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By

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ABSTRACT

A QUANTITATIVE AND QUALITATIVE INQUIRY INTO THE ATTITUDES TOWARD SCIENCE OF COLLEGE STUDENTS

By

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The attitudes toward science of nonscience students and science students at Ferris State University were investigated using quantitative and qualitative methods of inquiry. Three areas were evaluated by quantitative methods: (a) differences in attitudes toward science between nonscience students and science students, (b) the effects of instruction on attitudes toward science, and (c) the relationship of attitudes toward science to achievement. A qualitative form of inquiry was used to investigate attitude development as it relates to science.

The Attitudes Toward Science Inventory (ATSI), which assessed the six attitudes of perception of the science teacher, anxiety toward science, value of science in society, self-concept in science, enjoyment of science, and motivation in science, was used for the quantitative investigation. The study group was composed of 102 nonscience students and 83 science students. Data from

the ATSI were analyzed by multivariate and univariate statistics.

Hotelling's T^2 showed a highly significant difference ($p = .000$) in attitudes between the two groups. Univariate t-tests were highly significant for all six variables on the ATSI. A highly significant difference ($p = .000$) was found between pretest and posttest results for the nonscience students. The t-tests revealed highly significant differences between the two sets of scores for all six variables and indicated a favorable change in attitudes. For the science students, a significant difference ($p < .05$) was demonstrated by Hotelling's T^2. The t-tests showed highly significant differences for four of the six variables and indicated a negative change. The t-tests conducted to determine the correlation between pretest and final grade were significant ($p < .05$) for two of the six variables. When the six variables were entered into a stepwise multiple regression to predict final grade, only value made a significant contribution.

Twenty-five nonscience students were interviewed for the qualitative area of the investigation. The interviews suggested that attitudes toward science are formed by interactions of both school and nonschool variables. Although past research has established a strong relationship between classroom environment and the formation of attitudes toward science, the interview results indicated that family environment and peer relationships may play a significant role in the development as well.

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CHAPTER I

INTRODUCTION

The status of science education and the scientific illiteracy of U.S. citizens have been widely documented (Hornbeck, 1988; Penick & Yager, 1986; Recer, 1988; "Upgrading Basic Science Education," 1987). In his Rede Lecture at Cambridge in 1959, Snow (1964) proposed the idea that there are two cultures into which our society has divided itself: the scientist and the nonscientist. Since that time, according to Prior (1983), the phrase "two cultures" has become somewhat of a cliche. Bernstein (1983) referred to the concept in his article, "The Two Cultures Revisited," saying that there are at least two cultures, that of the scientifically literate and that of the scientifically illiterate. The idea was reiterated by Koshland (1985), who said that the world today is divided into two conceptual groups, the scientist and the nonscientist, and the communication gap between them is wide and serious.

According to Lagowski (1987), scientific illiteracy in this country stems from the fact that American students do not study much science. There is increasing concern over dropping enrollments in high school and college science studies (Evans, 1985). In the decade ending in 1981, the number of high school students completing more than two years of science in grades 10 through 12 dropped from 31% to 25% ("In Pre-college Education," 1985). Although scientific research facilities in the United States rank among the world's best, the majority of college students in America receive only limited exposure to basic science courses (Worsnop, 1988). A report on undergraduate education released in 1986 by the National Science Board for the National Science Foundation said that there is a growing decline in students pursuing careers in science, mathematics, and engineering, and the report expressed concern for the inability of many specialty disciplines to attract the numbers and quality of practitioners they need. In discussing honors college freshmen who enroll in a biology class at Ball State University, Mertens (1983) said that although they are bright and enthusiastic, most are not science majors. Furthermore, they often come to college with negative preconceptions of science, science courses, and scientists.

Statement of the Problem

Many reasons have been given for the negative attitudes toward science. It has been suggested that one can trace student difficulties to the lack of knowledge or skills that were never explicitly taught, causing students to become discouraged when asked to perform tasks requiring prior knowledge (Reif, 1986). Others have thought that classroom experiences do not foster enthusiasm for science (Mertens, 1983), laboratory instruction is tedious and dull ("Crisis in Undergraduate Education," 1986), and much is rote memorization that is soon forgotten (Rotberg, 1984); therefore, students lose interest in science. However, Edwords (1986) argued that the interest is there, but attention is being directed away from the realm of exciting real science toward a fantasy world of pseudoscience and mysticism. Yet another explanation was offered by Mallow (1981). Referring to the "two cultures," he said the skills necessary for learning science are different from those needed for learning humanities, and this has led to a widespread fear that most science is simply beyond the abilities of the average person. Successive generations are socialized to fear, and therefore avoid, science.

Although all of these explanations may be plausible, none of them appear to be based on research, but rather on instinct and hearsay. The overwhelming majority of studies on attitudes toward science have dealt with attitude measures rather than causal factors. The few studies associated with determinants usually have focused on gender differences, trends over grade levels or time, or differences in attitude attributable to program effects (Haladyna, Olsen, & Shaughnessy, 1982). As the country embarks on an ambitious program to improve science education, there is concern that we are treating the symptoms and not the cause (Bonham, 1983). Rutherford, chief education officer for the American Association for the Advancement of Science, said, "the problem is not knowing what the problems are" (cited in Bonham, 1983).

Rarely has there been a time when the importance of science education and scientific literacy has been easier to demonstrate. Society is increasingly being shaped by science and technology, and it is important, not only for those students headed for careers in science, but for everyone, to acquire the skills necessary to respond to an ever-changing and unpredictable world.

Yet for many students, the learning of science involves negative feelings and attitudes which discourage further exposure to any scientific inquiry. Despite the rhetoric, little attempt has been made to define those attitudes or to investigate causal factors contributing to their development. Meanwhile, as many sources continue to lament the breach between the scientist and the nonscientist, no progress appears to be made in narrowing the gap.

Purpose of the Study

The purpose of this study was to investigate the attitudes toward science of freshman college students at Ferris State University and to determine whether there were significant differences in attitudes between science majors and nonscience majors. Although the attitudes of both science majors and nonscience majors were measured, the study focused more specifically on the attitudes toward science of nonscience majors. It not only attempted to measure their attitudes toward science, but it also investigated the basis for their attitude formation. In addition, the relationship of achievement to attitudes toward science was investigated.

The nonscience majors were students enrolled in Biology 105, a biology course with no science prerequisites. Students enrolled in Biology 105 typically have no background in chemistry and physics, and often have never taken a high school biology course. They have diverse socioeconomic backgrounds and come from many regions of the country.

The science majors sampled were drawn from Biology 122, a course designed for students in curricula that require subsequent courses in biology. Students enrolled in this course are generally preprofessional students who intend to enter medicine, dentistry, engineering, pharmacy, or optometry, or are students who plan to earn a baccalaureate degree in applied biology.

The study provided insight into the particular problems that a nonscientist encounters when confronting science-related issues. The information gained from this study has applications to strategies for teaching nonscience students.

Context of the Study

The study measured the attitudes toward science of a sample of science majors and nonscience majors at Ferris State University, Big Rapids, Michigan. Ferris is a public university located in central lower Michigan that has an annual enrollment of approximately 11,000 students. A full range of occupationally oriented programs is offered by the university, extending from the certificate through selected graduate and professional degrees. Ferris is an "open-door" institution, committed to giving students the opportunity to be successful in college by providing for provisional admission with remedial and tutorial support classes. At the same time, programs in optometry, pharmacy, and biotechnology attract students with strong academic backgrounds. Consequently, the student population is a potpourri of ethnic, economic, and academic backgrounds.

The Importance of Attitude Measures in Science Education

There has been a trend over the past decade to give greater prominence to affective outcomes relative to cognitive outcomes in the science curricula, and increasing attention is being given to assessing attitudes toward science (Schibeci, 1983). According to Mumby (1983), any evaluation of science curricula ought to attend to affective as well as cognitive outcomes. The assessment of attitude objectives was included in the National Assessment of Educational Progress (1979) because it was recognized that attitudes toward science are as important as experiences in science in influencing students' decisions and actions.

The value of positive attitudes toward science education has been widely recognized (Billeh & Zakhariades, 1975; Fraser, 1978; Gabel, 1986). Two arguments have been made to support the value of affective outcomes in science education (Schibeci, 1983). The first argument is that student achievement and positive attitudes are inextricably linked.

The second argument, which is perhaps more relevant to this study than the first argument, is that affective objectives rather than cognitive objectives are the more important goals of education. Payne (1977) expanded on this position when he argued that attitudes influence the ability of a person to "participate effectively in a democratic society."

Need for the Study

The development of this study grew out of both a societal need and a curricular planning need. The societal need focuses on the subject of scientific literacy as an educational objective, whereas the curricular-planning need focuses on methods to better achieve this educational objective.

Societal Need

Upon leaving his position as president of the University of Michigan to assume the presidency of Princeton University, Shapiro cited the teaching of science to nonscientists as one of two major concerns of the university (Stroud, 1987). The value of science for nonscience majors has often centered on the need for providing a scientifically literate society. The lack in understanding of science and technology by the population in general has caused much concern. Shakhashiri, assistant director for science and engineering education at the National Science Foundation (NSF), said, "We are failing to provide an adequate background, an adequate introduction, and an adequate level of science literacy for the population as a whole" ("Upgrading Basic Science Education," 1987).

Many of the fundamental concepts and methodologies of science are not within the understanding of the vast majority of the population (Koshland, 1985). According to Edwords (1986), most people do not understand the scientific method or the way science works, and rarely have even a conversational knowledge of some of the most significant discoveries or major theories of our century. Most Americans outside the scientific professions understand so little about even the basics of science that experts believe the public is ill-equipped to confront policy decisions on scientific issues ("U.S. Science Education," 1986).

Although it is critical that as many citizens as possible have enough of a technical background to be able to separate the technical aspects of decisions from the political and moral ones, many people think that there is little value or use for science in everyday experiences. Science is somehow too specialized, too abstract, and too unrelated to the real experience (Brunkhorst & Yager, 1986).

Much of the available information suggests that common practices in science education result in negative attitudes toward science for the majority of students. Although Yager and Penick (1984) found that there is an approval rating for the usefulness of science in the early years (93%), they found it begins to wane around age nine, and by the time these students become working adults, the rating has dropped to 22%. These findings were supported by Haladyna et al. (1982), who reported that a high sense of fatalism that was associated with low attitudes toward science was already present in fourth-grade students. The sense of fatalism showed a significant increase in sixth-grade students and continued to rise in ninth-grade students. They concluded that the association apparently grew stronger with passing years. As Lagowski (1987) suggested in "Two Cultures: The Paradox Continues," the two cultures seem to develop early in the educational system in the United States. It would appear that as students progress through school, their disillusionment with the ultimate value of their science studies increases.

In view of the need for individuals to be able to use science, not only to cope with an increasingly technological world but also to prepare themselves to deal with science-related issues, the results of these and similar studies are disturbing. If most students initially have positive attitudes toward science, what happens to cause them to change their attitudes?

Curricular-Planning Need

Among the course offerings at Ferris State University is a biology course required by many nonscience programs that involves teaching the concepts and principles of human anatomy and physiology. The course is often approached by students with anxiety, with as many as 10% waiting until their final quarter on campus to take the class. Often students perceive little value in such a class, and therefore it is viewed only as a major hurdle to cross.

There is a need to better understand the attitudes toward science of nonscience students and to develop teaching strategies that enable them to leave the course with enthusiasm and self-confidence in subject matters that seemed strange and forbidding at the outset.

Research Questions

Following are the specific questions that were addressed in this study:

1. How do the attitudes toward science of nonscience-major students compare with the attitudes toward science of science-major students?

2. Do attitudes toward science change after exposure to science?

3. How closely is attitude toward science related to achievement?

4. What developmental experiences are associated with attitudes toward science?

Questions 1, 2, and 3 were quantitatively investigated with the use of a Likert-type assessment instrument. Question 4 was researched with the use of student interviews, a qualitative inquiry.

Definition of Terms

To provide a common basis for understanding, the following definitions are included for terms that were used in the study.

Attitudes toward science--beliefs one holds about the discipline of science (Mumby, 1983). The specific attitudes that this study investigated were anxiety toward science, value of science in society, self-concept in science, enjoyment of science, motivation in science, and perception of the science teacher.

Endogenous variables--variables under the control of the educational process, such as teacher, curriculum, and school environment.

Exogenous variables--variables outside the immediate influence of the educational process, such as gender of student, family background, and cultural factors.

Nonscience majors--students majoring in fields not associated with biology, chemistry, physics, geology, or mathematics, such as marketing, criminal justice, or building and trades.

Science majors--students majoring in fields associated with biology, chemistry, physics, geology, or mathematics, such as pharmacy, optometry, or medicine.

Limitations and Delimitations

The study was subject to restrictions imposed by the educational environment in which it was conducted. There were also restrictions imposed by the design of the research.

Limitations

Generalizability. The study was limited to the students enrolled in one section of Biology 105 and one section of Biology 122 during the winter quarter of 1987-1988. Generalizability should be limited to these groups and should not be routinely generalized to other academic settings.

Nonrandom groups. Because of the nature of class scheduling at Ferris State University, random assignment to lecture sections was not possible. However, class sections appeared to be representative.

Teacher effects. Two teachers were involved in the study. It is recognized that there may have been teacher effects, but the extent of the effects on the study is unknown.

Delimitations

Variable selection. The study of science-related attitudes encompasses a large number of topics. This study was limited to the following six variables within the construct of attitudes toward science: anxiety toward science, perception of the science teacher, value of science in society, self-concept in science, enjoyment of science, and motivation in science. The investigation of attitude determinants was limited to the variables of self-concept, home environment, school environment, and peer relationships.

Sample size. The sample size of the nonscience majors was limited to the enrollment of one lecture section of Biology 105, and the sample size of the science majors was limited to the enrollment of one lecture section of Biology 122. The sample size of the interviews was limited by the time and fiscal constraints of the investigator.

Conduct of the Study

The purpose and need for the study and the research questions that were investigated were presented in Chapter I. A discussion of the distinction between scientific attitudes and attitudes toward science, and a review of the relevant literature, follow in Chapter II. The procedures employed in conducting the study are described in Chapter III. Chapter IV contains a description of the findings, and in Chapter V the researcher summarizes the results and discusses the applications for teaching strategies.

CHAPTER II

REVIEW OF THE LITERATURE

Two searches of the literature compiled on attitudes toward science over the past 20 years were conducted for this study. The first search was carried out by the Educational Testing Service, Princeton, New Jersey. The second search was an ERIC search done by the library at Ferris State University, Big Rapids, Michigan. The information from these two searches was supplemented with references from Resources in Education and Current Index to Journals in Education.

The Distinction Between Scientific Attitudes and Attitudes Toward Science

Research on attitudes toward science is geographically focused in four areas: Australia, Great Britain, Israel, and the United States. According to Peterson and Carlson (1979), more than 30 studies a year are done on attitudes relating to science. However, a close look revealed that there have been different interpretations of what an attitude to science is. Some researchers have appeared to be investigating attitudes toward science, whereas others have investigated scientific attitudes. It is necessary, therefore, to distinguish between the two broad subsets of science-related attitudes, namely scientific attitudes and attitudes toward science. The emphasis is considerably different in each category; "scientific attitudes" have a predominantly cognitive orientation, while "attitudes toward science" have a predominantly affective orientation (Schibeci, 1983).

Scientific Attitudes

The term "scientific attitude" embodies the adoption of a particular approach to problem solving and assessing ideas. Typically, scientific attitudes are various styles of thinking which scientists are presumed to display, such as honesty, objectivity, open-mindedness, rationality, and suspended judgment.

Attitudes Toward Science

Attitudes toward science deal with feelings toward science and what one believes about the discipline. Variables in the attitudes toward science category would be those such as interest, anxiety, enjoyment, and value to society. This study was concerned only with attitudes toward science.

Research Studies

Relevant studies were reviewed in the areas of (a) attitude differences between science majors and nonscience majors, (b) attitude change relating to instruction, (c) relationship of achievement to attitudes toward science, and (d) attitude determinants. In addition, since interviewing comprised a portion of the study, studies using interviewing as a research technique were reviewed. Because a limited number of studies dealing with attitudes toward science at the college level appear in the literature, some studies are cited that were conducted at the secondary level.

Differences Between Science Majors and Nonscience Majors

Korth (1969) surveyed 865 science-oriented high school students and 628 nonscience high school students using the Korth Scale, a 52-item Likert instrument. Analysis of the data was performed on an item-by-item basis by grouping responses into three categories: (a) strongly disagree-disagree, (b) uncertain, and (c) agree-strongly agree. The groups were then compared through the use of a chi-square. The results of the study showed a significant difference in favor of science-oriented students for 34 of the 52 items. Korth concluded from his study that science-oriented students had a more positive attitude toward science, a better understanding of science, and a more realistic conception of scientists than did nonscience students.

Clark (1970) administered a 28-item Likert scale to 75 humanities teachers and 45 science teachers to identify the gap in attitudes toward science between the scientific culture and the humanistic culture in the secondary schools. The responses were analyzed by a nonparametric sign test. Clark concluded that a gap between the sciences and humanities did exist. The study also showed that both groups thought science was a more prestigious discipline than the humanities.

Shallis and Hills (1975) surveyed the readers of New Scientist and New Society. From 1,559 completed returns, it was concluded that young nonscientists often appeared hostile toward science, whereas young scientists exhibited optimism and enthusiastic attitudes toward science. The instrument employed in the survey contained six items with a sentence-completion or agree/disagree format.

Tilford (1971) surveyed 1,066 science majors and nonscience majors at three predominantly black institutions in Alabama, Oklahoma, and Texas to investigate attitude differences between the two groups. A t-test was used to compare the mean of the scores of students majoring in science with that of students majoring in nonscience fields of study. Significant differences in attitudes toward science were found to exist between science majors and nonscience majors. The survey was administered to 195 white students, and it was also concluded that black students' attitudes toward science were similar to those of white students.

Attitude Change Relating
to Instruction

A study to measure the change in attitudes toward science upon completion of a one-semester general education physical science course at the junior-college level was conducted by Fellers (1972). An experimental group consisting of 510 students enrolled in physical science was compared with a control group of 180 history students using a 55-item Likert scale. The study showed that there was a significant difference in favorable attitudes demonstrated by the experimental group.

Baldwin and Boedeker (1975) conducted general attitude polls in introductory physical science and earth science courses. Pre- and posttests were used in an attempt to measure changes in student attitudes as a result of their exposure to these science courses. The instrument used in the study contained five true/false statements. The results indicated that a high percentage of students enjoyed both courses, and it was concluded that there was no anti-science attitude among students.

Leavers (1975) observed a positive attitude change in students enrolled in a chemistry course for nonscientists. An opinion survey containing four Likert-like statements was administered the first and ninth weeks of a ten-week course. Improvement was noted in three out of the four areas, and Leavers concluded that negative attitudes toward science were somewhat reversible.

A science and scientists' attitude inventory developed by Motz (1970) was used by Starring (1972) to measure the effects on attitudes toward science of an experimental course for ninth-grade science-shy students. The 50-item Likert scale was administered in pre- and posttests to 1,099 students. The study showed the total student group improved significantly in attitude on 10 of the 50 items. The group also showed a significant decline in 2 of the 50 items.

A Likert scale of 95 items to measure attitudes toward science was developed by Allen (1959). The Allen Scale was used by Giddings (1965) to measure attitude change in junior high school students in disadvantaged areas of New York City, by Fiasca (1966) to measure how various physical science courses affect attitude, and by Brown (1967) to measure attitude change between chemistry and nonchemistry students in Tacoma Public Schools. The results of all three of these studies indicated that student attitudes toward science changed little over instruction.

The effects of an interdisciplinary course on attitudes toward science were measured by Arntson (1975) using a 40-item Likert scale. The study was conducted for one semester in a two-year college using experimental and control groups. Arntson concluded that there was no significant attitude change between the two groups.

Gardner (1972) conducted a study on the attitudes toward science of high school physics students. The Gardner Scale, a 40-item Likert instrument, was administered to 1,014 eleventh-grade students at the beginning and end of the school year. The pre- and posttest design indicated that there was a deterioration of the high school students' attitudes toward science. The view of physics as an open discipline declined significantly, as did the view of scientists as normal. Although the enjoyment of physics was initially high, it declined sharply with exposure.

In a later study, Gardner (1973) used analysis of covariance to identify the main and interaction effects of the previous study. He concluded that the decline of physical enjoyment was not uniform but was related to the interaction of intellectual and achievement-motivated students with intellectual and achievement-pressing teachers.

The following two studies dealt with both of the above areas of review: attitude differences between science majors and nonmajors and attitude change relating to instruction.

Sadava (1976) conducted a study to research how attitudes toward science and technology of nonscience-major college students compared with those of the general public, and whether student attitudes changed after students were exposed to a science course. He administered an opinion survey designed by the Opinion Research Corporation, Princeton, New Jersey, under the auspices of the NSF to nonscience majors before and after completing a course on principles of natural science. He compared student scores to those received by the general public on a survey taken by Opinion Research Corporation. The results indicated that, before the course, students had more negative attitudes than the general population toward science and technology. After exposure to the science course, students' opinions were even more negative than they had been when the course started. Sadava concluded that courses oriented for nonscience students tended to emphasize negative aspects of applied science, particularly if they were environmental courses. If students entered a science course with preconceived misgivings about science, this tendency reinforced opinions already formed.

Gabel (1981) undertook a study to determine whether preservice teachers' attitudes toward science differed from those of other majors, whether the number of courses taken influenced attitudes, and whether the enrollment in a special course relating science to science teaching effected attitude change. The study indicated that science majors had more positive attitudes toward science than did nonmajors. The study also indicated that, although one particular course did not change students' attitudes, the number of science courses a student took may have had a cumulative effect in positively influencing attitude. The researcher attempted to identify the number of science courses that a student must take to cause a significant change in attitude. Findings of the study indicated that four courses appeared to be the minimum number of courses in which students should enroll.

Relationship of Achievement to Attitudes Toward Science

Willson (1980) completed a meta-analysis of 14 studies that investigated the relationship between science students' attitudes and achievement in secondary science students in Australia, Great Britain, Israel, and the United States. The correlation coefficients ranged from -.18 to .48, with an overall mean of .11. It was found that the magnitude of the relationship of achievement to attitude was independent of students' grade level, ability, and gender.

A similar study was carried out by Ligon, Baenen, and Matuszek (1977), who reviewed ten studies that had been conducted on the relationship of achievement to attitude in a variety of subject areas. Ligon et al. concluded that the correlation between these factors was small or zero.

Campbell and Martinez-Perez (1976) tested the hypothesis that there are positive correlations among attitudes toward science, self-concept, and achievement of science process skills. The instruments used in the study were the Moore and Sutman (1970) Scientific Attitude Inventory (SAI), Basic Science Process Skills and Integrated Process Skills, and the Tennessee Self-Concept Scale. Data were analyzed using Pearson's product-moment correlation coefficients. Campbell and Martinez-Perez concluded that there were positive correlations between basic science process skills and attitudes toward science, integrated science process skills and attitudes toward science, and attitudes toward science and self-concept. However, Moore and Sutman's SAI is an instrument for measuring scientific attitudes, not for measuring attitudes toward science, which they indicated was the intention of the study.

Attitude Determinants

Dapper (1978) conducted a study on undergraduate science majors to determine the relationship of various factors to attitudes toward science. The variables chosen for study were science aptitude, general scholastic aptitude, college science background, achievement in college science courses, scientific attitude, interest in science, and locus of control. The instruments used were the Scientific Attitude Inventory, Three Scales to Measure Three Dimensions of Locus of Control, and the natural science reading test scores and composite test scores of ACT tests. Using multiple regression, Dapper found the predictor variables for determining attitudes toward science in order as follows: interest in science, scientific attitude, locus of control, achievement in college courses, and general scholastic aptitude.

Kamchatural (1978) carried out a study on nonscience college students to determine whether the number of science courses taken in high school was related to achievement in biology, and whether the number of courses taken was related to attitudes toward science. The results indicated that both the number of courses taken in high school and attitudes toward science influenced achievement, but the number of courses taken in high school did not affect attitudes toward science.

Haladyna et al. (1982) developed a study to assess the relationships of student, teacher, and learning environment to attitudes toward science. The population of the study included students from grades four, seven, and nine. The testing instrument applied was the Inventory of Affective Aspects of Schooling. Statistical treatment included correlation analyses and stepwise regression. Findings of the study strongly indicated that positive attitudes toward science and other subject matters may have been causally linked to a perception about oneself and one's ability to learn. The relationship between attitudes toward science and students' perceptions of overall teacher quality was also found to be very strong. Although it is believed that the learning environment is related to attitudes toward science, no clear patterns emerged from the study. It was concluded that efforts to strengthen overall teacher quality and the learning environment would have a positive effect on student attitudes toward science.

Talton and Simpson (1986) examined the relationships of self, family, and classroom environment with attitudes toward science in grades six through ten. The instrument used was a 60-item Likert scale developed by Simpson and Troost (1982). Regression studies showed that the five variables of climate, curriculum, friends, science self-concept, and family science were the most consistent predictors of attitudes toward science across grade levels. The findings indicated that all three categories of variables--self, family, and classroom environment--had a positive relationship with attitudes toward science, but the researchers concluded that classroom environment had the strongest relationship.

Interviewing

A nonstatistical study was designed by Wilson (1985) to gain information about how successful and unsuccessful remedial college algebra students viewed and applied algebraic processes relevant to the concepts and related principles of exponents. Seven of the most successful and seven of the least successful students in the program were interviewed. A "thinking aloud" interviewing technique was used in an effort to rate each of the 14 students' processes as they solved problems pertaining to exponents. The findings indicated that students at either level rarely had any relational understanding of the concepts and principles of exponents. Indications were that the successful students, who had supposedly mastered the material, had simply memorized enough algebra to "pass," and after taking the examinations, promptly forgot the rules. Wilson concluded that the interview results were ominous with respect to any future mathematical endeavors of those students. He strongly suggested that similar studies should be conducted at other institutions on other algebraic concepts, sampling more mathematically advanced students as well, to see if the interview findings were representative of students' understanding of algebra.

Davidson (1986) conducted a study to characterize the development of students' conception of education. Seventy students in grades 3 through 12 were interviewed about issues relating to the purposes of education, the process of learning, the nature of intelligence, and what should be taught in the schools. Both increasing linear age trends and U-shaped developmental patterns were found. The overall pattern of results demonstrated three stages of developmental progression and suggested a restructuring of knowledge about education across the school years.

Summary

The literature reviewed on attitude differences between science majors and nonscience majors was fairly consistent. The findings of all the studies acknowledged a difference in attitudes between the two groups, with science majors having more favorable attitudes toward science than nonscience majors.

The results of the studies dealing with attitude change after instruction were mixed: Four studies reported a change with more positive attitudes after instruction, two studies reported a change with more negative attitudes after instruction, four studies reported no change after instruction, and one study reported no change after a single course of instruction but the possibility of a cumulative positive effect after more than one course.

The meta-analyses of both Willson and Ligon et al. found little correlation between achievement and attitude. Campbell and Martinez-Perez found positive correlations between achievement and attitude, but they mixed the theoretical constructs of attitudes toward science and scientific attitudes, which could invalidate the findings (Mumby, 1983).

The studies on attitude determinants all differed on the variables investigated, depending on the emphasis of the research. Most of the studies focused on the direct schooling process and did not consider the competing influence of school and nonschool variables.

A thorough search of the literature did not reveal any studies on attitudes toward science using the interview as an investigative tool. The two studies cited in the review were both conducted at the College of Education, Michigan State University.

CHAPTER III

METHODOLOGY

This chapter includes descriptions of the population, research design, measurement instruments, and hypotheses tested. The methods were designed to achieve clear results for hypothesis testing and appropriate conclusions.

Population of the Study

The population of the study comprised students enrolled in one section of Biology 105 and one section of Biology 122 during the winter quarter of the 1987-88 academic year. There was a fairly equal distribution of male and female students in both courses. The age of the students typically fell in the range of 18 to 22 years. However, the population included some students who were older. Although these courses are designed for freshman-level students, approximately 25% of the population comprised a combination of sophomore, junior, and senior students. The population consisted of 183 students. Of these, about 55% were nonscience majors, and 45% were science majors.

Course Descriptions

Biology 105

Biology 105, Basic Human Anatomy and Physiology, is a biology course with no science prerequisites. It is considered to be a terminal biology course. Students enrolled in the course typically have a weak background in the sciences, with most students having taken no chemistry and physics and many having taken no high school biology.

Two sections of Biology 105 were offered during the winter quarter. The nonscience-major sample consisted of one section of Biology 105 and comprised 102 students.

Biology 122

Biology 122 is one of three courses within the freshman biology sequence, General Biology 1, 2, and 3. These courses are designed for students who will be taking subsequent courses in biology. Students enrolled in these courses generally have a strong high school background in the sciences, with most students having completed chemistry and physics.

Two sections of Biology 122 were offered during the winter quarter. The science-major sample consisted of one of the two sections of Biology 122. Choice of the section was contingent on enrollment numbers and instructor cooperation. The sample consisted of 81 science majors.

Basic Design of the Study

Pretest Administration

The Attitudes Toward Science Inventory, a Likert-type survey instrument designed to measure attitudes toward science, was administered to all students enrolled in one section of Biology 105 and to all students enrolled in one section of Biology 122 during the first class meeting of the quarter.

Posttest Administration

The posttest consisted of retesting both the science majors and the nonscience majors who took the Attitude Toward Science Inventory pretest. The posttest was administered during the final week of the quarter.

The final course grade also served as a posttest measure for those students enrolled in Biology 105. The final grade was recorded using the 12-point scale for A, A-, B+, B, B-, C+, C, C-, D+, D, D-, F.

Attrition Effects

Losses in participation due to attrition result in missing data, which is potentially damaging to the validity of the evaluation results (Watts, Peck, & Tausig, 1977). Therefore, all participants were monitored for attrition, and incomplete data were eliminated from the evaluation.

Teacher Effects

Two instructors were involved in the study. The instructors involved were the same age, and both possessed a master's degree in biological science. One instructor had had nine years of teaching experience, and the other had taught for 25 years. Both instructors used similar methods for material presentation and testing. They shared common beliefs in their philosophies of education and were both available to students for additional help. It is recognized that there may have been teacher effects, but the extent of those effects on the study is unknown.

Interviewing

A random selection of students was interviewed to investigate the developmental experiences that are associated with attitudes toward science. Because the intention of this study was to focus on the attitudes toward science of nonscience majors, the interview sample of 25 students was drawn from Biology 105.

Students enrolled in Biology 105 were assigned numbers in order, beginning with the first student on the class list. A table of random numbers was then used to select the participants for the interviews (Anderson & Sclove, 1974).

Consent Procedures

A consent form was distributed to all students in the classes involved in the survey and collected separately from the survey. The survey was then distributed and collected following consent. Consent was obtained additionally from those students who participated in the interviews. Forms were signed before an interview began. Appendix A contains copies of the consent forms.

Instrumentation

Two evaluation instruments were used in the study. The first instrument, the Attitudes Toward Science Inventory, was administered the first and final weeks of the winter quarter. The questionnaire used during the interviewing procedure was developed by the researcher and was used throughout the quarter to survey the random sample from Biology 105.

Attitudes Toward Science Inventory

The Attitudes Toward Science Inventory (ATSI) is a modification of an instrument developed by Sandman (1973) to assess attitudes toward mathematics in students from the eighth through the eleventh grade. The reliability and validity of the instrument were affirmed by Swartz (1982) in its use to assess attitudes toward mathematics in a college population. Using the item shell technique, the instrument was rewritten to evaluate attitudes toward science. Item shells are developed from successfully used items that have been stripped of specific content but contain the syntactic structure. The syntactic structure of a high-quality item is useful for generating items with similar syntax which retain the qualities of the original item (Haladyna et al., 1987). The rewritten instrument was used to evaluate attitudes toward science in the study.

The ATSI is a 48-item, Likert-type instrument comprising six scales with eight items per scale. The six scales are:

1. Anxiety toward science--the uneasiness a student feels in situations involving science.

2. Value of science in society--a student's view regarding the usefulness of scientific knowledge.

3. Self-concept in science--a student's perception of his/her own competence in science.

4. Enjoyment of science--the pleasure a student receives from participating in science-related activities.

5. Motivation in science--a student's desire to work in science beyond the class requirements.

6. Perception of the science teacher--a student's view regarding the teaching characteristics of his/her science teacher.

Students were asked to respond to the forced-choice system (strongly agree, agree, disagree, strongly disagree). Items were scored 4, 3, 2, 1, respectively, and summed across the eight items for each scale. This yielded six separate scores for the attitudinal dimensions, rather than a single score, which is common in many attitude scales.

Following are items from both the original and rewritten instruments to illustrate that parallels were maintained between the two instruments:

Original instrument
1. Mathematics is useful for the problems of everyday life.
2. Mathematics is something which I enjoy very much.
3. I like the easy mathematics problems best.
4. I don't do very well in mathematics.

Rewritten instrument
1. Science is useful for the problems of everyday life.
2. Science is something which I enjoy very much.
3. I like the easy science assignments best.
4. I don't do very well in science.

Appendix B contains a complete copy of the ATSI.

Pilot testing for validity and reliability. A pilot using the ATSI was conducted during the fall quarter of 1987 on 60 students enrolled in Biology 105 at Ferris State University. Since the essential conditions under which a pilot survey is conducted should not be materially different from the conditions under which the study survey is to be taken (Raj, 1972), the pilot survey was administered during a class session at the beginning of the fall quarter. This approximated the conditions for the study group. Data were compiled, and validity and reliability coefficients were computed.

Construct validity was determined in the form of nonspurious item-to-scale correlations comparing the validity coefficients of Swartz (1982) with the pilot sample (Table 3.1). A comparison of the validity coefficients for the pilot group and the original norm population showed a high similarity for 44 of the 48 items. Since Items 3, 29, 32, and 45 were inconsistent with data from the other items, they were rewritten before being administered to the study group during the winter quarter.

Alpha reliability coefficients for the pilot group and norm group were also compared (Table 3.2). Since a correlation of .70 and above shows that a measurement method is sufficiently reliable (Fink & Kosecoff, 1985; Henerson, Morris, & Fitz-Gibbon, 1978), the coefficients were considered adequate to support the use of the survey in the study.

Table 3.1.—Nonspurious item-to-scale correlations for the Attitudes Toward Science Inventory.[a]

Perception of the Science Teacher			Anxiety Toward Science			Value of Science in Society			Self-Concept in Science			Enjoyment of Science			Motivation in Science		
Item	Norm	Pilot	Item	Norm	Pilot	Item	Norm	Pilot	Item	Norm	Pilot	Item	Norm	Pilot	Item	Norm	Pilot
31	.67	.57	7	.62	.53	1	.45	.48	4	.71	.62	26	.76	.49	3	.26	.06
40	.67	.46	11	.65	.70	9	.51	.32	10	.76	.61	28	.72	.68	8	.44	.48
44	.47	.41	20	.62	.56	12	.40	.47	16	.59	.57	29	.60	.21	14	.40	.49
46	.51	.50	25	.78	.74	15	.54	.42	19	.67	.53	45	.66	.11	32	.45	.16
5	.56	.57	34	.66	.59	23	.48	.40	22	.56	.54	2	.63	.74	37	.45	.40
17	.81	.56	36	.65	.61	24	.50	.38	30	.78	.61	6	.65	.45	41	.48	.52
21	.69	.55	39	.61	.66	33	.51	.47	35	.55	.59	13	.57	.54	42	.38	.49
27	.62	.40	43	.83	.66	38	.42	.35	48	.36	.47	18	.54	.65	47	.57	.57
Mean	.66	.50		.69	.63		.47	.40		.62	.57		.64	.48		.43	.39

[a]Norm data—Swartz, 1982.
Pilot data—Gogolin, 1987.

Table 3.2.--Alpha reliability coefficients for the six scales of the Attitudes Toward Science Inventory.

Scale	Group[a]	
	Norm	Pilot
Perception of the Science Teacher	.88	.80
Anxiety Toward Science	.89	.87
Value of Science in Society	.77	.70
Self-concept in Science	.87	.83
Enjoyment of Science	.88	.77
Motivation in Science	.74	.70

[a]Norm data--Swartz, 1985
Pilot data--Gogolin, 1988

Interviewing

Qualitative data in the form of words rather than numbers have long been the staple of the social sciences. In the past decade, researchers in fields with a traditional quantitative emphasis (e.g., psychology, urban planning, program evaluation, and educational research) have also been shifting to a more qualitative paradigm as a legitimate form of inquiry (Miles & Huberman, 1984). A prestructured interview served as the survey instrument to investigate the developmental experiences that are associated with attitudes toward science. Despite its limitations, it was thought that for this segment of the study, the interview was a necessary instrument to probe for deeper understanding of this complex issue. Although a conceptual framework provided a basis for the investigation and gave focus to the survey, the interview allowed students to describe more closely their real views and provided information on the students' reactions.

Conceptual framework. Although there are many theories of learning, motivation, and self-concept, there is no parallel in the studies of attitudes (Haladyna & Shaughnessy, 1980). Consequently, researchers develop their own theories and models for study. According to Miles and Huberman (1984), theory building relies on a few general constructs that subsume a mountain of particulars. A framework that specifies the constructs and variables can serve as a focus for a study and guide the research toward the relatedness of the variables.

All variables can be classified as exogenous or endogenous (Haladyna & Shaughnessy, 1980). In this study, the exogenous variables are variables outside the immediate influence of the educational process, such as gender of student, family background, and cultural factors. Endogenous variables are variables that are under the control of the educational process, such as teacher, curriculum, and school environment. Most research in attitudes toward science has been directed toward endogenous variables. According to Schibeci (1983), most studies have not considered the interaction of school and nonschool variables. After reviewing several studies relating to social and psychological influences on science learning, Kremer and Walberg (1981) concluded that "science educators have paid little attention to student motivation, home environment, and peer environment variables in the study of science achievement."

Positive relationships have been reported between self-concept and both cognitive and affective outcomes (Bloom, 1976; Haladyna et al., 1982; Kremer & Walberg, 1981; Simpson & Troost, 1982; Talton & Simpson, 1986). Family has been found to influence attitudes toward science in adolescents (Talton & Simpson, 1986). Another variable reported to strongly influence attitudes toward science is the classroom environment (Haladyna et al., 1983; Talton & Simpson, 1986). Although it has been little investigated, the peer group is suspected to play a significant role in the formation of attitudes toward science (Kremer & Walberg, 1981; Talton & Simpson, 1986).

The above findings suggest that self-concept, home environment, school environment, and peer interaction play important roles in shaping attitudes toward science. These four major categories formed the framework for the interviewing procedures of the study. The interactions of these four variables with attitudes toward science are illustrated in the conceptual model shown in Figure 3.1.

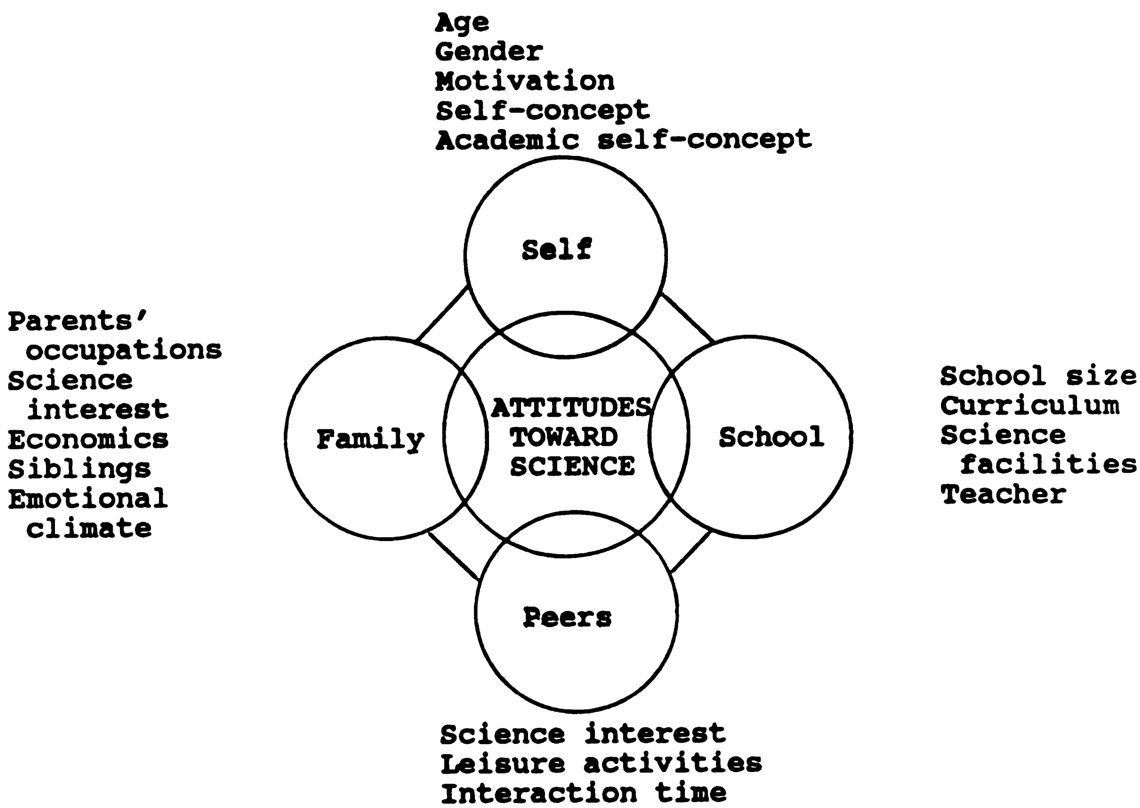

Figure 3.1.--Conceptual model.

<u>Interview questionnaire</u>. The interview questionnaire followed a standardized format. Questions were a combination of closed and open-ended questions. According to Raj (1976), closed questions should be used where the possible alternatives for answering are limited, but where an issue is complex or the relevant dimensions are unknown, the open type of question can be used to better advantage. Closed questions were used in the questionnaire where a clear-cut response was expected. However, students were encouraged to elaborate and present reasons for their

views if they desired. Open-ended questions were used where an exhaustive list of alternatives could not be anticipated. Some questions were adapted from instruments developed by Haladyna et al. (1982) and Talton and Simpson (1986). A copy of the interview questionnaire is included in Appendix C.

Interviewers. To reduce interviewer bias, two interviewers in addition to the principal investigator were employed for this study. Interviewers were carefully selected and trained to insure consistent presentation of questions and collection of data (Berdie, Anderson, & Niebuhr, 1986).

Criteria for the selection of interviewers included their interest in the study, ability to achieve rapport with students, accuracy and attention to detail, and adherence to ethical standards. Both of the interviewers selected had bachelor of science degrees in biology. One interviewer was male and one was female. Both had had previous experience interviewing, and both had had extensive experience interacting with college students.

Interviewer training included the following general topics suggested by Fowler (1984):

1. Procedures for contacting students and introducing the study.

2. Procedures for probing inadequate answers in a nondirective way.

3. Procedures for recording answers to open-ended and closed questions.

4. Rules and guidelines for handling the interpersonal aspects of the interview in a nonbiasing way.

Pilot interviewing. Tape-recorded pilot interviews were conducted during the fall quarter of 1987 on six students who were enrolled in Biology 105. These interviews were used to identify questions that were difficult for students to understand and to enable a coding system to be developed (Fowler, 1984). Since the objective of the pilot interviews was to test the procedure of the interview process, a random sample was not necessary (Raj, 1976). Students were selected to be interviewed on the basis of their willingness to participate, and no attempt was made to randomize the sample.

As a result of the pilot interviews, the questionnaire was modified before being administered during the winter quarter. The order of questions was changed in some categories, and alternatives were added to some of the closed-question responses.

Interviewing procedure. The 25 students who had been randomly selected from Biology 105 for interviewing were asked to meet as a group after a class meeting. At that time, the general purpose of the study and the interviewing procedures were explained. Students were asked to fill out a form indicating their present schedule and information about how they could be contacted. The names of the interviewers and brief descriptions of each were given to the students. Students were informed they would be contacted for the interviews and were cautioned against consenting to interviews by other persons.

Interviews were conducted in a quiet faculty office at the convenience of the students. Before each interview began, the student was asked to sign a consent form. The interview then began by the interviewer reading the following:

> Since most people have not been in a survey like this before, let me tell you a little bit about the interview process before we begin. You will be asked two kinds of questions during the interview. In some cases you will be asked to answer questions in your own words. For other questions, you will be asked to choose an answer from a set of answers. Even though none of the answers may fit your view exactly, choosing the response closest to your views will enable us to compare your answers more easily with those of others we are interviewing.
>
> It is important that you answer as accurately as you can. Respond giving your own views, not how you think you probably should respond. Take your time. Ask me to clarify any question you do not understand.

The interviewer then continued by asking the questions from the questionnaire. Responses to the questionnaire were recorded by the interviewer.

Data Processing

Students entered their responses for the ATSI on National Computers Systems (NCS) answer sheets. The marked sheets were processed by a NCS computer transmitted to a host IBM PCXT. The data file created was uploaded to the mainframe IBM computer at Ferris State University. The data were analyzed using the BMDP and SPSSx statistical packages.

The creation of the computer record involved three stages: the raw data file including responses to each item for both the pre- and posttests, the ATSI scores for the pre- and posttests, and a merged record for all scores, including a course grade. The various record formats follow.

Uploaded Records

Raw Data

		Pretest	Posttest
Lines:	1-9	ID	ID
	10	Blank	Blank
	11	Major code 1=nonscience 2=science	Blank
	12	Blank	Blank
	13-60	ATSI responses	ATSI responses

Processed Data

		Pretest	Posttest
Lines:	1-9	ID	ID
	10	Blank	Blank
	11	Major code 1=nonscience 2=science	Bland
	12	Blank	Blank
	13-24	6 ATSI scores	6 ATSI scores
	25	Blank	Blank
	26-28	Blank	Course grade

Merged Record

Lines:	1-9	ID
	10	Blank
	11	Major code
	12	Blank
	13-24	6 ATSI pretest scores
	25	Blank
	26-37	6 ATSI posttest scores
	38	Blank
	39-41	Course grade

Analysis

Research Question 1

The first research question involved determining the attitudes toward science of nonscience students, determining the attitudes toward science of science-major students, and then comparing the attitudes of the two groups. Research Hypothesis 1 is:

> Ho 1: There is no difference between the attitudes toward science of nonscience-major students and the attitudes toward science of science-major students.

Multivariate analysis of variance (MANOVA) was used to test for significant differences in attitudes toward science between nonscience majors and science majors. The use of MANOVA minimized the potential for Type I errors inherent in using separate analyses of variance (ANOVA). A special treatment of MANOVA is Hotelling's T^2, which was used to test the hypothesis that two groups differ on a composite set of measures. It was used to infer whether the combined averages of the six attitudes toward science for the two groups differ, relative to the overlap between students in the two groups on the six attitudes toward science (Tabachnick & Fidell, 1983). Since no direction was implied, it was a two-tailed test. The alpha level of .05 was used.

Research Question 2

The second research question involved comparing the pretest scores of each group of students with their posttest scores. The research hypothesis for each group is:

Ho 2: There is no change in attitudes toward science after taking a science course.

MANOVA was used for testing the hypothesis for this research question. Hotelling's T^2 was used to compare the pretest and posttest scores for each group. It was a two-tailed test with an alpha level of .05.

Research Question 3

The third research question involved comparing the pretest ATSI scores of Biology 105 students with the final grade received in the course. The research hypothesis is:

Ho 3: Attitude toward science is not related to achievement in a science course.

This hypothesis was tested using a t-test for each of the six ATSI measures to determine if they were significantly different from zero (Milton, Corbet, &

McTeer, 1986; Summers, Peters, & Armstrong, 1985). The .05 alpha level was used for the two tailed test.

As a follow-up, the six ATSI measures were used in a multiple-regression process as rival predictors to predict the final course grade. Those variables that made a significant contribution to the prediction are noted in Chapter IV.

Research Question 4

The fourth research question involved determining the relationship of the four variables--self, family, school, and peer group--to the development of attitudes toward science. The research design of this question called for qualitative rather than quantitative analysis.

According to Miles and Huberman (1984), although there are few agreed-upon canons for qualitative analysis, the three concurrent flows of activity, data reduction, data display, and conclusion drawing, are going on continuously throughout the analysis procedure.

Data were reduced by the process of selecting, simplifying, and transforming raw data by coding, doing summaries, and teasing out themes. Data displays, such as matrices, charts, and networks, were used to organize information into an accessible form so that regularities, recurring patterns, and causal flows could be noted.

Summary

The study was conducted at Ferris State University during the winter quarter of the 1987-88 academic year. The study sample comprised 102 nonscience-major students and 81 science-major students.

Quantitative methods were used to assess differences in attitudes toward science between nonscience-major students and science-major students, the effects of instruction on attitudes toward science, and the relationship of attitudes toward science to achievement. The Attitudes Toward Science Inventory, a Likert-type instrument, was administered to both groups of students as a pretest and as a posttest. In addition, the final course grade served as a posttest measure for the nonscience-major students. Data were analyzed by multivariate and univariate statistics using the alpha level of .05.

A random sample of 25 nonscience-major students was interviewed to investigate the developmental experiences that are associated with attitudes toward science. The interview was prestructured and followed a standardized format. Three interviewers conducted the interview process. The interview questionnaire, which was developed by the researcher, was composed of a combination of closed and open-ended questions. Qualitative methods of analysis were used to assess the students' responses to the questionnaire.

CHAPTER IV

FINDINGS

The study investigated the attitudes toward science of college students at Ferris State University. The following three areas were evaluated by quantitative methods: (a) differences in attitudes toward science between nonscience-major students and science-major students, (b) the effects of instruction on attitudes toward science, and (c) the relationship of attitudes toward science to achievement. In addition, a qualitative form of inquiry was used to investigate the area of attitude development as it relates to attitudes toward science. The methodology and criteria for evaluation were presented in the previous chapter.

Data-Collection Results

The Attitudes Toward Science Inventory (ATSI) was administered to a total of 102 nonscience-major students and 81 science-major students. However, five nonscience-major students and five science-major students took only the ATSI pretest, and one nonscience-major student took only the ATSI posttest. In addition, two nonscience-major students failed to respond to two items on the ATSI posttest, and one science-major student failed to respond to one item on the ATSI posttest. This presented the problem of throwing out all the collected data on the affected students or introducing estimated scores for the missing data.

According to Tabachnik and Fidell (1983), inserting well-educated guesses into a large data set with few values missing will not distort a multivariate solution. A procedure recommended by Tabachnick and Fidell was used to estimate the missing scores of the three students who failed to respond to the single items on the ATSI posttest. For each missing score, a mean was calculated from the available data from the other seven items in each affected scale. These means were inserted into the students' records to substitute for the missing scores.

Since the missing data treatment could not be applied to entire sets of scores, the incomplete data from the 11 students who completed the pretest or posttest only were eliminated from the evaluation. Consequently, the quantitative analysis of the ATSI was based on responses from 96 nonscience-major students and 76 science-major students.

Validity and Reliability

Validity

Construct validity was determined in the form of nonspurious item-to-scale correlations. The files of the nonscience-major students (n = 96) and science-major students (n = 76) were merged, and validity coefficients were determined for the posttest scores of the combined group. A comparison of the validity coefficients of Swartz (1982) with the study group demonstrated similarity for 47 of the 48 items on the ATSI (Table 4.1).

The mean correlations for the six individual scales of the ATSI were positive and ranged in magnitude from .46 to .64 for the study group. According to Gable (1986), good affective measures have average inter-item correlations in the .30 to .40 range. The lowest average correlation for any of the six scales on the ATSI was .46, which is above the acceptable range. Therefore, all of the average correlations were quite high and were supportive of internal consistency within each set of items.

For affective scales, the acceptable range for individual item correlations is .30 to .50 (Gable, 1986). Examination of the 48 items on the ATSI showed 28 items were above the acceptable range, 19 items were within the acceptable range, and one item was below the acceptable

Table 4.1.—Nonspurious item-to-scale correlations for the Attitudes Toward Science Inventory.[a]

Perception of the Science Teacher			Anxiety Toward Science			Value of Science in Society			Self-Concept in Science			Enjoyment of Science			Motivation in Science		
Item	Norm	Study	Item	Norm	Study	Item	Norm	Study	Item	Norm	Study	Item	Norm	Study	Item	Norm	Study
31	.67	.48	7	.62	.61	1	.45	.49	4	.71	.54	26	.76	.81	3	.26	.30
40	.67	.59	11	.65	.72	9	.51	.51	10	.76	.62	28	.72	.31	8	.44	.61
44	.47	.46	20	.62	.72	12	.40	.32	16	.59	.53	29	.60	.62	14	.40	.47
46	.51	.53	25	.78	.46	15	.54	.48	19	.67	.58	45	.66	.53	32	.45	.59
5	.56	.51	34	.66	.55	23	.48	.47	22	.56	.42	2	.63	.60	37	.45	.16
17	.81	.57	36	.65	.70	24	.50	.48	30	.78	.44	6	.65	.63	41	.48	.59
21	.69	.50	39	.61	.64	33	.51	.45	35	.55	.44	13	.57	.52	42	.38	.42
27	.62	.36	43	.83	.68	38	.42	.50	48	.36	.30	18	.54	.74	47	.57	.64
Mean	.66	.50		.69	.64		.47	.46		.62	.48		.64	.60		.43	.47

[a]Norm data—Swartz, 1982.
Study data—Combined nonscience and science posttest scores, Gogolin, 1988.

range (Table 4.2). Only Item 37 on the motivation scale exhibited a correlation below the .30 to .50 range. According to Gable, if a scale has a large enough number of items, the deletion from the scale of an item with a low item-to-scale correlation may not alter the reliability of the scale. The overall coefficient generated by the eight items on the motivation scale for the posttest was .77. With Item 37 deleted, the alpha would be .79. The difference may have minimal effects on the results. However, changes should be made in a scale only if that item contributes to a great variation in scale scores when it is deleted (Gable, 1986).

Table 4.2.--Correlation distribution of items within the six scales of the Attitudes Toward Science Inventory.

Scale	Range[a]		
	<.30	.30-.50	>.50
Perception of the Science Teacher	0	3	5
Anxiety Toward Science	0	1	7
Value of Science in Society	0	7	1
Self-concept in Science	0	4	4
Enjoyment of Science	0	1	7
Motivation in Science	1	3	4
Total	1	19	28

[a]Combined nonscience and science posttest scores.

Reliability

The accepted levels of reliability for an instrument depend on the use of the instrument and what the instrument is attempting to measure. In general, attitudes are not as stable as skills, and therefore, affective measures tend to have lower reliability levels than cognitive measures (Henerson et al., 1978). Although it is typical for good cognitive tests to have alpha reliabilities in the high .80s or low .90s, good affective instruments frequently report reliabilities as low as .70 (Gable, 1986).

Alpha reliability coefficients were determined for both the pretest and posttest scores on the merged files of the nonscience-major students and science-major students. When setting a criterion level at a minimum of .70, the alpha reliability coefficients for the six scales of the ATSI were found to be well above the minimum for each scale in both the pretest and posttest results (Table 4.3).

Table 4.3.--Alpha reliability coefficients for the six scales of the Attitudes Toward Science Inventory.

Scale	Group[a]		
	Norm	Pre-test	Post-test
Perception of the Science Teacher	.88	.73	.79
Anxiety Toward Science	.89	.90	.88
Value of Science in Society	.77	.76	.77
Self-concept in Science	.87	.83	.78
Enjoyment of Science	.88	.88	.85
Motivation in Science	.74	.82	.77

[a]Norm--Swartz, 1982.
Pretest--Combined nonscience and science study pretest scores.
Posttest--Combined nonscience and science study posttest scores.

Further examination of the alpha reliability coefficients revealed a striking similarity across disciplines. When the coefficients of the study posttest were compared with the coefficients of Swartz (1982) and the coefficients of the original instrument developed by Sandman (1973), the three coefficients for each scale paralleled each other in magnitude and rank order (Table 4.4). Anxiety toward science demonstrated the highest level of reliability in each administration of the instrument, with motivation in science showing the lowest. The other four scales were also similar in rank. The instrument appeared to perform consistently across samples and across disciplines.

Table 4.4.--Rank order of alpha reliability coefficients for the six scales of the survey testing instrument.

Scale	Group[a]		
	Sandman	Swartz	Posttest
Teacher	3.5 (.83)	2.5 (.88)	3 (.79)
Anxiety	1 (.86)	1 (.89)	1 (.88)
Value	5 (.77)	5 (.77)	5.5 (.77)
Self-concept	3.5 (.83)	4 (.87)	4 (.78)
Enjoyment	2 (.85)	2.5 (.88)	2 (.85)
Motivation	6 (.76)	6 (.74)	5.5 (.77)

[a]Sandman, 1973.
Swartz, 1982.
Posttest--Combined nonscience and science study posttest scores.

Analysis of Research Questions

The first three of the four research questions were evaluated by quantitative methods. Data were analyzed using the BMDP and SPSSx statistical packages. The fourth research question was analyzed qualitatively.

Differences in Attitudes Toward Science

The first research question was: How do the attitudes toward science of nonscience-major students compare with the attitudes toward science of science-major students?

> Ho 1: There is no difference between the attitudes toward science of nonscience-major students and the attitudes toward science of science-major students.

MANOVA was used to test the hypothesis that the two groups of students differed in their attitudes toward science. Hotelling's T^2 produced a value of 50.32 with an F-value of 8.140. The probability level was highly significant at .000 (Table 4.5). Consequently, there was a significant difference in attitudes toward science between nonscience-major students and science-major students, and the null hypothesis was rejected.

Table 4.5.--Comparison of pretest attitudes toward science of nonscience-major students and science-major students.

Variable	Nonscience		Science		t	Prob.
	Mean	S.D.	Mean	S.D.		
Teacher	23.8	2.82	25.0	2.95	+2.69	.008
Anxiety	17.4	4.22	13.8	3.32	-5.99	.000
Value	24.1	2.76	26.0	3.25	+4.13	.000
Self-concept	21.0	3.83	24.2	2.68	+6.27	.000
Enjoyment	21.5	4.57	25.6	3.43	+6.48	.000
Motivation	19.7	3.84	23.0	3.60	+5.86	.000

Hotelling's T^2 = 50.32
F-value = 8.140, df = 6,165, p = .000

Univariate t-tests were conducted comparing the mean scores of the individual variables between groups. An examination of the t-value for each scale revealed a significant difference between groups for all six variables. The two groups showed the greatest difference in enjoyment of science (6.48), but self-concept in science also showed a very high t-value (6.27). High t-values were also recorded for motivation in science (5.86) and value of science to society (4.13). The two groups differed least in the perception of the science teacher (2.69). Anxiety toward science registered a negative t-value (-5.99) because of reverse scoring for that variable. A low mean score on the anxiety scale indicates a low level of anxiety and a more positive attitude, whereas for the other five attitudinal scales, a high mean score indicates a more positive attitude.

Both groups showed the highest mean scores for value of science to society (nonscience = 24.1, science = 26.0), indicating that for both groups it was the most positive attitude at the outset of the study.

The difference in mean scores between groups was smallest (1.2) for perception of the science teacher (Table 4.6). Both groups registered fairly high mean scores (nonscience = 23.8, science = 25.0), indicating that initially both groups had quite positive feelings about science teachers in general.

Table 4.6.--Differences in mean pretest scores between nonscience-major students and science-major students.

Variable	Nonscience Mean	Science Mean	Difference in Means
Teacher	23.8	25.0	-1.2
Anxiety	17.4	13.8	+3.6
Value	24.1	26.0	-1.9
Self-concept	21.0	24.2	-3.2
Enjoyment	21.5	25.6	-4.1
Motivation	19.7	23.0	-3.3

The greatest difference in mean scores between groups was recorded for enjoyment of science (4.1). Although science-major students scored nearly as high on enjoyment (25.6) as they did on value (26.0), nonscience-major students indicated enjoyment of science at a much lower level (21.5). Similar differences in mean scores between groups were recorded for self-concept in science (3.2) and motivation in science (3.3).

The difference in mean scores between groups for anxiety toward science was 3.6. Although the science-major students recorded relatively low levels of anxiety (13.8), the nonscience-major students reported significantly higher mean scores (17.4), indicating higher anxiety levels when confronted with science-related material.

Effects of Instruction on Attitudes Toward Science

The second research question was: Do attitudes toward science change after exposure to science?

> Ho 2: There is no change in attitudes toward science after taking a science course.

Using MANOVA, the posttest scores of the ATSI for each group were compared with the pretest scores to test the hypothesis that the two sets of scores differed. Follow-up univariate t-tests were conducted on each variable. The data analysis for each group is presented separately in the following paragraphs.

Nonscience-major students. Hotelling's T^2 produced a value of 50.32 with an associated F-value of 8.140. The probability level was highly significant at .000 (Table 4.7). MANOVA demonstrated that there was a significant difference between the two sets of scores for the nonscience-major students. Therefore, the null hypothesis was rejected.

The t-tests revealed highly significant differences between the posttest scores and the pretest scores for each of the six variables on the ATSI (Table 4.7). The highest mean gain was reported for perception of the science teacher (+2.21), showing a very high posttest score of 26.0. Self-concept in science and enjoyment of science demonstrated high mean gains of +1.57 and +1.47, respectively. Value of science in society, the highest

Table 4.7.--Nonscience-major students: posttest and gain ATSI scores.

Variable	Pretest		Posttest		Gain		t	Prob.
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
Teacher	23.8	2.82	26.0	3.51	+2.21	3.62	+5.97	0.000
Anxiety	17.4	4.22	16.3	4.01	-1.14	3.07	-3.62	0.000
Value	24.1	2.76	24.9	3.06	+0.79	2.93	+2.65	0.010
Self-concept	21.0	3.82	22.6	3.58	+1.57	3.06	+5.04	0.000
Enjoyment	21.5	4.57	23.0	4.30	+1.47	3.09	+4.66	0.000
Motivation	19.7	3.84	20.4	3.34	+0.78	2.86	+2.68	0.009

Hotelling's T^2 = 48.30.

F-value = 7.626, df = 6,90, p-value = 0.000.

reported score for the pretest with 24.1, revealed a gain (+0.79) and was the second highest score recorded for the posttest (24.9). The lowest mean gain (+0.78) was reported for motivation in science. Anxiety in science showed a mean decline (-1.14), decreasing mean anxiety scores from the pretest level of 17.4 to a posttest level of 16.3.

The nonscience students ranked the variables in similar fashion from pretest to posttest. The only exception was perception of the science teacher, which was assigned the highest score on the posttest, raising it above the value of science in society, which had ranked highest on the pretest.

The test results indicated a significant decrease in anxiety levels and a significant increase in the other five attitudinal dimensions on the ATSI for the nonscience-major students after taking a science course. The scores indicated that from pretest to posttest, the students improved in their perceptions of science teachers, gained confidence in science, enjoyed science to a greater extent, valued science more, and had a greater desire to participate in science-related activities.

<u>Science-major students</u>. A significant difference between the pretest and posttest scores for the science majors was demonstrated at the .05 level. Therefore, the null hypothesis was rejected. A value of 16.14 was

generated by Hotelling's T^2 with an associated F-value of 2.51. The probability level was 0.029 (Table 4.8).

The t-tests showed highly significant differences between the posttest scores and pretest scores for four of the six variables on the ATSI (Table 4.8). A lower significant difference was shown for one variable, and a nonsignificant difference was shown for one variable. Five of the six variables reported negative t-values, and one variable reported a positive t-value, indicating a decline in the mean of five of the scores from pretest to posttest and one increase in mean score.

The largest decrease in mean score was shown for motivation in science (-1.18). Significant decreases were also reported for enjoyment of science (-0.91) and self-concept in science (-0.79). A lower decrease in mean score was shown for perception of the science teacher (-0.21). Value of science in society showed a slight decrease in mean score (-0.12). An increase in mean score was reported for anxiety toward science (+0.79).

The rank order of the variable stayed fairly constant from pretest to posttest. The exception was perception of the science teacher. Although it showed a decline, it was relatively small, which gave it the second highest score by the science-major students on the posttest and moved it ahead of enjoyment of science.

Table 4.8.--Science-major students: posttest and gain ATSI scores.

Variable	Pretest		Posttest		Gain		t	Prob.
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
Teacher	25.0	2.95	24.8	2.45	-0.21	2.28	-0.80	0.424
Anxiety	13.8	3.32	14.6	3.15	+0.79	2.49	+2.76	0.007
Value	26.0	3.25	25.9	3.02	-0.12	2.48	-0.42	0.678
Self-concept	24.2	2.68	23.4	3.02	-0.79	2.18	-3.16	0.002
Enjoyment	25.6	3.43	24.7	3.83	-0.91	2.43	-3.26	0.002
Motivation	23.0	3.60	21.8	3.87	-1.18	2.28	-4.53	0.000

Hotelling's T^2 = 16.14.

F-value = 2.51, df = 6,70, p-value = 0.029.

The results of the tests indicated a significant decrease in attitude among the science-major students toward the three variables of self-concept, enjoyment, and motivation and a significant increase in the levels of anxiety toward science. A small decrease in the perception of the science teacher was also indicated. The decrease in value of science in society was minor and nonsignificant.

Relationship of Attitudes Toward Science to Achievement

The third research question was: How closely is attitude toward science related to achievement?

> Ho 3: Attitude toward science is not related to achievement in a science course.

The hypothesis was tested by using t-tests to determine if the correlations between the final grade received in Biology 105 and the pretest scores of the nonscience-major students for the six variables on the ATSI were significantly different from zero (Table 4.9). Of the six variables, value of science in society and self-concept in science were significant at the .05 level. Therefore, the null hypothesis was rejected. Perception of the teacher, anxiety toward science, enjoyment of science, and motivation of science all produced values greater or less than the respective critical t-value of +1.985.

]Table 4.9.--Relationship of ATSI scores to final grade for nonscience-major students.

Variable	Correlation With Grade	t	Significance
Teacher	+.074	+0.72	$p > .05$
Anxiety	-.156	-1.53	$p > .05$
Value	+.225	+2.24	$p < .05$
Self-concept	+.207	+2.05	$p < .05$
Enjoyment	+.132	+1.29	$p > .05$
Motivation	+.053	+0.52	$p > .05$

Critical $t_{.05} = \pm 1.985$.

When using the six variables in a multiple-regression process as rival predictors to predict the final course grade, only value of science in society made a significant contribution (Table 4.10). Although value of science and self-concept in science were both significantly correlated with final course grade at the .05 level, the first and only variable entered into the stepwise regression program was value of science, where $r = .225$. Originally, self-concept in science was correlated with final grade, where $r = .207$. However, after value of science was processed, the residual correlation of self-concept in science to final grade was .137. That correlation produced a t-value of +1.34, which was not significant at the .05 level. Consequently, self-concept in science was not entered, and the regression was stopped after the first step.

Table 4.10.--Stepwise multiple regression for prediction of grades of nonscience-major students from ATSI pretest scores.

Step No.	Variable Entered	Multiple R	Multiple R^2	Increase in R^2	F to Enter
1	Value	.2251	.0507	.0507	5.016

Attitude Determinants

The fourth research question was: What developmental experiences are associated with attitudes toward science?

For this segment of the study, a random selection of 25 students was interviewed to investigate attitude determinants as they relate to science. Because this researcher's intention was to focus on the attitudes toward science of nonscience-major students, the interview group was taken from Biology 105. Of the 25 students interviewed, 13 were male and 12 were female. The average age of the students in the group was 21.

A conceptual model was developed to aid in the design and give focus to the study. Both exogenous and endogenous variables were investigated. Since most research on attitudes toward science has investigated primarily endogenous variables (Schibeci, 1983), particular attention was directed toward the exogenous variables of self, home, and peers. An aim of the study was to examine the interaction of school and nonschool variables. The four specific areas of investigation were home environment, school environment, peer relationships, and self.

The survey instrument used during the interview procedure was a questionnaire developed by the researcher (Appendix C). The questionnaire followed a standardized format and used a combination of closed and open-ended questions. Three interviewers conducted the interview process. Ten students were interviewed by the first interviewer, nine students were interviewed by the second interviewer, and six students were interviewed by the third interviewer. The individual interviews were conducted in private faculty offices.

Family environment. The 25 students interviewed reported the occupations of their fathers to be as follows:[1] Agriculture (1), Construction (3), Executive and Managerial (2), Management Support (2), Marketing and Sales (5), Mechanics and Repair (2), Production (3), Service (3), Teaching (1), Technical (1), and Transportation (1). The father of one student had been deceased since the student's infancy.

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[1]The occupational categories were taken from the Occupational Outlook Handbook (U.S. Department of Labor, 1986). A breakdown of the individual occupations for both fathers and mothers appears in Appendix D.

The mothers of 12 of the students had been employed while the students were growing up. Their occupations were in the following areas: Administrative Support (5), Executive and Managerial (1), Marketing and Sales (1), Production (3), Service (1), and Teaching (1). The number of mothers employed increased over the years, and 19 students reported that their mothers were presently employed.

The average family unit of those students interviewed consisted of five members. The majority of the students seemed to come from happy, cohesive families. All 25 of the students reported they were members of happy families, and 21 students said they spent either a great amount or quite a lot of time together as a family.

When asked whether the family watched the Public Broadcasting System (PBS) television channel, only one student of the 25 replied that the family watched PBS often. Six students said they watched PBS occasionally, and 18 replied they watched PBS rarely or never. When questioned about the frequency of viewing science programs on television, 3 students said their families watched science programs quite often, 10 students replied they watched them occasionally, and 12 students said they watched them rarely or never. The results were similar when students were asked whether the family attended such things as science fairs or science museums. Two students said they attended quite often, 9 students said they attended occasionally, and 14 said they attended rarely or never.

Fourteen students could think of things in their home environment that they thought influenced how they felt about science. Those things most frequently cited were pets, plants, gardens, living on a farm, and living in a wooded setting. One student thought an early interest in reading had had a positive effect on how she felt about science. Another student said his mother was interested in education, and he believed that had influenced his feelings about science. A negative influence was cited by a girl who said that her brother had had a chemistry set, but she had not been permitted to play with it.

There was an apparent interest on the part of all the parents in their children's education, and their expectations were relatively high. Nine students said their parents expected them to excel in school, and 16 students said their parents expected them to do as well as they could.

Although the students appeared to have been raised in close family units, the preceding results suggest that there was little in the family environment to stimulate an early interest in science. Only one family watched educational television with any regularity, and just three families watched science programs on more than an occasional basis. The only science programs cited by the students who watched such programs were outdoor wildlife programs. Family outings seldom included science-related activities, and most of the science influences in their family life that students could think of were environmental influences.

This seeming lack of family interest in science may be linked to the occupation of the parents. No parent, either father or mother, was employed in a science-related occupation during the students' developmental years. This may indicate a parental lack of interest in science that was unwittingly passed on to their children.

School environment. Eleven of the 25 students interviewed had attended a large elementary school (more than 600 pupils), eight students had attended a medium-sized elementary school (between 200 and 600 pupils), and six students had attended a small elementary school (fewer than 200 pupils).

The students indicated that there was very little hands-on inquiry in their elementary science classes. Only four students reported that they often did science experiments, 11 students said they occasionally did science experiments, and 10 students replied that they seldom or never did science experiments.

When asked whether they had enjoyed science in elementary school, 22 responded that they had; one student commented that "it didn't seem like science then." The response was less positive when students were asked whether they thought they were learning important things in science classes in elementary school. Fifteen students said they did, six students replied they did not, and four students either did not know or could not remember.

For their high school education, ten students had attended a Class A high school (more than 1,150 students), five students had attended a Class B high school (1,149 to 587 students), nine students had attended a Class C high school (586 to 311 students), and one student had attended a Class D high school (fewer than 310 students). All except one high school were equipped with science laboratories.

When listing science classes taken in high school, 9 of the 25 students had taken a basic science class, 21 had taken a biology class, and 12 students had taken chemistry. Only three students had taken physics. A number of other courses, such as energy, geology, and astronomy, were listed by individual students. One student said, "I only took conservation. I didn't think much of the science was important." Another student commented that he had tried to take chemistry, but it had been full so he had had to take some other class. He said that he just never got back to science after that.

As indicated by the students' responses on the ATSI, most of the students interviewed had quite good feelings about their science teachers. Twenty-three of the 25 students thought their science teachers had been knowledgeable.

When asked whether they had been encouraged or discouraged by their science teachers, 17 students responded that they had been encouraged, 4 students said they had been discouraged, and 4 students were undecided. Although many students said they thought they had been encouraged by their teachers to do their best, others cited a subtle, rather than an overt, form of discouragement. One student said, "He let better people excel--maybe that held me back." "He concentrated on the better students," was another student's comment, and a third student noted, "I can't remember encouragement. I wasn't sure whether I was doing good or not. There was no reinforcement, and I guess I need that."

When questioned whether they remembered their science teachers with positive or negative feelings, no one reported entirely negative feelings. Nineteen students said they remembered their science teachers with positive feelings, and the other six students said they remembered them with mixed feelings. On the positive side, students cited teacher traits such as enthusiasm and sense of humor and an effort on the teacher's part to "make it fun." One student remembered a teacher in particular with negative feelings because "he gave us the answers instead of letting us find out for ourselves."

The interview results on school environment revealed little difference in science offerings across schools, regardless of size. Even though many students expressed enjoyment of science in elementary school, most of the students had had limited exposure to science. Very few students had had any opportunity to "do" science.

Without some experience in actually doing some of the same kinds of things scientists do, it is difficult to build an understanding of what the scientific enterprise is all about. To add this factor to students who come from a background of low science interest to begin with, it would be unrealistic to expect them to develop an interest in science as a discipline for study. This may have had a bearing on the low enrollment of these students in high school science courses, for fewer than one-half of them had taken more than one year of science in high school.

Teachers may also have influenced the success of these students in science classes. Although the majority of the students thought their teachers had been knowledgeable, teachers may have displayed negative teaching behaviors that discouraged some of the students. This was illustrated by a student who expressed the feeling of being left behind. She said the teacher would keep going when the student did not understand, saying "Everyone else understands, so let's go on." This was echoed by another student who said, "It seems most teachers assume you know things from before, but I don't know what they're talking about." As another student put it, "Teaching methods and teacher attitudes are important in any subject--not just science. But it's doubly important in a class when you don't think you'll do well."

Peer relationships. As a whole, the students interviewed had been social, outgoing individuals. Sixteen of the 25 students thought they had had a lot of friends when they were growing up, and eight students said they had had the average number. Only one student said he had had just a few friends.

Students cited the usual types of recreational activities that they had engaged in during elementary school age--athletics, fishing, sleepovers, and outdoor games. Only four students said they had had access to any science-related materials such as microscopes, chemistry sets, or erector sets, suggesting that little stimulus for science activity was present for most of the students.

When asked whether their friends had liked science in elementary school, 13 students thought they had liked it, 5 students thought they had not, and 7 students were undecided or could not remember. The students responded similarly when asked whether their friends had done well in science class in elementary school. Fourteen said they had done well, two said they had not, and nine were undecided or could not remember.

All 25 students reported their friends had taken some math and science in high school. When asked whether they had taken biology, chemistry, physics, and math classes, most students replied that their friends had just taken biology and some type of a math class. Few said their friends had taken physics. A student who had been active in athletics in high school said, "It seems like athletes took only the necessary classes. The school counselors didn't encourage athletes to take science."

The peer groups were active in extracurricular activities in high school. All 25 students said their friends had participated in athletics, and 16 said their friends had been active in various club activities. Eight students said their friends had been in student government, and three students mentioned National Honor Society.

Twenty of the 25 students said they spent a lot of time with their friends outside of school activities.

Those activities most frequently mentioned as leisure pastimes were movies, sports, hanging out, and cruising. Working was the reason given by those who thought they did not have much contact with friends outside of school.

Thirteen students believed their friends had had an influence on their choice of classes in high school. Several students said that they wanted to be in the same classes, so they would get together to talk over "what and who to take." The remaining 12 students said their friends had had no influence on their choice of classes.

Although those 12 students thought their friends did not influence their choices of classes in high school, the results of the interviews indicated that there may have been more influence than was realized. The science classes that were taken by the peer groups paralleled the science classes taken by the interview group. The close associations of the students with their peer groups may have reinforced behaviors that led to similar choices in science classes.

Self. The overwhelming majority of the students who were interviewed appeared to have very good self-concepts. Twenty-four of the students said they thought they were capable of becoming anything they wanted. Those 24 students also said they thought they had a number of good qualities.

All 25 students said that they did not believe luck was more important in life than hard work. Eighteen students thought they had quite a lot of control over what happens to them. The remaining seven students thought they had at least some control.

The results were somewhat mixed in the area of motivation. Although all 25 students said they believed that they did better when they tried harder, only 9 students said they tried very hard always to do their best. An additional 14 students responded that they tried quite hard, but 2 students said they did not try to do their best.

Twenty-three students stated that they were under a moderate to a great amount of pressure at school. Seventeen of those 23 students thought the pressure came from within because of goals they had set for themselves. Other specific sources of pressure they identified were parents, teachers, peers, and society.

Using their own definition for success, students were asked to judge how successful they were as students. Twenty-four students judged themselves to be moderately to very successful. Those things which they equated with success were achieving what they want to achieve, having a reasonably active social life, involvement in extracurricular activities, and getting good grades.

For 20 of the students, it was very important to get good grades. Another four students said it was somewhat important, but the remaining student said it was not important to get good grades as long as he felt he was learning, and the grade would "get me through the course."

The amount of time the students estimated they spent on homework each week ranged from less than 5 hours to more than 25 hours per week. Two students said they spent fewer than 5 hours, four students estimated 5 to 10 hours, seven students estimated 10 to 15 hours, seven students estimated 15 to 20 hours, one student estimated 20 to 25 hours, and four students estimated they spent more than 25 hours on homework each week.

When asked whether they could think of a peak experience they had had relating to science, 14 students described experiences that had had an influence on them. Two students cited teachers they had had, five students related something they had observed on television or in a museum, and seven students described something they had done.

Of the seven students who cited a specific activity in which they had participated, four had conducted an experiment in a science or psychology class. A fifth student described a wilderness survival trip. The remaining two students had entered projects in the science fair in junior high school. One of these students had entered the competition for two consecutive years, placing second in his first year and winning first place in his second year. When this student was questioned further about why he was no longer interested in science, he said he did not really know. This was the same student who had tried to enroll in chemistry class in high school but had been unable to get in because the class was full.

Students were asked whether they thought they would do well in science if they tried to major in it. Five students replied that they thought they would, 7 students said they would not, and 13 believed it would depend on various factors. Because the students' comments provide much insight into their attitudes toward science as a discipline for study, their individual comments follow.

<u>Would do well</u>:

I would do well because I'm interested in science.
Yes, I would do well because I like it.
I enjoy it when it relates to what I need to know.
I like it. I enjoy science.
I would do well, but I'm not necessarily interested in doing it for a career.

<u>It would depend</u>:

If I was interested. I would do well to get a good job and good pay.
If I was interested and motivated, I would do well.
If I was interested or motivated to do well.
If my interest was in science, I would have the motivation.
If it was my area of interest, I would do well.
If I was interested in it.
If I was interested in it, but I find it a little overwhelming.

If I made a commitment to science as my major, I would do okay.
If it was interesting and the teachers were concerned about an individual's progress.
If the material was well organized and the teacher was knowledgeable.
If the class was structured I would do well, otherwise not.
If I could compete with the same background as the other students, I think I'd do okay [a minority student's comment].
In math I would probably do well, but I'm not crazy about dissecting and stuff.

Would not do well:

Science doesn't make sense. It's hard to remember, hard to recall.
Some science is just too difficult.
Science is not my line of study. It's interesting, but it's so complex.
I'm not made to do science stuff.
When you get into upper levels, science is just too confusing.
I enjoy some of it. But not chemistry--it's too confusing.
Science doesn't come naturally. I would have to work very hard.

The comments reflected the students' personal experiences with science. The five students who said they would do well indicated an enjoyment and interest in science, although one student was uncertain whether it would be a good career choice. The 13 students who believed that they might do well under certain circumstances cited interest and motivation most often as the necessary conditions for success, along with supportive teachers. These students were apparently lacking in any experiences with science that served to either interest them or motivate them to participate in future scientific endeavors. The remaining seven students thought they would not do well in science because they perceived science to be beyond their abilities as students. Some of these students had experienced difficulties in science classes in the past.

The interviews ended by asking the students to describe their feelings about science. All of the students expressed positive feelings to varying degrees. Their individual responses depended on their perception of what was being asked. Some students viewed the question in a global context, citing advancements in medical science, the value of science in addressing environmental and agricultural concerns, and the importance of understanding natural phenomena. Others based their answers on their personal experiences with science in their studies, citing negative as well as positive aspects.

The majority of the students expressed an awareness of the importance of science, but at the same time there appeared to be an underlying frustration on the part of many students with their own inabilities to grasp scientific concepts. One student remarked in exasperation, "I know science is important, but I just don't understand it." That seemed to be a recurring theme expressed by several students, not only in response to this particular question, but in other areas of the interview as well.

Summary

The writer investigated the attitudes toward science of college students at Ferris State University. The four areas of investigation focused on the differences in attitudes toward science between nonscience-major students and science-major students, the effects of instruction on attitudes toward science, the relationship of attitudes toward science to achievement, and attitude development as it relates to science. The data-collection results and the validity and reliability measurement of the survey instrument were reported.

The results of the data analyses revealed that there was a significant difference between nonscience-major students and science-major students in their attitudes toward science, and that the attitudes toward science in both groups changed significantly after taking a science course. It was also found that, for nonscience-major students, attitudes toward science were related to achievement in a science course.

The interview results indicated that although the nonscience-major students had come from diverse socioeconomic backgrounds, they had shared common experiences in their home and school environments that had implications for the development of their attitudes toward science.

A summary and discussion of the analyses are presented in the following chapter. Included are recommendations for teaching science to nonscience-major college students and for future research.

CHAPTER V

SUMMARY AND DISCUSSION

The attitudes toward science of nonscience-major students and science-major students at Ferris State University were investigated using quantitative and qualitative methods of inquiry. Four research questions formed the basis for the investigation. The quantitatively oriented questions dealt with (a) differences in attitudes between nonscience-major students and science-major students, (b) the effects of instruction on attitudes toward science, and (c) the relationship of attitudes to achievement. The qualitatively oriented question dealt with the developmental experiences that are associated with attitudes toward science.

Validity and Reliability

The posttest scores of the nonscience-major students and science-major students were combined, and nonspurious item-to-scale correlations were used to demonstrate the construct validity of the ATSI. The mean correlations for the six individual scales on the ATSI were positive and ranged in magnitude from .46 to .64, above the acceptable average inter-item correlation range of .30 to .40 (Gable, 1986). Therefore, the average correlations of all six scales were supportive of internal consistency within each set of items.

Examination of the 48 items on the ATSI showed 47 of the 48 items had correlations that were within or above the acceptable range of .30 to .50 for individual item correlations (Gable, 1986). A correlation below .30 was exhibited by Item 37 on the motivation scale. Deletion of that item from the scale would not cause a large variation in scale score and would have little effect on the overall reliability coefficient. However, the difference may have minimal effects on the results.

Alpha reliability coefficients were determined for both the pretest scores and the posttest scores on the combined files of the nonscience students and science students. When setting a criterion level at a minimum of .70 (Gable, 1986), the reliability coefficients for the six scales of the ATSI were found to be well above the minimum for each scale in both the pretest and posttest results.

Differences in Attitudes Toward Science

Summary

MANOVA was used to test the hypothesis that nonscience-major students and science-major students differed in their attitudes toward science. Hotelling's

T^2 implied that there was a significant difference between the two groups in their scores on the ATSI, and the null hypothesis was rejected.

Univariate t-tests were conducted to compare the mean scores of the individual variables between groups. Significant differences were found between groups for all six variables. The two groups showed the greatest difference in enjoyment of science. The science-major students recorded much higher levels of enjoyment than nonscience-major students. The variable that showed the least difference between groups was perception of the science teacher. Both groups recorded high mean scores for that variable, which suggested that initially both groups had positive feelings about science teachers in general.

The highest mean score for both groups was shown for value of science in society, which indicated that value was the most positive attitude for both nonscience-major students and science-major students at the onset of the study.

Discussion

The findings of this study supported the literature that was reviewed on the differences in attitudes toward science between nonscience-major students and science-major students. As with the studies that were reviewed

(Clark, 1970; Korth, 1969; Shallis & Hills, 1975; Tilford, 1971), a significant difference was found between the two groups. The science-major students not only demonstrated more positive attitudes toward science, they also showed significantly lower levels of anxiety when confronted with science-related material.

Haladyna et al. (1983) found that student perception of the importance of science was consistently the most significant of the student variables they investigated. The findings of this study were similar in that for both nonscience-major students and science-major students, the highest mean score was reported for value of science in society.

Effects of Instruction on Attitudes Toward Science

Summary

Using MANOVA, the pretest and posttest scores of the ATSI for each group were compared to test the hypothesis that the two sets of scores differed. Univariate t-tests were conducted on the posttest and pretest scores of each variable to determine which variables were significantly affected.

Nonscience-major students. MANOVA demonstrated that there was a significant difference in the two sets of scores for the nonscience-major students; therefore, the null hypothesis was rejected. The t-tests revealed highly significant differences in the two sets of scores for each of the six variables. The five variables of value of science, self-concept in science, enjoyment of science, motivation in science, and perception of the science teacher recorded gains, while anxiety toward science recorded a decrease. The highest mean gain was reported for perception of the science teacher. Motivation in science recorded the smallest mean gain.

Science-major students. Hotelling's T^2 indicated a statistically significant difference between the posttest and pretest scores of the science-major students. Consequently, the null hypothesis was rejected. The t-tests revealed highly significant differences for the four variables of self-concept in science, enjoyment of science, motivation in science, and anxiety toward science. Self-concept, enjoyment, and motivation recorded decreases in mean scores, and anxiety reported a gain. A small decrease was also indicated for perception of the science teacher. Value of science in society reported a nonsignificant decrease.

Discussion

The literature that was reviewed on studies that dealt with attitude change after instruction was mixed. Some studies reported positive changes (Baldwin & Boedeker, 1975; Fellers, 1972; Leavers, 1975; Starring), some reported negative changes (Gardner, 1972; Sadava, 1976), and some reported no changes (Arntson, 1975; Brown, 1967; Fiasca, 1966; Giddings, 1965). The results of this study showed significant changes, but in opposite directions for the two groups. The nonscience-major students improved in their attitudes and decreased their anxiety levels, while the science-major students showed a decline in their attitudes and an increase in their anxiety levels.

Sadava (1976) concluded that courses designed for nonscience students tend to emphasize the negative aspects of applied science, particularly if they are environmental courses. Biology 105, although a course designed for nonscience students, is not environmental, but human in its orientation and filled with applications for daily living. There are no prerequisites for the course, and therefore, if it is taught in the manner intended, nothing is assumed about the students' knowledge base. Since the course is personally relevant, even the least knowledgeable students have an opportunity to achieve success with a topic of interest--themselves. The improved attitudes and lower anxiety levels suggest that nonscience-major students felt comfortable and gained confidence to some degree in this particular science class.

Biology 122 is only one part of a year-long general biology sequence. As students cycle through such a sequence, it is not unusual for them to encounter material that is less stimulating than previous units of study. Biology 122 includes several sections on botany, material that typically is not met with a great deal of enthusiasm by many students. This may explain the decrease in some attitudes and a rise in anxiety levels for the science-major students, for, despite the change, perception of the science teacher and value of science in society remained high.

Therefore, the findings of this research question indicated that attitudes toward science changed after taking a science class, but the direction of change was related to course content.

Relationship of Attitudes Toward Science to Achievement

Summary

The hypothesis to determine whether the correlations between the final grade received in Biology 105 and the pretest scores of the nonscience-major students were significantly different from zero was tested by using t-tests. Value of science and self-concept in science were significant at the .05 level; therefore, the null hypothesis was rejected.

When the six variables were entered into a stepwise multiple-regression process to predict the final course grade, only value of science made a significant contribution. The residual correlations for self-concept and the remaining variables were not statistically significant. Consequently, the regression was stopped after the first step.

Discussion

The meta-analyses of both Willson (1980) and Ligon et al. (1977) found little correlation between attitudes and achievement. In Willson's study, the mean of the correlation coefficients was .11. Ligon et al. concluded that the correlation was small or close to zero. The results of this study tended to support those findings. The mean of the correlation coefficients for the four nonsignificant variables was .10. The mean of the five residual correlation coefficients was .05. Therefore, with the exception of the value attitude, the findings of this study closely paralleled the studies of Willson and Ligon et al.

Attitude Determinants

Summary

A random selection of 25 nonscience-major students was interviewed to investigate attitude determinants as they relate to science. The four areas of home environment, school environment, peer relationships, and self were explored in an effort to examine the interaction of school and nonschool variables in the development of attitudes toward science.

The interview results indicated that the students in the interview group shared common traits and experiences. Although there were social distinctions among students, the majority of the students came from backgrounds of similar low science interest, which had implications for their development relative to science. Their family environments may have affected the students' perceptions of science and limited the opportunities they experienced for science growth as children.

As the students developed social connections with peer groups, they chose groups with values and behaviors that were much like those to which they were accustomed. Although they emerged from their socialization with high self-concepts and an appreciation for education, they had had limited exposure to science and little opportunity for an interest in science to develop.

Since these students had little knowledge of science from nonschool activity, the schools were presented with a formidable task. Although most of the students gained insight into the importance of science and a healthy respect for science teachers during the educational process, many of their experiences in the classroom apparently did not foster an interest in science. Several students related their science experiences to feelings of tedium stemming from what they considered were meaningless memorizations. Others reported negative experiences with teachers, which contributed to feelings of anxiety and confusion and affected their ability to understand science.

For these students, there appeared to be an aura and a mystery that surrounded the word "science" and an uneasiness and lack of understanding about the nature of the scientific enterprise. This sentiment was expressed clearly by the student who concluded his interview with the remark, "Sometime I'd like to take a science class just to see that science really is."

Discussion

The interview results lend support to Dapper's (1978) finding that interest is the greatest predictor for attitudes toward science. Although the variables selected for this study were different from those of Dapper, interest in science was an issue that surfaced in each of the four areas of investigation. With a low initial family interest in science, it appeared to become increasingly difficult to generate an interest as the students matured in their peer relationships and school experiences.

Haladyna et al. (1982) concluded that positive attitudes toward science were related to the student's perception of self and the ability to learn, and the student's perception of overall teacher quality. This was supported somewhat by the student responses. Seven of the students clearly indicated that they would not do well in science because they did not have the ability to succeed in science. For many of those students, however, this was linked not so much to their perception of teacher quality, but to teacher behaviors.

Of the three variables of self, family, and classroom environment that were studied by Talton and Simpson (1986), it was concluded that classroom environment had the strongest relationship to attitudes toward science. The interview results suggested that the teacher played an important role in attitude formation through various teaching behaviors. Other school variables such as school counselors and class scheduling also influenced attitudes, but the home environment and peer relationships had a strong effect on that development as well.

It appears there is an interaction of both endogenous and exogenous variables that determine attitudes toward science. Early science interest could be an important indicator of positive attitudes toward science. By strengthening family commitment to science and enhancing the opportunities for science interest to develop as children, the school would have greater success in nurturing that interest through involvement in science-related activities in the classroom.

Recommendations for Teaching Strategies and Research

When considering teaching strategies, the effectiveness or appropriateness of teaching approaches differs significantly, depending on the context of instruction. The teaching strategies recommended here are intended for postsecondary nonscience students enrolled in science courses.

Affective Versus Achievement Goals

A major consideration in deciding which strategy is most appropriate is to determine the importance of affective goals relative to achievement goals. Strategies that maximize positive attitudes are not necessarily the same strategies that maximize learning. Although little research has been done on affective goals and achievement goals in postsecondary education, research in elementary and secondary education has suggested that attempting to maximize learning beyond a certain point causes students to feel unduly pressured and reduces progress toward affective goals. At the same time, concentrating on maximizing positive attitudes will probably decrease progress toward achievement goals (Brophy, 1980).

If the desired outcome is to increase students' self-confidence in their ability to learn and instill in them an inclination to learn more, it would seem that positive affective goals would be the more important consideration for nonscience-major students enrolled in science courses. It is recommended that future research be conducted on the relative effects of affective goals and achievement goals for nonscience students in science courses.

Teacher Orientation

It is logical to suggest that nonscience students would be more successful with science teachers who are oriented more toward individuals than subject matter. The subject-oriented teacher tends to get the most from students by challenging them to stretch themselves intellectually. These teachers are long on criticism, but short on praise. Research has shown that although they are successful with the more capable students, they tend to alienate other students, who become anxious and discouraged (Brophy, 1980). Anxious students respond well to teachers who get to know them personally and establish themselves as concerned helpers rather than authority figures. These teachers get top performance from students by fostering it gradually through encouragement. As the students' tolerance for challenge increases, the teachers can become more demanding. Nonscience students who are anxious and insecure in a science course would be responsive to such a teaching approach. It would allow them to build their science self-concept by going slowly at first, and then as they gain confidence in their ability to succeed, accelerate their exposure to science.

It is recommended that the effect of variations in teacher orientation on affect and achievement be investigated in future research.

Course Structure

Since nonscience students are low in motivation in science, as indicated on the ATSI, it is recommended that they enroll in a highly structured science course rather than in one that gives the students much of the responsibility for their own learning. Many of them are not motivated sufficiently to sustain a level of concentration that will enable them to identify and understand concepts without clear direction from the teacher.

In a laboratory setting, detailed instructions must be given, and frequent feedback provided so these students know exactly how they are doing. If an adjustment must be made in a procedure, time should be given for reflection and the opportunity to try again. For these students, always getting the right answer should be deemphasized as the main criterion for success.

There is a need for affective measures to be developed that can be included in assessment for grade determination. Major scientific concepts cannot be learned in any significant way by nonscience students during one science course. Once the course is completed, most cognitive learning will be forgotten; yet the general science affect will remain. Any performance evaluation should measure affective outcomes as well as factual recall.

It is recommended that future research explore variations in course structure with attention to the role of affective assessment in grading.

Socialization of the Student

Consideration should be given to facilitate the socialization of the student. The researcher noted that almost every student interviewed became more actively involved in the class shortly after the interview took place. The student appeared to be more at ease in the lecture hall and demonstrated increased initiative in the laboratory. It is suggested that short individual interviews could be a positive agent for both teacher and student.

If qualitative assessment was to be conducted part way into a course so it could be documented when positive attitude change occurred, an agenda for instructional improvement could be developed. Instructional strategies could be targeted to accelerate at this point, which would result in greater success with both affective and achievement outcomes.

Further inquiry into socialization strategies and attendant attitude change is recommended.

Conclusion

The findings of this study indicated that there was a significant difference between nonscience students and science students in their attitudes toward science. This suggests that the "gap between the two cultures" that Snow (1964) alluded to is still very much present in our society.

The findings also indicated that attitudes toward science changed with exposure to science, but the direction of change was related to the quality of that exposure.

It was further concluded that attitudes toward science, as researched in this study, did not play a major role in achievement in a science course. Although there was a positive correlation between all of the attitudes and achievement, with the exception of value of science, the contribution of each variable was not significant.

Although only tentative conclusions could be drawn from the findings of the interviews, the overall pattern of responses suggested that attitudes toward science were formed by interactions of both endogenous and exogenous variables. Educational research in the past has focused on the classroom and has established a strong relationship between attitude formation and classroom environment. The interview results indicated that family environment and peer relationships may also play an important role in their development. Further research is needed to evaluate this interpretation.

APPENDICES

APPENDIX A

CONSENT FORMS

CONSENT FORM
ATTITUDES TOWARD SCIENCE INVENTORY

Explanation of Research

This survey is being conducted as part of a doctoral study to investigate the attitudes toward science of college students at Ferris State College. The purpose of this segment of the study is to determine whether there are significant differences in attitudes between science-major students and nonscience-major students and to determine whether these attitudes are related to achievement in a science course.

You will be asked to read 48 statements relating to science, decide how you feel about the statements, and record your responses on a machine-graded answer sheet. The survey should take you about 20 minutes to complete.

You will be free to withdraw your participation from the study at any time without recrimination. Your grade will not be affected by your decision.

Consent to Participate:

I have been informed that this study is being conducted to investigate the attitudes toward science of college students. The purposes and procedures of the study have been explained to me, and I voluntarily agree to participate in the research.

I understand that I am free to withdraw my participation at any time without recrimination.

I understand all information will remain completely anonymous, and that the results of the study will be available to me upon request.

Name (please print) ____________________
Signature ____________________
Date ____________________

CONSENT FORM
STUDENT INTERVIEWS

Explanation of Research:

These interviews are being conducted as part of a doctoral study to investigate the attitudes toward science of college students at Ferris State College. The purpose of this segment of the study is to investigate various factors relating to the development of attitudes toward science.

An interviewer will ask you a series of questions relating to your feelings about yourself, family, friends, and school environment. Your answers will be recorded on a standard form by the interviewer. The interview will last about 30 to 35 minutes.

You will be free to withdraw your participation from the interview at any time without recrimination. Your grade will not be affected by your decision.

Consent to Participate:

I have been informed that this study is being conducted to investigate the attitudes toward science of college students. The purposes and procedures of the study have been explained to me, and I voluntarily agree to participate in the research.

I understand that I am free to withdraw my participation at any time without recrimination.

I understand all information will remain completely anonymous and that the results of the study will be available to me upon request.

Name (please print) ____________________
Signature ____________________
Date ____________________

APPENDIX B

ATTITUDES TOWARD SCIENCE INVENTORY

ATTITUDES TOWARD SCIENCE INVENTORY

Directions

The following statements are about the study of science. Please read each statement carefully and decide whether it describes the way _you_ feel about science. Then, find the number of the statement on the answer sheet, and blacken one of the spaces according to the following directions.

If you _strongly agree_ with the statement, blacken space _1_.
If you _agree_ with the statement, blacken space _2_.
If you _disagree_ with the statement, blacken space _3_.
If you _strongly disagree_ with the statement, blacken space _4_.

Be sure to blacken only _one_ space for each statement. Mark your answers _only_ on the answer sheet. Please do not write on this sheet.

Be sure to answer every question. You will have about 20 minutes to complete the 48 statements of the inventory. Remember to answer each statement according to the way _you_ feel at the present time.

1. Science is useful for the problems of everyday life.

2. Science is something which I enjoy very much.

3. I like the easy science assignments best.

4. I don't do very well in science.

5. Science teachers show little interest in the students.

6. Doing science labs are fun.

7. I feel at ease in a science class.

8. I would like to do some outside reading in science.

9. There is little need for science in most jobs.

10. Science is easy for me.

11. When I hear the word science, I have a feeling of dislike.

12. Most people should study some science.

13. I would like to spend less time in school studying science.

14. Sometimes I read ahead in our science book.

15. Science is helpful in understanding today's world.

16. I usually understand what we are talking about in science class.

17. Science teachers make science interesting.

18. I don't like anything about science.

19. No matter how hard I try, I cannot understand science.

20. I feel tense when someone talks to me about science.

21. Science teachers present material in a clear way.

22. I often think, "I can't do it," when a science assignment seems hard.

23. Science is of great importance to a country's development.

24. It is important to know science in order to get a good job.

25. It doesn't disturb me to do science assignments.

26. I would like a job which doesn't use any science.

27. Science teachers know when we are having trouble with our assignments.

28. I enjoy talking to other people about science.

29. I would enjoy watching a science program on television.

30. I am good at working science labs.

31. Science teachers don't seem to enjoy teaching science.

32. I like the challenge of science assignments.

33. You can get along perfectly well in everyday life without science.

34. Working with science upsets me.

35. I remember most of the things I learn in science class.

36. It makes me nervous to even think about doing science.

37. I would rather be told scientific facts than find them out from experiments.

38. Most of the ideas in science aren't very useful.

39. It scares me to have to take a science class.

40. Science teachers are wiling to give us individual help.

41. The only reason I'm taking science is because I have to.

42. It is important to me to understand the work I do in a science class.

43. I have a good feeling toward science.

44. Science teachers know a lot about science.

45. Science is one of my favorite subjects.

46. Science teachers don't like students to ask questions.

47. I have a real desire to learn science.

48. If I don't see how to do a science assignment right away, I never get it.

APPENDIX C

INTERVIEW QUESTIONNAIRE

INTERVIEW QUESTIONNAIRE

Student No.____________ Gender________ Age___________

Family Environment:

1. What is your father's occupation?_____________________

2. Did your mother work outside the home when you were growing up?

   Yes___ No___ Occupation_______________________

3. Is she employed now?

   Yes___ No___ Occupation_______________________

4. How many brothers and sisters do you have?

   Brothers____ Sisters____

5. Does your family watch PBS?

   Quite a lot Occasionally Rarely Never

6. Does your family watch science programs when they are on TV?

   Quite a lot Occasionally Rarely Never

7. How much time did you spend together as a family when you were growing up?

   A great amount   Quite a lot   Occasionally   Seldom

8. Did your family attend things such as science fairs or science museums when you were growing up?

   Quite often   Occasionally   Rarely   Never

9. Would you say that you are a member of a happy family?

   Yes   No

10. Do your parents expect you to do well in school?

    Expect me to excel ____
    Do as well as I can ____
    Never say anything ____

11. Can you think of anything in your home environment that has influenced how you feel about science?

<u>School Environment</u>:

1. How large was your elementary school?

   Small (less than 200) ____
   Medium (200-600) ____
   Large (over 600) ____

2. Did you do science experiments in elementary school?

   Often Occasionally Seldom Never

3. Did you enjoy science class when you were in elementary school?

   Yes No

4. Did you think you were learning important things in science class in elementary school?

   Yes No

5. How large was your high school?

Class A	Class B	Class C	Class D
(over 1,150)	(1,149-587)	(586-311)	(less than 310)

6. Were there science laboratories in your high school?

    Yes No

7. What science classes did you take in high school?

    List those taken:

8. Do you feel the science teachers you've had have been knowledgeable?

    Yes No

9. Did they (science teachers) encourage you in science, or did they discourage you or make you feel inadequate in any way?

    Encouraged Discouraged

10. Do you remember your science teachers with positive or negative feelings?

    Positive Negative

Peers

1. Did you feel you had a lot of friends when you were growing up?

    Many   Average number   Just a few

2. What did you and your friends do for fun (elementary school age)? (erector set, chemistry set, microscope set, etc.?)

3. Did your friends like science?

    Yes   No

4. Did they do well in science class?

    Yes   No

5. In high school, did your friends take biology, chemistry, math, and physics classes?

    Yes   No

6. In high school, in what extracurricular activities did your best friends participate?

7. In high school, did you spend much time with your friends outside of school activities?

Yes No

8. In high school, how did you and your friends spend your leisure?

9. Do you feel your friends had any influence on your choices of classes in high school?

Self:

1. Do you think luck is more important in life than hard work?

Yes No

2. How much control do you feel you have over what happens to you?

   Quite a lot   Some   Very little   None

3. Do you feel you do better when you try harder?

   Yes   No

4. How hard do you try to always do your best?

   Very hard   Quite hard   Not very hard

5. Do you think you are capable of becoming anything you want?

   Yes   No

6. Do you feel you have a number of good qualities?

   Yes   No

7. How much pressure do you feel you are under at school?

A lot   A moderate amount   Very little   None

8. How successful do you feel you are as a student? (Student is free to define successful.)

Very   Moderately   Not very   Not at all

9. How important is it for you to get good grades?

Very   Somewhat   Not very   Not at all

10. How much time would you estimate you spend on homework each week?

11. Can you think of a peak experience you have had relating to science? Describe.

12. **Would you do well in science if you tried to major** in **it? Why did you answer as you did?**

13. **What are your feelings about science (good, bad)?** Why **do you think you feel that way?**

FATHER'S OCCUPATION

<u>Transportation</u>
Truck driver

<u>Service</u>
Correctional officer
Custodian
Fireman

<u>Mechanics and Repair</u>
Mechanic (2)

<u>Production</u>
Factory foreman
Factory line worker (2)

<u>Agriculture</u>
Farmer

<u>Executive and Managerial</u>
Executive (2)

<u>Construction</u>
Plumber
Carpenter
Subsurface contractor

<u>Management Support</u>
Highway inspector
Auditor

<u>Marketing and Sales</u>
Purchasing agent
Salesman (2)
Merchant (2)

<u>Teaching</u>
Teacher

<u>Technical</u>
Computer programmer

MOTHER'S OCCUPATION (when student was growing up)

<u>Administrative Support</u>
Teacher's aide
Secretary (2)
Data entry
Bookkeeper

<u>Teaching</u>
Teacher

<u>Production</u>
Factory line worker

<u>Service</u>
Cook

<u>Executive and Managerial</u>
Elementary principal

<u>Marketing and Sales</u>
Retail clerk

MOTHER'S OCCUPATION (present)

Administrative Support
- Bank loan clerk
- Secretary
- Shipping/receiving clerk

Teaching
- Teacher (2)

Production
- Factory line worker (4)

Health Technology
- Practical nurse

Service
- Waitress

Executive and Managerial
- Elementary principal
- Financial firm (vice-president)

Marketing and Sales
- Retail clerk (4)

Technical
- Computer programmer (2)

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