: "Cognitive awareness of male and female behavior is established by the age of five..." (p. 412)

3) For this study, science anxiety did not increase with grade level. Contradictory to previous research that suggested anxiety increased with grade or age level, students at grade four were more anxious about science than older students in grade eight. Therefore, it would appear that grade level changes may be unclear. One might conclude several reasons for the conflicting results of this study. One, the fourth grade may have been more anxious merely because of inexperience. In many schools, as in the Bowling Green School District, primary age students do not always have their own science textbook, and science is not necessarily taught on a daily basis. In general, fourth grade seems to be the first grade level where science is seriously taught as an "academic subject." This realization at fourth grade that science is a subject to be taken seriously, may be part of the reason the fourth grade was more anxious toward science. Second, another possible reason that the fourth grade was more anxious than the eighth grade on two variables (testing and direct application of scientific principles) may, again, be because of inexperience. Fourth grade, many times, is the first grade level where students take tests in subject areas. Therefore, the science anxiety displayed in this area may in reality just have been "test anxiety." It seems that fourth grade is also often the first grade level where students seriously begin doing experiments in science. Thus, again, the

newness of the experience may be the reason that the fourth graders were more anxious toward this area.

Several reasons might also explain why the ninth grade was generally more anxious than the eighth grade. One, eighth grade science in the Bowling Green School District is earth science, whereas ninth grade science is physical science. The literature has repeatedly shown students to be more anxious toward physical science than other areas of science. Second, the ninth grade is the first grade where course credit counts toward high school graduation. One might speculate that this causes more concern about school subjects - and possibly causes more anxiety.

4) Since only 30 per cent of fourth and sixth grade teachers rated science as first choice when asked to rate preferences for teaching five different subject areas while 100 per cent of junior high teachers rated science as their first choice, one might speculate that teachers' attitudes affect feelings toward science. This would especially seem possible when one examines the fact that the fourth grade was shown to be more anxious than the eighth grade, and fourth grade teachers, generally, did not enjoy teaching science as much as eighth grade teachers.

5) Significant differences on science achievement in relation to science anxiety were seen with high levels of science anxiety correlating with low science achievement scores. This would suggest that high levels of science anxiety may limit one's ability to achieve in science. Stated conversely, this might suggest that low achievers in science, possibly with little hope of doing better, become anxious toward science.

Recommendations for Future Research

The results of this study suggest that, as posed by Mallow (1981), high science anxiety can affect science achievement by lowering science achievement scores, and science anxiety seems to affect females more than males. The implications of this conclusion indicate that future research should focus on methods to alleviate anxiety toward science and make science more desirable. Decisions about science instruction should focus on making science interesting and less stressful to students, especially female students. Research should be repeated with other populations over longer and different periods of time to determine the effects of science anxiety more conclusively.

Since a discrepancy was noted in this study in regard to age or grade level differences, similar studies should be repeated. Studies should also be executed with other age groups.

Because of the difficulty mentioned previously in finding a suitable instrument to measure science anxiety in students for grades four through nine, research should be performed to develop and refine instruments for such a purpose. Research should also be repeated with the questionnaire designed for this study (see Appendix A) to better determine the reliability of the questionnaire.

Another area of research would be to compare the effects of classroom teachers' attitudes on students' attitudes toward science. Since a relatively small proportion of elementary teachers (30%) indicated they enjoyed teaching science, it would seem this a noteworthy area to investigate.

A related area of research would be to investigate the impact of elementary teacher-training programs and in-service programs on attitudes toward teaching science. It would be useful to conduct studies aimed at improving teacher attitudes toward teaching science.

The literature alluded to the complexities of the causes of science anxiety. Additional research should attempt to examine the causes of science anxiety. Finally, because the causes of science anxiety may be difficult to determine, and possibly even more difficult to correct, more programs should be instituted to deal with and attempt to reduce science anxiety being displayed by students.

## References


Aiken, L. R., Jr. Intellective Variables and Mathematics Achievement. Directions for Research, Journal of School Psychology, 1971, 9, (2), 201-211.

Ahlgren, and Walberg, H. J. Changing Attitudes Toward Science Among Adolescents, Nature, 1973, 245, 187-190.

Bridgham, R., Ease of Grading and Enrollments in Secondary School Science, Journal of Research in Science Teaching, 1972, 9, 323.

Carlsmith, L. Effects of Early Father-Absence on Scholastic Aptitude, Harvard Education Review, 1964, 32, 3.

Child, D. and Smithers, A. Some Cognitive and Affective Factors in Subject Choice, Research in Education, 1971, 5, (1).

Comber, L. C., and Keeves, J. P. Science Education in Nineteen Countries, Stockholm: Almqvist and Wiksell and New York: Wiley-Halsted Press, 1973.

Cropley, A. J. and Field, T. W. Intellectual Style and High School Science, Nature, 1968, 217, 1211.

CTBS Forms U and V Preliminary Technical Report, Monterey, California: CTB/McGraw-Hill, 1982.

DeFries, J. C. et al. Parent-Offspring Resemblance for Specific Cognitive Abilities in Two Ethnic Groups, Nature, 1976, 261, 131.

Ernest, J. Mathematics and Sex. Santa Barbara, California: Mathematics Department, University of California 1976.

Fennema, E. Women and Girls in Mathematics - Equity in Mathematics Education in Educational Studies in Mathematics, 1979, 10, (4), 389-400.

Fennema, E. Sex Differences in Mathematics Learning: Why? Elementary School Journal, 1974, 75, 183.

Field, T. W. and Cropley, A. J. Cognitive Style and Science Achievement, Journal of Research on Science Teaching, 1969, 2, (2).

Fry, E. B. A readability formula that saves time, Journal of Reading, 1976, 11, 513-516. In Hopkins, K. D. and Stanley, J. C., Educational and Psychological Measurement and Evaluation. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1981.

Gardner, P. L. Attitudes to Science: A Review, Studies in Science Education, 1975, 2, (1).

Hansen, R. and Neujahr, J. Career Development of Males and Females Gifted in Science, Journal of Educational Research, 1974, 68, 43.

Hudson, L. Contrary Imaginations, Penguin, 1966, in Kelly, A. Girls in Science. Stockholm, Sveden: Almqvist and Wiksell International, 1978.

Hudson, L. Frames of Mind, Penguin, 1968, in Kelly, A. Girls in Science. Stockholm, Sveden: Almqvist and Wiksell International, 1978.

Keating, D. P. and Stanley, J. C. Extreme Measures of the Exceptionally Gifted in Mathematics and Science, Education Researcher, 1972, 1, 3.

Kelly, A. Girls in Science. Stockholm, Sveden: Almqvist and Wiksell International, University of Manchester and Institute of International Education, University of Stockholm, IEA (International Association for the Evaluation of Educational Achievement - IEA Monograph Studies No. 9), 1978.

Kohlberg, L. A Cognitive-developmental analysis of children's sex-role concepts and attitudes, in E. E. Maccoby (Ed.), The Development of Sex Differences. Stanford, California: Stanford University Press, 1966.

Knarnes, R. G. Anxiety and Math Anxiety: Some Theoretical Considerations, a paper written for the Senior Seminar on the Study of Math Anxiety Funded by HEW Women's Educational Equity Act, 1979-1980.

Lawson, A. Sex Differences in Concrete and Formal Reasoning Ability as Measured by Manipulative and Written Tasks, Science Education, 1975, 59, 397.

Lovell, K. Intellectual Growth and Understanding Science, Studies in Science Education, 1974, 1, (1).

Maccoby, E. E. Feminine Intellect and the Demands of Science, Impact of Science on Society, 1970, 20, 13.

Maccoby, E. E. and Jacklin, C. N. The Psychology of Sex Differences. Stanford University Press, 1974.

Mallow, J. Science Anxiety: Fear of Science and How to Overcome It. New York: Van Nostrand Reinhold, 1981.

Mealings, R. J. Problem Solving and Science Teaching, Education Review, 1963, 15, 194.

Milton, G. A. Five Studies of the Relation Between Sex-Role Identification and Achievement in Problem Solving. Yale University, Technical Report 3, 1958, in Kelly, A. Girls in Science. Stockholm, Sveden: Almqvist and Wiksell International, 1978.

National Assessment of Educational Progress, National Assessments of Science, 1969 and 1973: A Capsule Description of Changes in Science Achievement, Report R-04-S-00, February, 1975.

Oetzel, R. M. Annotated Bibliography and Classified Summary of Research in Sex Differences in Maccoby, E. E. (Ed.), The Development of Sex Differences. Stanford University Press, 1966.

Renner, J. W. (et al.). Research, Teaching, and Learning with the Piaget Model. Norman, Oklahoma: University of Oklahoma Press, 1966, 66.

Roe, A. The Making of a Scientist. New York: Dodd, Mead and Company, 1953.

Rossi, A. Barriers to the Career Choice of Engineering, Medicine or Science Among American Women in Mattfeld, J. A. and Van Aken, C. G. Women and the Scientific Professions. M.I.T. Symposium, 1965.

Sadker, M. and Sadker, D. Sexism in Schools: An Issue for the 70's, Education Digest, April, 1974, 6, 58.

Sells, L. Mathematics as a Critical Filter, The Science Teacher, February, 1978, 45, 28-29.

Shaycoft, M. F., Dailey, J. T., Orr, D. B., Neyman, G. A. and Sherman, S. E. The Identification, Development and Utilization of Human Talents, Studies of a Complete Age Group, Age 15, Project TALENT, Pittsburg, 1963.

Sherman, J. Effects of Biological Factors on Sex-Related Differences in Mathematics Achievement in Shoemaker, J. S. (Ed.), Women and Mathematics: Research Perspectives for Change. Washington, D.C., 1977.

Strassberg-Rosenberg, B. and Donlon, T. F. Content Influences on Sex Differences in Performance on Aptitude Tests. Buffalo: State University of New York, NCME, 1975.

Walberg, H. J. Physics, Femininity and Creativity, Developmental Psychology, 1969, 1, 47.

Witkin, H. A. The Role of Cognitive Style in Academic Performance and in Teacher-Student Relations. RB-73-11, Educational Testing Service, Princeton, N.J., 1973.

4/1

## Appendix A

## The Science Anxiety Questionnaire

QUESTIONNAIRE

GRADE_____ FEMALE_____ MALE_____

The statements in this questionnaire are about science and science related experiences. For each statement, place an X on the line under the column that best describes how you would feel in that situation.

| EXAMPLE: | Very Calm | Fairly Calm | Neutral | A Little Nervous | Very Nervous |
|---|---|---|---|---|---|
| Giving an oral book report. | _____ | _____ | _____ | X | _____ |

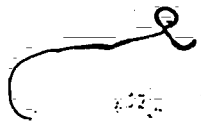
(If giving an oral book report makes you nervous only a little amount, you would place an X on "A Little Nervous".)

| | Very Calm | Fairly Calm | Neutral | A Little Nervous | Very Nervous |
|---|---|---|---|---|---|
| 1. Starting science class. | _____ | _____ | _____ | _____ | _____ |
| 2. Having someone watch you do an experiment. | _____ | _____ | _____ | _____ | _____ |
| 3. Studying for a test in science. | _____ | _____ | _____ | _____ | _____ |
| 4. Planning a well-balanced meal to pack for lunch. | _____ | _____ | _____ | _____ | _____ |
| 5. Looking through the science book for your class. | _____ | _____ | _____ | _____ | _____ |
| 6. Mixing boiling water and ice to get water to reach the right temperature for an experiment. | _____ | _____ | _____ | _____ | _____ |
| 7. Studying for a test about the earth. | _____ | _____ | _____ | _____ | _____ |
| 8. Visiting a science museum. | _____ | _____ | _____ | _____ | _____ |
| 9. Being asked to explain a topic in science class. | _____ | _____ | _____ | _____ | _____ |
| 10. Using a thermometer to measure the temperature of water in an experiment. | _____ | _____ | _____ | _____ | _____ |
| 11. Taking a science test. | _____ | _____ | _____ | _____ | _____ |

| | Very Calm | Fairly Calm | Neutral | A Little Nervous | Very Nervous |
|---|---|---|---|---|---|
| 2. Measuring a cup of sugar to make cookies. | | | | | |
| 3. Being called on in science class. | | | | | |
| 4. Showing a classmate the results of your experiment. | | | | | |
| 5. Taking a quiz in science. | | | | | |
| 6. Cooling down a hot sink of water to the right temperature to be able to wash dishes. | | | | | |
| 7. Asking the teacher a question in science class. | | | | | |
| 8. Weighing something to use in an experiment. | | | | | |
| 9. Memorizing the names of parts of the body for a science test. | | | | | |
| 10. Lighting a grill for a barbeque. | | | | | |
| 11. Doing a science home-work assignment. | | | | | |
| 12. Figuring out how to connect a light bulb in an electrical experiment. | | | | | |
| 13. Memorizing the names of things in space for a science test. | | | | | |
| 14. Following the steps to build a model. | | | | | |

| | Very Calm | Fairly Calm | Neutral | A Little Nervous | Very Nervous |
|---|---|---|---|---|---|
| 25. Listening to the teacher in science class. | | | | | |
| 26. Adding a small amount of powder to a liquid in an experiment. | | | | | |
| 27. Showing your parents your last science test. | | | | | |
| 28. Reading a science magazine and having a friend ask you about it. | | | | | |
| 29. Writing a report for science class. | | | | | |
| 30. Following directions to do an experiment. | | | | | |
| 31. Showing your parents your science grade on your report card. | | | | | |
| 32. Focusing a camera to take a picture of some friends. | | | | | |
| 33. Having a classmate listen to your science report. | | | | | |
| 34. Focusing a microscope. | | | | | |
| 35. Thinking about a test in science one day before you are to take it. | | | | | |
| 36. Replacing a dead bulb in a lamp. | | | | | |
| 37. Reading a chapter in your science book and being asked to explain it. | | | | | |

| | Very Calm | Fairly Calm | Neutral | A Little Nervous | Very Nervous |
|---|---|---|---|---|---|
| 38. Blowing up a balloon to the right size for a science experiment on air. | | | | | |
| 39. Thinking about a science test one hour before you are to take it. | | | | | |
| 40. Filling your bicycle tire with the right amount of air. | | | | | |



## Appendix B

## Tables and Figures

TABLE I

RELIABILITY SCORES OBTAINED ON THE SCIENCE ANXIETY QUESTIONNAIRE USING CRONBACH'S COEFFICIENT ALPHA FORMULA ON THE ORIGINAL FORTY-EIGHT QUESTIONS AND THE FORTY QUESTIONS USED IN THIS STUDY

| | |
|---|---|
| 48 items | 0.952 |
| 48 items - male, grade 5 | 0.942 |
| 48 items - female, grade 5 | 0.958 |
| 48 items - male, grade 7 | 0.943 |
| 48 items - female, grade 7 | 0.946 |
| 40 items | 0.939 |
| 40 items - male, grade 5 | 0.925 |
| 40 items - female, grade 5 | 0.942 |
| 40 items - male, grade 7 | 0.929 |
| 40 items - female, grade 7 | 0.935 |

TABLE II

FACTOR ANALYSIS

| Factor | Eigenvalue | % of variation explained by each factor | % of variation explained by each factor by rotated factor pattern |
|---|---|---|---|
| 1 | 12.794355 | 29.13 | 12.45 |
| 2 | 3.00722 | 8.00 | 10.21 |
| 3 | 1.611397 | 4.53 | 8.75 |
| 4 | 1.403125 | 4.23 | 6.09 |
| 5 | 1.345057 | 3.80 | 4.87 |
| 6 | 1.060056 | 3.56 | 4.61 |

TABLE III

MEANS AND CORRELATION COEFFICIENTS FOR EACH FACTOR

| Factor | Mean | Correlation Coefficient |
|---|---|---|
| Testing | 2.883 | .82 |
| Direct Application of Scientific Principles | 1.857 | .85 |
| General Application of Scientific Principles | 1.746 | .79 |
| Performance in Front of Others | 2.663 | .87 |
| TOTAL | 2.246 | 1.00 |

TABLE IV

MANOVA RESULTS FOR OVERALL SCIENCE ANXIETY BY SEX, GRADE, AND SEX/GRADE

| Factor | F value | df | P value | Significant at .05 |
|---|---|---|---|---|
| Sex | 25.71 | 4,540 | .0001 | * |
| Grade | 6.10 | 12,1626 | .0001 | * |
| Sex/grade | .94 | 12,1626 | .5085 | |

TABLE V

ANOVA RESULTS FOR EACH FACTOR BY SEX, GRADE LEVEL, AND SEX/GRADE

| Factor | DF | PR F | F Value | Significant at .05 |
|---|---|---|---|---|
| Testing | | | | |
| sex | 1 | .0001 | 47.66 | * |
| grade | 3 | .0001 | 12.04 | * |
| sex/grade | 3 | .7050 | .47 | |
| Direct Application | | | | |
| sex | 1 | .0001 | 28.84 | * |
| grade | 3 | .0001 | 12.54 | * |
| sex/grade | 3 | .0362 | 2.85 | * |
| General Application | | | | |
| sex | 1 | .8290 | .04 | |
| grade | 3 | .0002 | 7.22 | * |
| sex/grade | 3 | .1147 | 1.98 | |
| Performance in Front of Others | | | | |
| sex | 1 | .0001 | 24.67 | * |
| grade | 3 | .0001 | 9.40 | * |
| sex/grade | 3 | .2031 | 1.53 | |

TABLE VI

SCHEFFE RESULTS FOR OVERALL SCIENCE ANXIETY BY SEX

| Sex | Mean | Scheffe[a] |
|---|---|---|
| Female | 2.3788 | A |
| Male | 2.0894 | B |

[a]For this test, if groups did exhibit significant differences, they would have different letters.

TABLE VII

RESULTS OF THE SCHEFFE TEST FOR EACH VARIABLE BY SEX

| Factor | Means | Scheffe[a] |
|---|---|---|
| Testing | | |
| female | 3.1359 | A |
| male | 2.5850 | B |
| Direct Application | | |
| female | 1.9830 | A |
| male | 1.7084 | B |
| General Application | | |
| female | 1.7519 | A |
| male | 1.7412 | A |
| Performance in Front of Others | | |
| female | 2.8164 | A |
| male | 2.4818 | B |

[a]For this test, if groups did exhibit significant differences, they would have different letters.

TABLE VIII

RESULTS OF THE SCHEFFE FOR OVERALL SCIENCE ANXIETY BY GRADE LEVEL

| Grade Comparisons | Difference Between Means | Significant at .05 |
|---|---|---|
| 4th by 6th | .1509 | |
| 4th by 8th | .3990 | * |
| 4th by 9th | .2954 | |
| 6th by 4th | -.1509 | |
| 6th by 8th | .2481 | |
| 6th by 9th | .1445 | |
| 8th by 4th | -.3990 | * |
| 8th by 6th | -.2481 | |
| 8th by 9th | -.1036 | |
| 9th by 4th | -.2954 | |
| 9th by 6th | -.1445 | |
| 9th by 8th | .1036 | |

TABLE IX

RESULTS OF SCHEFFE TEST ON EACH VARIABLE BY GRADE LEVELS

| Factor | Difference Between Means[a] | Factor | Difference Between Means[a] |
|---|---|---|---|
| **Testing** | | **General Application** | |
| 4th by 6th | .0469 | 4th by 6th | .2006 |
| 4th by 8th | .5373* | 4th by 8th | .2385 |
| 4th by 9th | .2735 | 4th by 9th | .3321 |
| 6th by 4th | -.0469 | 6th by 4th | -.2206 |
| 6th by 8th | .4904 | 6th by 8th | .0379 |
| 6th by 9th | .2265 | 6th by 9th | .1315 |
| 8th by 4th | -.5373* | 8th by 4th | -.2385 |
| 8th by 6th | -.4904 | 8th by 6th | -.0379 |
| 8th by 9th | -.2638 | 8th by 9th | .0936 |
| 9th by 4th | -.2735 | 9th by 4th | -.3321 |
| 9th by 6th | -.2265 | 9th by 6th | -.1315 |
| 9th by 8th | .2638 | 9th by 8th | -.0936 |
| **Direct Application** | | **Performance** | |
| 4th by 6th | .2283 | 4th by 6th | .1024 |
| 4th by 8th | .3991* | 4th by 8th | .4262 |
| 4th by 9th | .3828 | 4th by 9th | .1764 |
| 6th by 4th | -.2283 | 6th by 4th | -.1024 |
| 6th by 8th | .1709 | 6th by 8th | .3238 |
| 6th by 9th | .1546 | 6th by 9th | .0739 |
| 8th by 4th | -.3991* | 8th by 4th | -.4262 |
| 8th by 6th | -.1709 | 8th by 6th | -.3238 |
| 8th by 9th | -.0163 | 8th by 9th | -.2499 |
| 9th by 4th | -.3828 | 9th by 4th | -.1764 |
| 9th by 6th | -.1546 | 9th by 6th | -.0739 |
| 9th by 8th | .0163 | 9th by 8th | .2499 |

[a]For this test, numerals with an asterisk are significant at alpha .05.

TABLE X

CORRELATION ANALYSIS FOR SCIENCE ACHIEVEMENT

| Factor | Mean | std dev | Probability[a] | Correlation Coefficients With Total |
|---|---|---|---|---|
| TOTAL | 2.246 | .64061698 | ---- | ---- |
| National Percentile | 66.729 | 25.3771652 | .0001* | -.17238 |
| Local Percentile | 54.820 | 27.88427928 | .0001* | -.17731 |

[a]Significance at the .05 level is indicated with an asterisk.

TABLE XI

UNIVARIATE ANALYSIS OF COVARIANCE

| Factor | DF | PR>F | F Value | Significant at .05 |
|---|---|---|---|---|
| **Testing** | | | | |
| National Percentile | 1 | .0021 | 9.56 | * |
| Local Percentile | 1 | .0104 | 6.62 | * |
| Sex | 1 | .0001 | 44.77 | * |
| Grade | 3 | .0001 | 13.93 | * |
| Sex/grade | 3 | .5974 | 0.63 | |
| **Direct Application of Scientific Principles** | | | | |
| National Percentile | 1 | .0202 | 5.43 | |
| Local Percentile | 1 | .2227 | 1.49 | |
| Sex | 1 | .0001 | 28.62 | * |
| Grade | 3 | .0001 | 14.99 | * |
| Sex/grade | 3 | .0889 | 2.17 | |
| **General Application of Scientific Principles** | | | | |
| National Percentile | 1 | .0002 | 14.16 | |
| Local Percentile | 1 | .7658 | 0.09 | |
| Sex | 1 | .9932 | 0.00 | |
| Grade | 3 | .0001 | 7.99 | * |
| Sex/grade | 3 | .2145 | 1.49 | |
| **Performance in Front of Others** | | | | |
| National Percentile | 1 | .0001 | 28.60 | * |
| Local Percentile | 1 | .0053 | 3.69 | |
| Sex | 1 | .0001 | 26.40 | * |
| Grade | 3 | .0001 | 12.33 | * |
| Sex/grade | 3 | .1168 | 1.96 | |

TABLE XII

ANOVA RESULTS FOR SEX WHEN MEANS ARE ADJUSTED TO NATIONAL AND LOCAL PERCENTILE SCORE

| Factor | Probability Level | Significant at .05 |
|---|---|---|
| Testing | | |
| female | .0001 | * |
| male | | |
| Direct Application | | |
| female | .0001 | * |
| male | | |
| General Application | | |
| female | .8214 | |
| male | | |
| Performance in Front of Others | | |
| female | .0001 | * |
| male | | |

TABLE XIII

ANOVA RESULTS FOR GRADE LEVEL WHEN MEANS WERE ADJUSTED TO NATIONAL AND LOCAL PERCENTILE SCORES[a]

TESTING MEAN

| Grade: | 4 | 6 | 8 | 9 |
|---|---|---|---|---|
| 4 | X | .4343 | .0001* | .0175 |
| 6 | .4343 | X | .0001* | .0915 |
| 8 | .0001* | .0001* | X | .0046* |
| 9 | .0175 | .0915 | .0046* | X |

DIRECT APPLICATION MEAN

| Grade: | 4 | 6 | 8 | 9 |
|---|---|---|---|---|
| 4 | X | .0017* | .0001* | .0001* |
| 6 | .0017* | X | .0042* | .0164 |
| 8 | .0001* | .0042* | X | .9335 |
| 9 | .0001* | .0164 | .9335 | X |

GENERAL APPLICATION MEAN

| Grade: | 4 | 6 | 8 | 9 |
|---|---|---|---|---|
| 4 | X | .0139 | .0001* | .0001* |
| 6 | .0139 | X | .1534 | .0296 |
| 8 | .0001* | .1534 | X | .3165 |
| 9 | .0001* | .0296 | .3165 | X |

PERFORMANCE MEANS

| Grade: | 4 | 6 | 8 | 9 |
|---|---|---|---|---|
| 4 | X | .2952 | .0001* | .0701 |
| 6 | .2952 | X | .0001* | .3918 |
| 8 | .0001* | .0001* | X | .0012* |
| 9 | .0701 | .3918 | .0012* | X |

[a]For this test, numerals with an asterisk are significant at .05.

TABLE XIV

LEAST SQUARES MEANS AND STANDARD ERROR FOR ADJUSTED SCIENCE ANXIETY SCORES

| Factor | Least Squares Means | Standard Error |
|---|---|---|
| **Testing** | | |
| 4th | 3.16 | .85 |
| 6th | 3.07 | .08 |
| 8th | 2.53 | .07 |
| 9th | 2.86 | .09 |
| **Direct Application of Scientific Principles** | | |
| 4th | 2.17 | .06 |
| 6th | 1.91 | .06 |
| 8th | 1.69 | .05 |
| 9th | 1.70 | .06 |
| **General Application of Scientific Principles** | | |
| 4th | 1.96 | .05 |
| 6th | 1.78 | .05 |
| 8th | 1.68 | .04 |
| 9th | 1.61 | .58 |
| **Performance in Front of Others** | | |
| 4th | 2.89 | .07 |
| 6th | 2.79 | .07 |
| 8th | 2.37 | .06 |
| 9th | 2.70 | .08 |

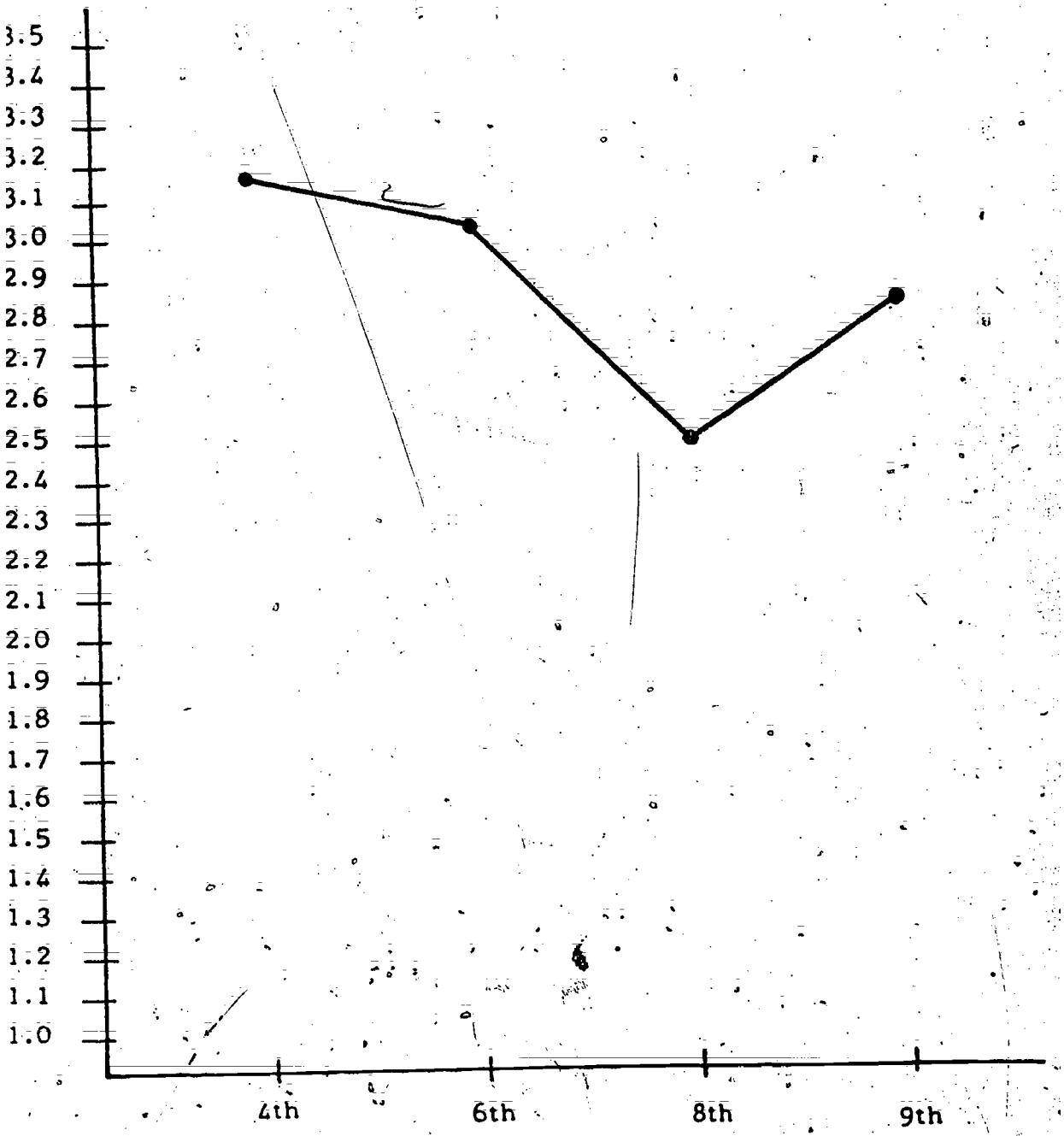

3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
4th
6th
8th
9th
Grade Level

FIGURE 1

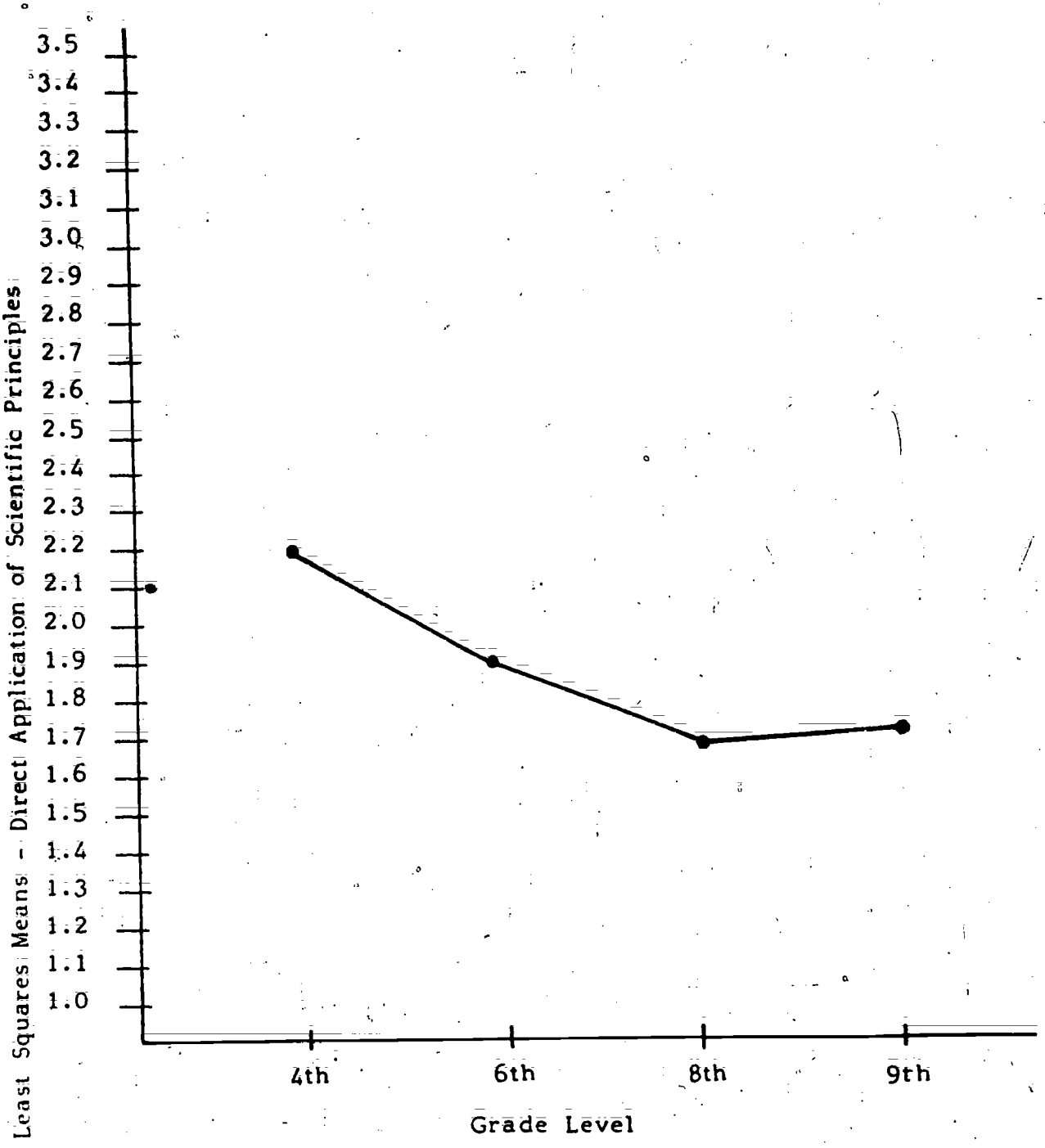

Least Squares Means - Direct Application of Scientific Principles
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
4th
6th
8th
9th
Grade Level

FIGURE 2

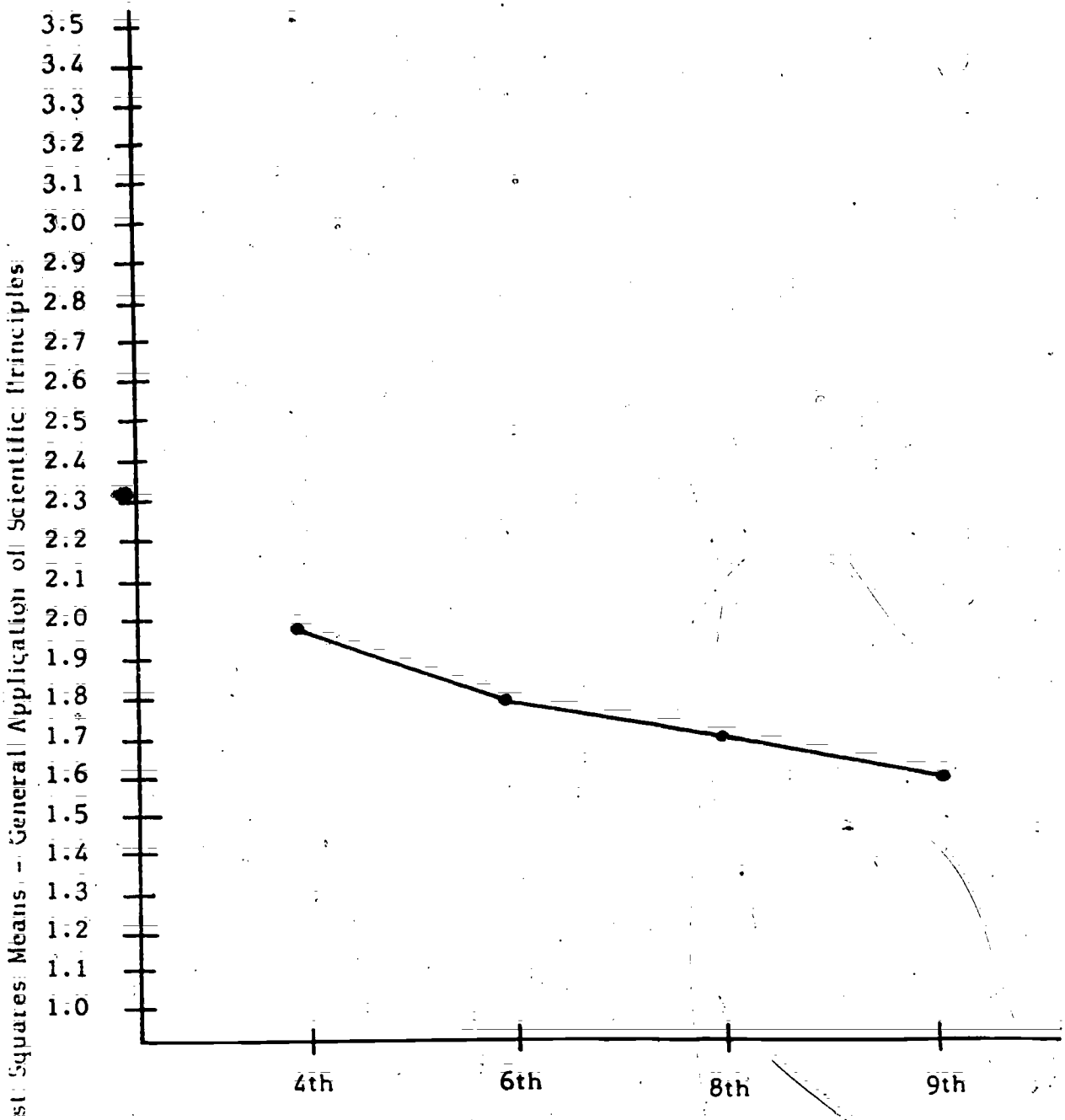

Least Squares Means - General Application of Scientific Principles
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
4th
6th
8th
9th
Grade Level

FIGURE 3

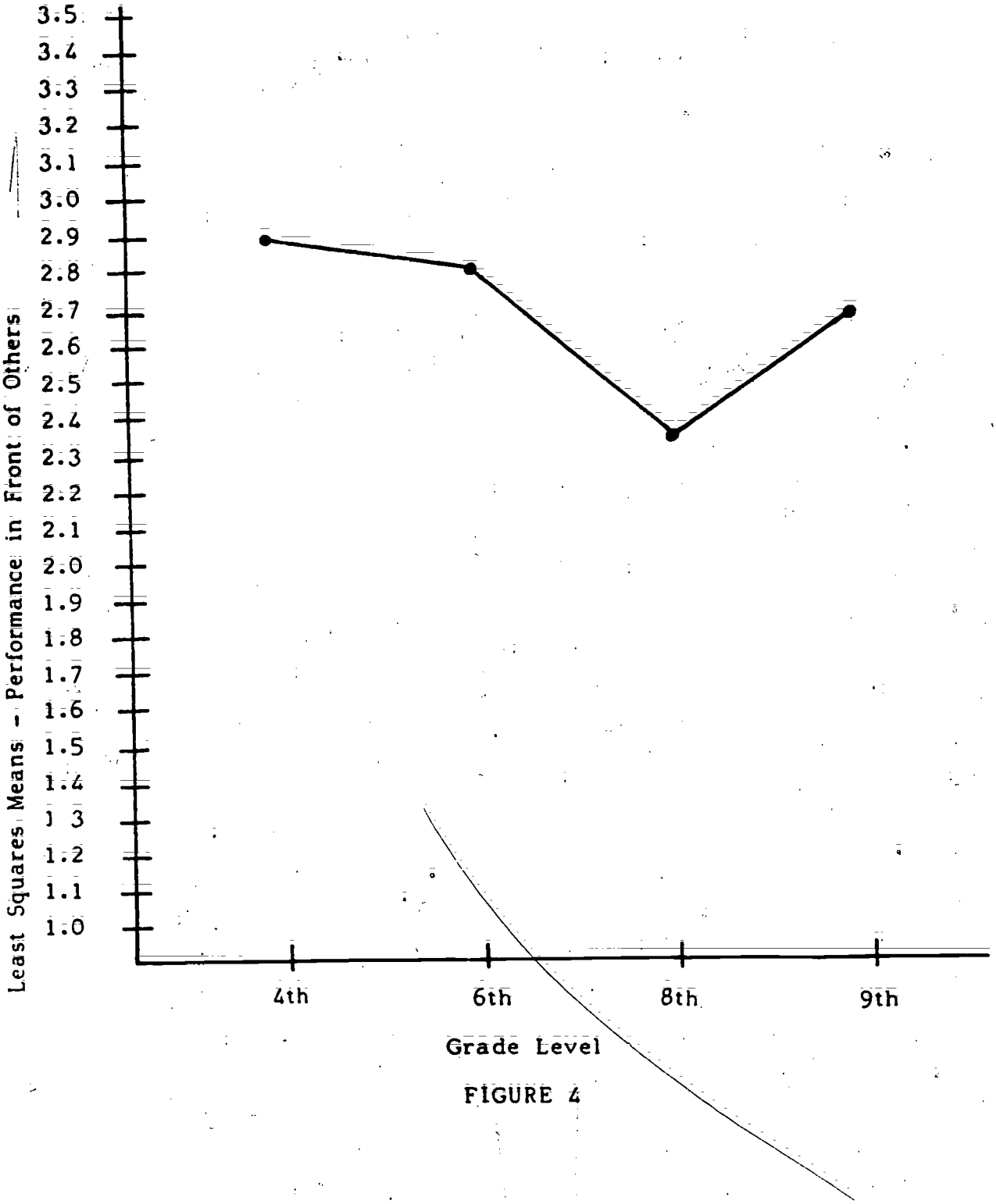

Least Squares Means - Performance in Front of Others
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
4th
6th
8th
9th
Grade Level

FIGURE 4

TABLE XV

TEACHERS' PERCEPTIONS ABOUT NUMBER OF STUDENTS ANXIOUS TOWARD SCIENCE WHO DID NOT TAKE THE SCIENCE ANXIETY QUESTIONNAIRE

| Grade | Number who did not take the science anxiety questionnaire | Per cent felt by teacher to be anxious about science (of those who did not take the questionnaire) |
|---|---|---|
| 4th | 129 | 46.5% |
| 6th | 171 | 32.7% |
| 8th | 84 | 42.8% |
| 9th | 152 | 42.1% |

TABLE XVI

TEACHERS' PREFERENCE FOR TEACHING SCIENCE IN RELATION TO FOUR OTHER SUBJECT AREAS

| Grade the Teacher Teaches | Preference for teaching science in comparison to mathematics, social studies, language arts, or reading. |
|---|---|
| 4th | second |
| 4th | first |
| 4th | third |
| 4th | third |
| 4th | third |
| 4th | third |
| 4th | second |
| 4th | fourth |
| 4th | fourth |
| 4th | fifth |
| 6th | third |
| 6th | first |
| 6th | fifth |
| 6th | first |
| 6th | fourth |
| 6th | third |
| 6th | fourth |
| 6th | fifth |
| 6th | second |
| 6th | fifth |
| 8th | first |
| 8th | first |
| 9th | first |
| 9th | first |