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DEVELOPMENT OF AN INSTRUMENT TO MEASURE
ATTITUDES TOWARD SCIENCE AND
THE SCIENTIST

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

by

John Roswell Cummings, A.B., M.S.

** ** ** **

The Ohio State University

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CHAPTER I

INTRODUCTION

Justification of the Study and Statement of the Problem

The objective, to develop positive attitudes toward science and scientists, may be found in nearly every list of the most important objectives of science teaching. However, investigations dealing with attitudes toward science and scientists have provided science educators with very little information concerning the effective means of promoting such development. If the development of attitudes is an important objective of science instruction, then investigations must be conducted to develop or identify programs which will effectively promote this objective.

In our ever increasingly scientific and technical world, there is an increasing demand for scientists, engineers and technologists. Studies such as Mead's indicate that there is a relationship between students' attitudes toward science and scientists and their desire to enter science connected occupations.1 If our schools and colleges

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are going to provide the manpower needs for our evolving society, then science educators must promote the development of positive attitudes toward science and scientists. Furthermore, many science educators believe that satisfactory attitudes toward science and scientists are necessary to become a competent citizen in our highly scientific and technical age. In view of the continuing pollution of our environment, it is necessary to develop proper attitudes toward science to insure survival of the human race.  

If teachers' attitudes toward science and scientists are significantly related to the development of students' attitudes toward science and scientists, then it is imperative that research be conducted to identify or develop science teacher education programs which are effective in this development. Before much progress can be accomplished in the development of these programs, reliable and valid instruments with discriminatory power over a wide range of experimental populations must be developed.

Because of the need for reliable and valid instruments to measure attitudes toward science and scientists, the investigator attempted to develop such an instrument.

**Purpose**

The purpose of this study was to develop a reliable

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and valid instrument to measure the attitudes toward science and scientists of students enrolled in elementary science methods courses.

Hypothesis

An instrument can be developed which will provide reliable and valid measurement of the attitudes toward science and scientists of students enrolled in elementary science methods courses.

Definition of Terms

attitude—a relatively enduring system of evaluative, affective reactions based upon and reflecting the evaluative concepts or beliefs which have been learned about the characteristics of a social object or class of social objects.3

science—(1) activity carried on as an effort to make the diversity of our sense experiences correspond to a logically uniform system of thought; in this activity experiences are correlated with a previously constructed theoretic structure of thought and understanding in an effort to make the resulting coordination in agreement with all observed properties or behavior; (2) in the personal experience of an individual, science is an activity by means of which the person seeks to relate current sense experiences to his total structure of understanding in a manner that is in agreement with all his pertinent observations of properties and behavior; such activity is believed to be inherent in the behavior of individuals at all levels of maturity; the individual gains, through practice, in his ability to correlate his current experience with his previously conceived structure of understanding, however, naive or sophisticated that structure may be.4


scientific attitude—a set of emotionally toned ideas about science, scientists, and scientific methods and related directly or indirectly to a course of action.  

item analysis—(1) a method used in test validation or improvement to determine how well a given question or item discriminates among individuals of different degrees of ability or among individuals differing in some other characteristics; (2) the act or process of determining any systematic information such as discrimination, difficulty, etc., about a test item.

factor analysis—a statistical technique based on intercorrelating all the items with one another, which enables one to abstract one or more factors that the items, or some of them, have in common.

reliability—the accuracy with which a measuring device measures something; the degree to which a test or other instrument of evaluation measures stability or consistently, whatever, it does in fact measure.

split-half reliability—a method of estimating the reliability of a test or other variables by splitting it into comparable halves (usually the odd-number items and the even-numbered items) correlating the scores of the two halves, and applying the Spearman-Brown prophecy formula to estimate the correlation between the entire test and a comparable alternate form.

validity—the extent to which a test or other measuring instrument fulfills the purpose for which it is used.

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5Ibid., p. 48.

6Ibid., p. 28.


9Ibid., p. 518.

10Ibid., p. 593.
construct—postulated attribute of people, assumed to be reflected in test performance.11

construct validity—a type of validity which is evaluated by a determination of the relationships between the attitude score and other specified variables. Theoretical notions about the attitude lead to the postulation of various kinds and degrees of relationships between the attitude and other specified variables. If our definition of the underlying attitude leads to the expectation that two or more groups should hold different attitudes toward a given object, it follows that a valid scale to measure the attitude in question should yield different scores for these groups.12

scientist—an expert in science, especially one of the physical or natural sciences.13

elementary science methods courses—courses designed to teach the pre-professional elementary teacher how to teach science in the elementary school.

the instrument—attitude measuring device or scale to be developed in the study.

Assumptions

The assumptions of this study are as follows:

1. An adequate sampling of items necessary to measure attitudes toward science and scientists reliably and validly can be obtained from the literature.

2. Two samples of sixty-five subjects each are large


12Shaw and Wright, Scales for the Measurement of Attitudes, p. 19.

enough to provide sufficient item analysis data for initial item selection.

3. A sample of about two hundred pre-professional university elementary science methods students provides sufficient item analysis data to further refine the scale to produce a reliable and valid instrument.

4. Attitudes toward science and scientists can be reliably and validly measured by an objective-paper-pencil technique.

5. A group of scientists and science educators have highly positive attitudes toward science and scientists.

6. A group of scientists and science educators can identify the most relevant attitude items.

7. Secondary science teachers participating in The Ohio State University National Science Foundation Academic Year Institute have more positive attitudes toward science and scientists than will the sample of pre-professional elementary science teachers.

Limitations and Delimitations

1. The sample for the initial refinement of the scale was limited to 128 elementary science methods students enrolled at The Ohio State University.

2. The sample for the final refinement of the scale was limited to 349 elementary science methods students enrolled at The Ohio State University, University of Houston,
Indiana University, and The University of Texas.

3. The panel of experts was limited to six scientsts and six science educators.

4. The item sample was based on items available in the literature.

5. The study was limited to the development of a reliable and valid measurement of elementary science methods students' attitudes toward science and scientists.

**Overview of the Study**

Permission was sought to use items from several sources as models. Some of the sources are as follows:

1. *Scales for the Measurement of Attitudes*\(^{14}\)
2. *Personal Inventory on Science*\(^ {15}\)
3. *Allen's Inventory*\(^ {16}\)
4. *Dutton's Scale*\(^ {17}\)

\(^{14}\)Mead and Metraux, "Image of the Scientist...", p. 388.

\(^{15}\)Nancy Hamilton, "The Scientific Literacy of Seniors in Urban, Suburban and Rural High Schools in Kentucky" (Ph.D. dissertation, The Ohio State University, 1956), pp. 113-16.

\(^{16}\)Hugh Allen, Jr., *Attitudes of Certain High School Seniors Toward Science and Scientific Careers* (Science Manpower Project Monographs; Columbia University: Bureau of Publications, Teachers College, 1959)

Items obtained from various sources were sorted to eliminate duplicate items. The items were then separated into several categories based on their general content. The items were modified using a thesaurus and careful attention to attitude item criteria. An attempt was made to capture the idea of the original item using different wording and improving the item by close attention to attitude item criteria. Once the new items were prepared, the items were arranged randomly in two scales.

First refinement

The items were administered to two groups each of about sixty-five elementary science methods students enrolled at The Ohio State University.

Item analysis data on the items was obtained using


a program developed by Goode. 21 Using the data from the item analysis, a scale was selected which contained the most highly discriminating items.

In an attempt to develop a valid instrument, a measure of content validity was performed. A rating scale was used to help insure content validity. This scale contained the items selected by item analysis and arranged in several categories based upon attitude content. A jury of twelve scientists and science educators rated the items as highly relevant, somewhat relevant, and irrelevant with respect to the attitude category. Also this group rated the items as unambiguous, fairly clear, or ambiguous and responded strongly agree, agree, neutral, disagree, or strongly disagree. Using the data obtained from this group, irrelevant items were discarded. Using the suggestions of the jury, an attempt was made to remove the ambiguities.

Second refinement

The items remaining after the first refinement were arranged randomly in a scale which was further refined. A sample for the second refinement of the scale was selected.

21 Omar S. Goode, "Item Analysis," Columbus, Ohio: The Ohio State University Center for Human Resources Research 1967. (Mimeographed.)

in consultation with the writer's advisors. Approximately 350 students enrolled in elementary science methods courses at The Ohio State University, The University of Texas, Indiana University and The University of Houston participated in this part of the study.

The scale was subjected a second time to item analysis. Based upon the second item analysis, the scale was further refined to obtain the final scale.

When the final scale was selected, the responses of The Ohio State University National Science Foundation Academic Year Institute participants were compared with the elementary science methods students' responses. Since it was postulated that the group of Academic Year Institute participants possessed more positive attitudes toward science and scientists than the elementary science methods students, this comparison provides a measure of construct validity. The reliability of the final scale was calculated using the Kuder-Richardson scale reliability coefficient by means of the computer program developed by Goode.²³

Summary

Chapter I presented the following topics to introduce the study:

I. Justification of the Study and Statement of the Problem

II. Statement of the Purpose and Hypothesis of the Study

III. Definition of Terms used in the Study

IV. Assumptions, Limitations and Delimitations of the Study

V. Overview of the Study.

In Chapter II the review of related research is presented. Selected research studies are reviewed in the following categories:

I. Studies Concerned with Identifying Components of Scientific Attitudes and Attitudes toward Science

II. Studies Primarily Concerned with Techniques of Attitude Scale Construction

III. Studies Primarily Concerned with Measurement of Attitudes toward Science and Scientific Attitudes at the Various Educational Levels

IV. Studies Primarily Concerned with Measuring the Effectiveness of Various Methods in the Development of Attitudes toward Science and Scientific Attitudes

Chapter III presents the procedures for the study. The procedures are described through discussion of the following aspects of the study:

I. The Item Pool

II. First Refinement of the Scale

III. Attitude Item Rating Scale

IV. Second Refinement of the Scale

V. Construct Validity of the Scale

The results of the study are discussed in Chapter IV.
The organizational structure in which the results are presented is as follows:

I. Results of the First Refinement of the Scale

II. Results from the Attitude Item Rating Scale

III. Results from the Second Refinement of the Scale

IV. Results of the Construct Validity Measure.

The summary, conclusions, and implications of the study are presented in Chapter V.
CHAPTER II

REVIEW OF RELATED RESEARCH

The review of selected research studies related to the measurement and development of attitudes toward science and scientific attitudes will be organized in the following manner:

I. Studies Concerned with Identifying Components of Scientific Attitudes and Attitudes toward Science

II. Studies Primarily Concerned with Techniques of Attitude Scale Construction
   A. Methods of scale construction used in the development of instruments for elementary students
   B. Methods of scale construction used in the development of instruments for junior and senior high students
   C. Methods of scale construction used in the development of instruments for college students

III. Studies Primarily Concerned with Measurement of Attitudes toward Science and Scientific Attitudes at the Various Educational Levels
   A. Measurement of attitudes in elementary schools
   B. Measurement of attitudes in junior and senior high schools
   C. Measurement of attitudes in colleges
   D. Measurement of attitudes of teachers and scientists
   E. Measurement of attitudes of other groups

IV. Studies Primarily Concerned with Measuring the Effectiveness of Various Methods in the Development of Attitudes toward Science and Scientific Attitudes
A. Methods used in the elementary school
B. Methods used in the junior and senior high school
C. Methods of changing attitudes of college students and adults

Studies Concerned with Identifying Components of Scientific Attitudes and Attitudes toward Science

Ebel’s study

A study to determine the components of scientific attitudes was conducted by Ebel. From an original list of 432 suggestions relating to scientific attitudes, he applied five tests based on his definition of a scientific attitude and eliminated twenty suggestions. From the remaining suggestions, he developed a comprehensive statement of the components of scientific attitudes. The major headings in this statement are as follows:

"I. Readiness to be confident that human intelligence can understand the phenomena of nature, and through understanding, can become able to control the forces of life.

"II. Readiness to seek true understanding of the phenomena of nature.

"III. Readiness to seek correctness in work and thinking so that truth may be discovered."¹

Vitrogan’s method.

A method for determining a generalized attitude of

¹Robert L. Ebel, "What is the Scientific Attitude?" Science Education, XXII (February, 1938), 76-9.
high school students toward science was developed by Vitrogon. His criteria for a generalized attitude toward science was developed by reviewing literary contributions to scientific thought by Dewey, Pearson, Johnson, Cohen, Nagel, Russell, Kahn, Schwab and Frank. The characterization of a positive generalized attitude toward science resulting from the literature study is as follows:

(1) a predisposition to discern the degree to which one person or thing differs from another—a tendency to emphasize differences;
(2) a tendency to challenge authority, to list traditional beliefs and customs with actual observation and experience;
(3) a readiness to change as changing conditions require, a multiple and flexible approach to people and things;
(4) an ability to differentiate between controlled and reliable observation as opposed to casual observation;
(5) a basic notion that reality is to be regarded as a process implying continuous change—no two things are exactly alike, no one thing stays the same;
(6) structure in the form of relations and equations will be stressed over function—structure, the nature of the phenomenon, the broad unifying principle is stressed rather than application (detail) or function;
(7) greater concern for research rather than findings, greater emphasis on the inquiring—the questioning rather than the final answers obtained, the form of the question is considered more important than the answer observed;
(8) an emphasis on probability type—explanations rather than absolute solutions.²

Studies Primarily Concerned with Techniques of Attitude Scale Construction

Methods of scale construction used in the development of instruments for elementary students

The following report describes the method used in the development of a scale to measure attitudes toward science of elementary students.

Lowery's projective test. An attempt to measure attitude changes of 335 fifth grade students was made by Lowery. He developed a projective test to measure attitudes toward science, scientific processes and scientists. The Projective Test of Attitudes (PTOA) is an individually administered open-ended testing instrument which contains a word association test, an apperception test and a sentence completion test. Fifteen minutes are required to administer the set of tests to an individual. The author recommends that the three tests be given as a unit because of the cross validation within the three instruments.

The instrument developer concluded that this method of measuring changes in attitudes shows promise and hopes others will explore this approach to attitude testing in science education.  

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Methods of scale construction used in the development of instruments for junior and senior high students

Several reports are given below which describe the attempts by several investigators to develop instruments to measure attitudes toward science and scientific attitudes of junior and senior high school students.

Noll's measurement of scientific attitudes. In a study by Noll concerned with measuring scientific attitudes, scientific attitudes were defined as follows:

1. Habit of accuracy in all operations
2. Habit of intellectual honesty
3. Habit of open-mindedness
4. Habit of suspended judgment
5. Habit of looking for true cause and effect relationship
6. Habit of criticalness.

He designed several types of items to measure the habits listed above. These items were organized into four forms containing 71, 79, 85, and 86 items which were administered to a small junior and senior high school population; then the best items were reassembled into two forms of 112 items each. Using these instruments the investigator concluded the following: "There is clear evidence of a progressive increase in mean scores from eighth grade to twelfth grade with one outstanding exception, the ninth grade mean."

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5 Ibid., p. 151.
Davis' attempt to determine the elements of scientific attitudes. A study which attempted to determine the elements of scientific attitudes was conducted by Davis. A list of characteristics was submitted to 250 well-trained and experienced teachers in all parts of the United States for ranking of importance. He accepted those characteristics ranked highly by at least 80 per cent of the judges. The characteristics selected were the following:

1. Willingness to change opinion on the basis of evidence
2. Search for the whole truth regardless of personal, religious or social prejudice
3. Concept of cause and effect relationships
4. Habit of basing judgment on fact
5. Power or ability to distinguish between fact and theory
6. Freedom from superstitions.

A 66 item test was developed to measure cause and effect relationships and was administered to 295 students in six different high schools. Twenty-five outstanding science teachers served as a jury to determine best answers on the test. Also, a fact theory test was constructed containing 103 items. This instrument was administered to the same 295 students and judged by the same twenty-five teachers.

The investigator drew the following conclusions: (1) The sample of students used in the study were not super-

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stitious. (2) High school students rate almost as well as their teachers with respect to these two instruments. (3) Many teachers and students fail to distinguish clearly between facts and theories. (4) Pupils seem to have a fairly clear concept of cause and effect relationships. (5) Teachers don't teach directly for scientific attitude development.\(^7\)

**Belt's comparison of multiple choice and Likert-type items.** Belt conducted an attitude study comparing the effectiveness of factual multiple choice items with Likert-type items. The experimental sample was composed of 516 college bound seniors from twelve New Jersey high schools. These students were administered a multiple choice test and a Likert-type scale, both including essentially the same content.

Because the correlation coefficient between the two scales was low, the investigator concluded that the two tests did not measure the same attitudes. In addition, he concluded that the multiple-choice type items presented less ambiguous stimuli to the subjects. The study, also, showed that high ability students generally manifested favorable attitudes toward science and scientists.\(^8\)

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\(^7\)Ibid., p. 121

Hoff's test. Hoff prepared a test to measure scientific attitudes. The definition that guided him in the construction of the test was developed by Curtis from suggestions of fifty science teachers. The major headings in the definition are as follows:

"I. Conviction of universal basic cause and effect relations

"II. Sensitive curiosity concerning reasons for happenings, coupled with ideals

"III. Habit of delayed response, holding views tentatively for suitable reflection

"IV. Habit of weighing evidence with respect to its pertinence, soundness, and adequacy

"V. Respect for another's point of view, an open-mindedness and willingness to be convinced by evidence"

Hoff constructed 200 items based upon the definition and discarded fifty based on the judgments of a jury of fifteen experts. The test was administered to 337 twelfth grade pupils in four high schools.

He concluded that the instrument measured something different from scientific aptitude by correlating scores of the attitude test with scores on an aptitude test. In addition, the investigator concluded that ability in comprehension and speed of reading are not related to performance on the scientific attitude test and that students receiving

above average grades in science do not necessarily score high on the attitude test.\footnote{Ibid.; pp. 763-70}

**Methods of scale construction in the development of instruments for college students**

The following studies describe attempts to develop instruments to measure the attitudes toward science of pre-service elementary teachers and lower division undergraduates.

*Dutton's and Stephens' instrument.* An instrument for measuring attitudes toward science of prospective elementary teachers was developed by Dutton and Stephens. They used Thurstone's Method of Equal-Appearing Intervals. The statements for the scale were obtained from 200 prospective elementary school teachers who wrote short statements of their feelings about science. Using attitude item criteria by Wang, Thurstone, Likert, and Edwards, fifty edited statements about elementary science were prepared. The items were sorted into eleven piles, varying from strongly negative to highly positive, by 100 prospective elementary teachers. Scale values and Q values were then calculated. Twenty items were selected for the scale based upon Q values, distribution of scale values, and an equal number of positive and negative statements. These items were placed randomly in the final scale. The
scale also included free response items concerning those aspects of science liked and disliked. The scale was administered to 226 prospective elementary teachers at the University of California. The test and re-test reliability of the scale was 0.93.

The investigator concluded the following from the study: (1) The subjects of the study expressed considerable liking for elementary school science. (2) Thirty-nine per cent of the sample had no real dislike for science but indicated they would not study science independently. (3) Twenty-five per cent were afraid of bugs, worms, snakes and insects. (4) Free response statements by the subjects indicated favorable attitudes toward simple experiments, field trips and opportunities to do creative work.11

Schwirian's scale. Schwirian reported the development of a scale measuring attitudes toward science. The construction of the scale began by selecting a theoretical orientation from Bernard Barber's book, Science and the Social Order. The cultural values selected for a theoretical orientation are as follows: "(1) rationality, (2) utilitarianism, (3) universalism, (4) individualism, and (5) a belief in 'progress' and meliorism."12


Five subscales of twelve items each were constructed on the above five dimensions. These items were submitted to a jury of experts who judged their appropriateness. If the items were unacceptable to the judges, they were either omitted or modified. The scale was administered to a sample of 200 undergraduate students who were primarily non-science majors in lower division at two Mid-western universities. Based upon item analysis forty good items were retained for the final scale. The reliability of the final scale was .873.

The following conclusions were made by the investigator as a result of this study:

(1) that the items are indeed scalable, (2) that the items selected discriminate well..., and (3) that the scales so produced are fairly reliable. Furthermore, when the five, eight-item scales are combined, they produce a very reliable Science Support Scale.\(^{13}\)

Studies Primarily Concerned with Measurement of Attitudes toward Science and Scientific Attitudes at the Various Educational Levels

Measurement of attitudes in elementary schools

Several investigators have attempted to measure scientific attitudes and attitudes toward science of elementary school students. In the following section some of these measurement efforts are described.

\(^{13}\)Ibid., p. 179.
Perrodin's study. Using a projective type instrument, an attempt to measure children's attitudes toward elementary school science was conducted by Perrodin. The instrument contained twenty sentence fragments designed to stimulate students to express their feelings about science. The instrument was administered to 554 pupils enrolled in fourth, sixth, and eighth grades in three Georgia schools.

The results showed that the majority of fourth and sixth grade boys and girls had positive attitudes toward science. In addition, the investigator concluded:

In general it appears that fourth graders have very favorable attitudes toward science—favorable attitudes reach a peak in the sixth grade, and decline somewhat at the eighth grade level.14

Curtis' experiment. In order to determine the values derived from extensive reading in general science, Curtis performed the experiment described below. He attempted to determine the values derived from extensive reading in general science as an extra course, as part of usual required work, and as an addition to regularly required work. A test was designed to measure scientific attitudes and to compare the three experimental groups.

He concluded from the results the following:

1. General science students do not possess scientific attitudes to a very great extent.

2. Extensive reading in general science increases the students' scientific attitude development but not as much as a small amount of class time especially devoted to teaching scientific attitudes.

3. Training in scientific attitudes remains effective for a considerable period of time after the training experience.\textsuperscript{15}

**Brown's science information and attitude test.** An investigation which assessed the science information and science attitudes of elementary and junior high pupils was conducted by Brown. In 1951 a science information and attitude test was prepared and administered to 2,901 pupils in forty-one elementary and secondary schools in the State of California. The instrument contained sections dealing with biological sciences, physical sciences, conservation of natural resources, and consumer education. The science information part of the test had a reliability of .90. Whereas, the science attitude test had a reliability of .73.

\textsuperscript{15}Francis D. Curtis, *Some Values Derived from Extensive Reading in General Science* (Bureau of Publications Contribution No. 163; New York: Teachers College, Columbia University), pp. 2-112.
Based upon the findings of this study, the investigator concluded:

1. Fifth and eighth grade boys scored higher on the science information test than did the girls.

2. There was no significant difference between the boys' and girls' scores on the science attitude test.

3. There were significant differences between fifth and eighth grade pupils on the science information test.

4. There was only a slight gain in science attitude scores for eighth grade pupils over fifth grade pupils.

5. More than half the pupils in the study gave desirable responses to the science attitude test.  

**Baxter's investigation.** In a study of elementary children's science information and science attitudes, Baxter investigated the effect of five variables:

(1) teacher attitude toward science, (2) teacher degree of authoritarianism, (3) teacher attitude toward desirable teacher-pupil relations, (4) children's intelligence, and (5) children's sex.  

Using a pre-test and post-test design, he administered the following instruments: Edwards' and Kilpatrick's Attitude

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toward Science Scale, California F Scale, Minnesota Teacher Attitude Inventory, Brown's California Elementary School Science Information and Science Attitude Test, and the California Test of Mental Maturity. Sixty-two intermediate grade level teachers and 1,767 children participated in the study.

The data revealed the following:

1. It appears that teachers’ attitudes toward science are positively related to children’s gain in science information.

2. Teachers’ attitudes toward science are significant factors in children’s attitude changes.

3. Both science information and science attitudes were inversely related to children’s intelligence.\(^\text{18}\)

Measurement of attitudes in junior and senior high schools

Several attempts to measure attitudes toward science and scientific attitudes have been conducted using as samples junior and senior high school students. Descriptions of the efforts of several measurement investigations at the junior and senior high school level are presented in the following studies.

Mead and Metraux’s study. The specific objectives of a study performed by Mead and Metraux were to learn the\(^{18}\)

\(^{18}\)Ibid.
1. What ideas about the image of the scientist are expressed by American secondary school students?

2. What do American secondary school students think about becoming or marrying a scientist?

3. Is a generally positive attitude toward science a positive attitude toward becoming a scientist?

The total sample was composed of about 35,000 students. Sample A was drawn from 132 public high schools that were selected from schools associated with the Traveling High School Science Library Program. Sample B consisted of 13 special schools from the Eastern seaboard: four parochial schools, eight preparatory schools, and one public high school. The sample was randomized by drawing envelopes containing the completed forms randomly. Three data gathering forms were used but only one was used in any particular school. The three forms were as follows:

Form I: Complete the following statement in your own words. Write at least a full paragraph, but do not write more than a page.
When I think about a scientist, I think of

Form II: If you are a boy, complete the following statement in your own words. If I were going to be a scientist, I should like to be the kind of scientist who. If you are a girl, you may complete either the sentence above or this one. If I were going to marry a scientist, I should like to marry the kind of scientist who

Form III. If you are a boy, complete the following statement in your own words. If I were going to be a scientist, I would not like to be the
of scientist who_______. If you are a girl you may complete either the sentence above or this one. If I were going to marry a scientist, I would not like to marry the kind of scientist who_______.19

Six subsamples were analyzed by six different analysts working independently. After this preliminary analysis, a conference of the analysts was held and the discussion revealed that there was agreement on the homogeneity of the attitudes found in the materials from different sections of the country. In addition, a detailed pattern analysis was performed on 1,000 essays—chosen to represent both the homogeneous nationwide sample of public schools (Sample A) and the highly diversified schools (Sample B). From the data a composite statement about science and the scientist was composed which included both positive and negative statements concerning the image of the scientist.

The investigators concluded from their analysis of the data the following:

The official image of the scientist...the answer will be given without personal involvement is a positive one. The image is one which is likely to invoke a negative attitude as far as personal career or marriage choice is concerned.20


20 Ibid., p. 389.
Allen's investigation. An investigation conducted by Allen was concerned with the following questions:

1. In general, do high school seniors have positive, constructive attitudes toward science and scientific endeavor?

2. Do high school seniors choosing scientific careers have more positive constructive attitudes toward science and scientific endeavor?

3. Is the intelligence of high school seniors related to their attitudes regarding science and scientific endeavor?

4. Is there a difference in attitudes toward science and scientific careers between high-ability high school seniors who plan other careers?

The population for the study consisted of 3,057 graduating seniors from twenty high schools which were chosen to be representative of the various types of communities and high schools in the State of New Jersey. The sample was obtained by alphabetizing the names of all high schools in the state and selecting every tenth school on the list. The data gathering instrument was composed of three sections: (1) Personal Data, (2) Vocabulary Test, and (3) Attitude Scale. The instrument was administered by the teachers and guidance personnel of each school. The positiveness or negativeness of a particular attitude item on the attitude scale was established by a jury of experts consisting of scientists and professors of science.

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21 Allen, *Attitudes of Certain High School Seniors toward Science and Scientific Careers*, p. 6
In comparison of all responses with the judges' responses, a correlation between the scale score of the judges and the percentage of agreement for the total sample was .770 and the correlation between the judges and the total sample on percentage of disagreement was .808. A consistent decrease in percentage of constructive responses from the first quartile to the fourth quartile groups in intelligence on nearly 40 per cent of the items in the attitude scale was obtained. Comparisons, between the first and fourth quartile groups on 40 per cent of the items, revealed significant differences at the .01 level.

The investigator concluded the following:

One may justifiably conclude from the above correlations (.770 - .808) that the high school seniors included in this study when taken as a total group, do have positive and constructive attitudes toward science. Therefore, it seems reasonable to conclude that there was no significant difference between the science and non-science groups in their attitudes toward the scientific enterprise as indicated by the instrument employed. In general, it is fair to say that the higher the intelligence of the seniors included in this study, the greater the likelihood that they would show constructive attitudes toward the scientific enterprise. The correlations between the high ability science and high ability non-science groups on the scale of the judges were also high, indicating that the attitudes of both groups toward scientists and scientific enterprise were favorable and constructive.  

22Ibid., pp. 60-63.
Smith's NSF Institute study. An investigation of critical thinking abilities and attitudes of sixty high school participants in a National Science Foundation Institute was conducted by Smith. The evaluation instruments used were the Watson-Glaser Critical Thinking Appraisal and the Test on Understanding Science. The following conclusions were drawn from the investigation:

1. Students demonstrated high critical thinking ability.
2. The institute participants were below average in their perception of science and scientists.
3. Boys scored significantly higher than girls in critical thinking ability and attitudes toward science and the scientist. 23

Blackman's scale. After an extensive survey of the literature on scientific attitudes, Blackman constructed a scale for high school students. The scale was administered to 500 high school students and showed a .597 reliability. The test revealed no significant difference between the attitudes of boys and girls. Also, the scale showed that the average test score increased directly with increasing school level. 24


Cooley and Bassett's follow-up study. A follow-up study was conducted by Cooley and Bassett on fifty-five high school students who spent two weeks studying advanced topics in science and mathematics at Thayer Academy and eight weeks working with research scientists. Several instruments were administered as pre- and post-tests to evaluate the objectives of the program. Among the instruments used was the Facts About Science Test which measures students' images of science and scientists.

The investigator concluded that the major changes in student behavior were more realistic attitudes toward scientists and the distinction between science and technology became clearer. In addition, the students increased their abilities to screen hypotheses, interpret data, and quantitative reasoning as measured by the STEP Science Tests.\(^25\)

Several Purdue Opinion Panel Polls have been conducted to measure attitudes of high school students toward science. Two of these polls are presented below:

Baker's, Heath's, Stoker's and Remmers' study.

Baker and others investigated the attitudes and aptitudes of the nation's high school students toward science, scien-

tists, and various occupations. The Purdue Opinion Panel Poll No. 45 contained five parts: (1) Personal Data; (2) Scale for Measuring Attitudes toward any Occupation; (3) Scale for Measuring Attitudes toward any Institution; (4) Purdue Physical Science Test; and (5) Results. This poll was administered to a nation wide sample of about 15,000 high school students in April of 1956.

Analysis of the data of a representative sample of about 2,500 students revealed the following:

1. Housewife, physician, chemist, electrical engineer, high school teacher, mechanic, sales clerk, psychologist, storekeeper, and atomic scientist ranked one through ten respectively as desirable vocations.

2. There was no apparent relationship between attitudes toward scientific occupations and social or educational level.

3. Responses indicated lack of information about scientists as well as negative attitudes toward them.

4. Many high school students consider scientists to be some kind of undesirable 'brains.'

5. The writers concluded: "Such widespread negative attitudes can hardly fail to influence the supply of technically trained graduates."

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26P.C. Baker and Others, Physical Science Attitude and Attitudes toward Occupations (Report of Poll No. 45 of the Purdue Opinion Panel; Lafayette, Indiana: Division of Educational Reference, Purdue University, 1956)
Heath directed poll. A study concerned with measuring attitudes of youth toward science and scientists was directed by Heath. The poll was administered to 8,500 high school students in grades ten, eleven and twelve in October of 1957. From the 8,500 student sample a stratified representative sample of 2,000 students was selected for analysis.

Analysis of the poll data lead the investigators to the following conclusions:

1. Today's teenagers (1957) "have a disappointingly meager understanding of the nature of science, its goals, and its limitations."

2. Many agree with negative stereotype statements about scientists.

3. Many of those having negative attitudes are bright students.

4. Many are unaware of the role of science in our society.27

Hamilton's dissertation. A dissertation concerned with scientific literacy of high school seniors was written by Hamilton. Five urban, five suburban, and five rural schools were selected in an attempt to measure differences

27 R.W. Heath and others, High School Students Look at Science, (Report of Poll No. 50 of the Purdue Opinion Panel; Lafayette, Indiana: Division of Educational Reference, Purdue University, 1957)
between urban, suburban and rural high school students with respect to scientific literacy. The total population of 471 graduating high school seniors were given the following measuring instruments: The Iowa Tests of Educational Development; Test on Understanding Science; Otis Quick-scoring Mental Ability Test, New Edition; Personal Inventory on Science; sequential tests of educational progress; and a revised Occupational Scale for rating socioeconomic class.

Analysis of the data obtained revealed the following: (1) "Scientific literacy seems to depend upon mental ability." (2) There is no significant difference between students in urban and suburban areas in scientific literacy. (3) There is a positive relationship between the number of science courses taken and scientific literacy. (4) "Environment makes some contribution to scientific literacy." (5) "Boys might have a greater understanding of the scientist than girls." (6) There is no significant difference between the scientific literacy of high school senior boys and girls. (7) "The size of the graduating class does not appear to be an important contributing factor to scientific literacy."28

Baumel and Berger's attitude scale. Baumel and

Berger developed an attitude scale to measure the scientific point of view. They described the scientific point of view as follows:

(1) looks for the natural causes of events; (2) is openminded toward the work and opinion of others and toward information related to his problem; (3) bases opinion and conclusions on adequate evidence; (4) evaluates techniques and procedures used and information obtained; and (5) is curious concerning the things he observes.29

Results of administration of the scale to ninth grade students after a year of general science showed that students scoring high or low on the tests didn't necessarily receive low and high grades in science.30

Measurement of attitudes in colleges

Among the investigations of the attitudes toward science and scientific attitudes of college students are the following studies.

Mason's study involving biological science students.
A study of scientific attitudes and scientific thinking development at the college level in biological science was conducted by Mason. The investigation was performed at Michigan State College during a school year in the Depart-

30Ibid., pp.267-9
ment of Biological Science. The investigator taught two lecture and laboratory sections in which 81 and 90 students were enrolled. One group was given the traditional descriptive course and in the other group an attempt was made to teach for the development of the methods and attitudes of science.

To evaluate the two methods Nöll's *What Do You Think?* test and an investigator constructed test, *What Do You Think Relative to Certain Beliefs and Situations Pertaining to Biological Science?*, were administered. In conclusion the scientific thinking method "appeared to be slightly more effective in teaching scientific attitudes than the descriptive method." 31

**Sinclair's and Tolman's Investigation.** Sinclair and Tolman attempted to determine the effect of scientific training upon prejudice and illogicality of thought. The sample for the study was approximately fifty freshmen and fifty seniors at two different colleges. The measuring instrument used was Goodwin Watson's *Survey of Public Opinion on some Religious and Economic Issues*. The investigators compared students who had intensive training in science with students without such training.

31 John M. Mason, "An Experimental Study in the Teaching of Scientific Thinking in Biological Science at the College Level," *Science Education*, XXXVI (December, 1952), 283.
The investigators concluded from these comparisons that intensive training in science does not significantly change the student's inference making ability. In addition they found no evidence of transfer of habits of thought from scientific training to questions of economic, ethical and social judgments.32

Soy's questionnaire. Using a questionnaire Soy investigated the attitudes of prospective elementary teachers toward science. By means of the questionnaire, she collected five categories of information: (1) Personal and academic background; (2) Student's subject major; (3) Opportunities for investigation of subject fields; (4) Student's reason for his choice of subject field; and (5) Student's rating of his subject field background. The sample was made up of 529 sophomores, juniors, and seniors in elementary education at the State College of Iowa in 1963-64. Additional data was collected from a random sample of 165 students through an interview with the investigator.

Analysis of the data collected led the investigator to the following conclusions:

1. Prospective elementary teachers come to college

with a feeling of strength in the fields of language arts and social studies and they continue to select courses in these areas to increase their confidence.

2. Talented high school teachers are an important influence in developing interest in a particular area.

3. Counselors and other educators should encourage the elementary education major to choose electives in the areas of science and mathematics.

4. College curricula in elementary education should build competencies in the fields of science and mathematics.

Measurement of attitudes of teachers and scientists

Several investigations have been conducted to measure the attitudes of teachers. Some of these studies have related teacher attitudes to student learning outcomes and others have compared attitudes of science teachers with attitudes of scientists. Several of these investigations are described in the following pages.

Crowell's attitude and skill test. An attitude and skill test was developed by Crowell which contained twenty-nine attitudes and twenty-five skills considered essential to scientific methods. These attitudes and skills were

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ranked in order of importance by sixty-four college, university, and high school faculties from forty-nine institutions in twenty states throughout the United States.

The results revealed that there is substantial agreement among respondent science teachers with respect to the importance of the specific attitudes and skills in the instrument. Sixteen of the twenty-nine attitudes and twenty-three of the twenty-five skills were considered important by 80 per cent or more of the judges.

Another aspect of this study was to determine the treatment of these attitudes and skills in general science and biology texts. The correlation between important attitudes and skills and their presence in textbooks were "not very significant."[^34]

**Behnke's study of reactions.** A study of the reactions of scientists and science teachers toward statements about science and science teaching was conducted by Behnke. His scale contained items in the following categories: (1) Nature of science; (2) Science and society; (3) The scientist and society; and (4) The teaching of science.

The attitudes of a sample of 1,000 physical science and biology teachers were compared with those of 100 science

tists. Comparisons were made between various subgroups of the teachers and the scientists. The conclusion was that "the differences among the teachers were less marked than those between the scientists and the teachers."\textsuperscript{35}

Howe's study of learning outcomes, teacher factors and teaching methods. The relationships between learning outcomes, selected teacher factors and teaching methods were investigated by Howe. A stratified random sample of 51 classes in 51 schools in the State of Oregon was selected for the investigation. The following instruments were used to compare the relatedness between learning outcomes, selected teacher factors and teaching methods: Otis Mental Ability Test, Gamma: Form Em; The Nelson Biology Test, Forms Am and Bm; The Watson-Glaser Critical Thinking Appraisal, Forms Ym and Zm; The Reaction Inventory of Attitudes toward Science and Scientific Careers; and The Student Inventory.

Among the numerous teacher factors were: teacher age; academic preparation; attitudes toward science; scientific careers and science teaching; and critical thinking skill. Teaching methods selected were: (1) recitation from textbooks; (2) free discussion; (3) lecture-demon-

stration combination; (4) demonstration-discussion combination; (5) lecture; (6) laboratory; (7) laboratory-discussion combination; and (8) projects. The investigator used analysis of covariance to determine the statistical relatedness of the various factors to five learning outcomes.

Analysis of the data led the investigator to draw several conclusions among which are the following:

1. There are certain teacher factors which are related to the five learning outcomes at the .01 level or above.

2. The personal adjustment factor, which was measured by the principal, was the most important and significant factor related to the five learning outcomes.

3. The students developed more positive attitudes toward science and scientific careers during the school year.

4. Students' attitudes tended to change in the direction of their teachers' attitudes.

5. Teaching specifically for attitude development was shown to be effective in accomplishing the development.

6. Classes achieving high composite success for the five learning outcomes were characterized as being pupil-centric with emphasis on problem solving.  

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36 Robert W. Howe, "The Relationship of Learning Outcomes to Selected Teacher Factors and Teaching Methods
Kimball's study. Kimball conducted a study which compared scientists, science teachers and their understanding of the nature of science. A comprehensive statement delineating the nature of science was prepared from an extensive study of the literature. Based upon this statement, 200 short statements about the nature of science were prepared. These statements were submitted to a panel of nine experts and those items retained were administered to 54 subjects. Thirty-one items were selected through item analysis of the above data and organized into a second form of the instrument. The second form of the instrument was administered to 97 subjects of which about one-half had majored in science as undergraduates. The Spearman-Brown reliability of this scale was .72. Twenty-nine of the thirty-one items were arranged in a Likert-type scale and used for the research instrument.

The scale was sent to a 995 member sample drawn from science and philosophy majors graduated from Stanford University. One hundred nineteen members of the sample were philosophy majors and the remainder science majors. Seventy-four per cent replied and the corrected split-half reliability of the scale was .54.

The researcher made the following conclusions based in Tenth Grade Biology Classes in Oregon" (unpublished Ed.D dissertation, Oregon State University, 1964).
upon the sample of science and philosophy major graduates:

1. There are no differences between scientists and science teachers on the understanding of the nature of science.

2. Philosophy majors scored significantly higher than other members of the sample.

3. Scientists, nor teachers, showed evidence of changes of attitudes over a twelve year span of graduates from Stanford.

Based upon the study, the investigator also suggested that philosophy of science be included in the curricula for undergraduate science majors.37

Wytsiaz study of fifth grade teachers attitudes. Wytsiaz studied fifth grade teachers' attitudes toward their preparation for science teaching and toward science. A questionnaire was prepared to measure fifth grade teachers' attitudes toward science and their preparation for science teaching. Using this instrument, 70 fifth grade teachers in Cumberland County, New Jersey were asked to rank, with respect to preference, the elementary school subjects.

Results from a 64 per cent return showed the following: (1) Over one-half of the teachers felt their science

background insufficient for fifth grade science teaching.  
(2) Science ranked on the average 3.7 in relation to other fifth grade subjects.  

Measurement of attitudes of other groups  

A few attitude investigations involved broader samples than those previously described. The following studies involve samples of subjects in junior high, high school, college and adults.  

Withey's study of public opinion. Public opinion about science and scientists was investigated in pre and post Sputnik eras by Withey. The investigator presented a series of statements to which the subjects were required to agree or disagree. 

Comparing the responses of the respondents in the two eras, he found: (1) "no significant changes in the number who feel that science will solve our social problems, will make life better, will breakdown morality, or that scientists want to make life better for people;" (2) there was an increase in the number of respondents who felt that scientists meddle into areas which are none of their business and that science changes our lives too rapidly; (3)  

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scientists are looked upon as "well meaning, brilliant, hard working people but sometimes considered 'off-beat and peculiar;'" and (4) there is "some questioning, some alert watching, and considerable mistrust of scientists."

In conclusion, Withey states that medicine is the most highly thought of area of science and ranking next is science's contributions to human living and welfare.39

**Caldwell's and Lundeen's study of unfounded beliefs.**

A study of attitudes regarding unfounded beliefs was performed by Caldwell and Lundeen. The population for the study consisted of 918 high school seniors from several states and 264 college students from several colleges. These students were asked to indicate whether they were aware, believed, or influenced by each of 200 statements of unfounded beliefs.

The investigators found that rural students are influenced by more unfounded beliefs than students in large cities. Also, they found high school and college girls are influenced by more unfounded beliefs than are high school and college boys. They discovered, in addition, that high school seniors are more influenced by unfounded beliefs than are college students.40

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Moore's test of factual knowledge. A study relating scientific attitudes to factual knowledge was conducted by Moore. A test of factual knowledge was prepared covering the science subjects of the "greatest human interest." In addition, a judgment test was prepared which contained descriptions of fifty familiar situations with four or five possible explanations for each situation. The students were directed to mark the most reasonable explanation. These tests were administered to several groups some of which had studied science and some who had not studied science. The groups were composed of eighth and ninth grade students, high school students, junior college students, adults, elementary teachers and secondary teachers.

Based upon the findings, the investigator drew these conclusions: (1) The ability to distinguish between valid and invalid explanations is clearly related to possession of factual knowledge. (2) "Superior intelligence, general educational training, and experience increase the knowledge of facts and the ability to apply it." (3) There are not significant sex differences with respect to the amount of factual knowledge.41

Wilson's investigation of the nature of science.

Wilson conducted a study of opinions and attitudes related

to the nature of science. He composed twenty six statements about science drawn mainly from two books, *Science and Common Sense* and *The Path of Science*. These statements were submitted to 285 students composed of sophomores enrolled in general physical science, graduating seniors, junior and senior science majors, public school teachers enrolled in extension classes, and high school students enrolled in a college demonstration school.

The investigator made the following conclusions based upon the results of administration of the scale:

1. The majority of students do not distinguish clearly between pure science and technology.
2. The majority of students do not understand the necessity for freedom of investigation in science.
3. The majority of students consider man's physical comfort the primary purpose of science.
4. Many of these students feel we should accept the judgment of specialists rather than attempt to educate the general public to make public policy decisions.
5. These students believe that scientists are more logical, more objective in the solution of everyday problems than are other professionals.
6. The majority of them believe that use of the scientific method would yield great progress in all fields.

In summation of the above conclusions, the investigator states: "The responses of these students to this
set of statements about science indicates a considerable lack of understanding of science and its place in our society."\(^\text{42}\)

**Studies Primarily Concerned with Measuring the Effectiveness of Various Methods in the Development of Attitudes toward Science and Scientific Attitudes**

**Methods used in the elementary school**

Two investigations involving special efforts made to change elementary students' attitudes are described in this section.

**Lichtenstein's study.** A study which attempted to teach "a feeling of satisfaction in getting outdoors" was conducted by Lichtenstein. The sample for the study was composed of two groups of intermediate grade children. In one group, the teachers were directed to stress the above mentioned attitude. In the other group, the teachers were instructed to follow the regular course of study. The desire to get out of doors was measured by a student ballot on which the students indicated their preference for either a trip to the country or staying at home and seeing a movie. Students, also, were requested to keep a diary of their out-of-school activities for two weeks. These measures were used in a pre-test and post-test design.

The researcher concluded the following from the study:

1. Stressing preference for the outdoors showed no significant differences in students out-of-school behavior as revealed by the diaries.

2. The balloting of students' preferences revealed no significant differences. 43

Weller's measurement of attitudes and skills. Measuring attitudes and skills in elementary science was the concern of a study conducted by Weller. In three sixth grade science classes, an attempt was made to develop attitudes as well as factual knowledge. Whereas, in the other three classes no special effort was made to develop attitudes. These sixth grade children in Baltimore schools were given pre-tests and post-tests using instruments designed to measure both attitudes and factual knowledge. The attitudes test had a reliability coefficient of .74.

The findings revealed a significant difference in favor of the three classes in which the development of scientific attitudes was stressed. In conclusion, the investigator states:

...that the teaching of elementary science with proper guidance provides an opportunity to grow in other ways than in the accumulating of factual knowledge... provides the means of developing desirable attitudes and skills in problem solving. 44


Methods used in the junior and senior high school

Several different methods of changing junior high school students' attitudes have been employed. The attempts to change attitudes utilized several methods among which are the following: (1) class discussion to identify scientific attitudes in news articles; (2) field trips; (3) teacher emphasis upon scientific attitudes; and (4) field study.

Bennett's field study. A quite limited study conducted by Bennett at Jinks Junior High School sought to determine if junior high students taught under the field method would develop more positive attitudes toward science and scientists. Sixty students in the field group studied stream areas for a two week period. These students were compared with a classroom group and the results showed no significant differences in the attitudes of the two groups. The investigator felt that probably the attitudes test couldn't measure short term attitude changes.45

Eberhard's and Hunter's experiment. A study which follows-up Hoff's study was conducted by Eberhard and Hunter. They attempted to determine the scientific attitude development of ninth grade students in several different groups.

45Lloyd M. Bennett, "A Study of the Comparison of Two Instructional Methods, the Field Method and the Classroom Method, Involving Science Content in Ecology for the Seventh Grade" (unpublished Ph.D. dissertation, Florida State University, 1963)
The different classifications of groups were as follows: (1) general science classes with little or no emphasis on scientific attitude development; (2) ninth grade students with no formal training in general science or biology; and (3) classes in which emphasis was placed upon teaching scientific attitudes. The experiment was conducted at Beaumont, California, with a population of 100 students. After a year of experimental treatment, they compared matched pairs of students using Hoff's test for scientific attitude development.

After comparisons were made between the groups, the following conclusions were drawn: (1) that teaching for scientific attitude development "does not modify scientific attitude scores;" and (2) the time of the experiment was too short to change scientific attitude development through classroom teaching procedures. 46

Harvey's field trip method. The main problem in a study performed by Harvey was to determine whether there was a significant difference in the development of scientific attitudes between a group which participated in field trips and a group which experienced regular classroom procedures. Selection of the control and experimental groups in ninth

grade general science at Stillwater Minnesota Junior High School, was done through random sampling techniques. Two classes of 34 students each taught by the same teacher were used in the investigation. The control and experimental groups received comparable experiences including two field trips; but the field trips were made by the control group after the final examination. The field trips were planned co-operatively by the students and teacher and designed to provide functional understanding of scientific methods as well as a genuine addition to their real knowledge.

One-half of the Scientific Attitudes Test by Caldwell and Curtis was used as a pre-test and the other half as a post-test. Students in the experimental and control groups were matched on the basis of scores on the initial scientific attitudes test. Using the Otis Mental Achievement Test, it was determined that there were no significant differences in intelligence between the two groups. Final scores of the matched pairs were compared using the t-test and revealed differences at the .01 level.

The investigator states:

We may draw the conclusion that, as the whole, a ninth grade general science class which experiences field trips, show a greater development of scientific attitudes than a class of equal ability, as shown by I.Q.'s and pre-tests, which does not go on field trips, but which experiences regular classroom procedures of teaching comparable material by the same teacher.

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47 Helen Harvey, "An Experimental Study of the Effect
Kahn's current events method. The chief purpose of an investigation conducted by Kahn was to determine the effect of a selected procedure for teaching current events in science upon the development of scientific attitudes of seventh and eighth grade boys. The investigation was conducted from September to June of the 1953-54 school year by the investigator and a colleague. The major experiment was conducted in eight 8th grade classes and a concurrent experiment in seven 7th grade classes at Creston Junior High School, the Bronx, New York City. In the major experiment four classes of about 35 students each, who met twice weekly for one hour, were in the experimental group and the other four classes served as controls. I.Q.'s for the group of boys used in the experiment ranged from 64 to 130. All eight groups were provided essentially the same learning experiences. The concurrent experiment was conducted in a similar manner from February to June 1954 with four experimental and three control groups. Using Warner's formula the groups were classified on the average in a low-middle class in socio-economic status. The groups in the major experiment were equated on the basis of tests of intelligence, reading ability, subject matter knowledge and degree of possession of scientific attitudes. At the

of Field Trips upon the Development of the Scientific Attitudes of a Ninth Grade General Science Class," Science Education, XXXV (December, 1951), 248.
beginning of the experiment all students were required to take the Cooperative Science Test for Grades 7, 8, 9, Form Y; Noll's test What_Do_You_Think?, Form 1; Form 1 of Curtis' Test on Scientific Attitudes; and the first two pages of a questionnaire.

In the initial one hour class period, the students in the experimental groups were acquainted with the scientific attitudes of Caldwell and Curtis. Then approximately ten minutes of each class period was used to discuss student selected science news items in all experimental and control groups. The only significant difference between the experimental and control groups was that attempts were made through discussion to identify in the news items the scientific attitudes shown or lacking. Students were given in February (1) Cooperative Science Test for Grades 7, 8, 9, Form X; (2) Noll's test What_Do_You_Think, Form 2; (3) Curtis' Test on Scientific Attitudes, Form 2; and (4) page three of the questionnaire (given to the experimental group only).

The experimental group scored higher on all-tests of scientific attitudes and significantly higher on the Noll, Form 2 and the Curtis, Form 1 at .05 level and .01 level respectively. Results of the Cooperative General Science Test for Grades 7, 8, and 9 revealed no significant differences in acquisition of science knowledge and skill between experimental and control groups. The final test for the seventh grade groups on scientific attitudes by Curtis, Form
revealed significant differences at .01 level in favor of the experimental groups.

From the findings considered above, the investigator concluded that the experimental groups of seventh and eighth grade boys scored significantly higher on the test of scientific attitudes than the control groups with no loss of achievement in science subject matter.48

Several attempts to change students' attitudes have been conducted at the high school level. Among the methods employed in these efforts are the following: (1) science camps, (2) open-ended experiments, (3) History of Science Instruction Method, (4) films, (5) inductive-deductive approach in the laboratory, and (6) novels.

Anderson and Neeley's science camp. Anderson and Neeley conducted a science camp for 100 gifted high school science students in which they attempted to determine the attitudes of the students toward specific sciences. The campers spent two weeks participating in the following activities: (1) lecturers, question and answer sessions; (2) laboratory and demonstration sessions; and (3) meetings with outstanding researchers.

At the end of the camp the students were asked to

48P. Kahn, "Experimental Study to Determine the Effect of a Selected Procedure for Teaching the Scientific Attitudes to Seventh and Eighth Grade Boys through the use of Current Events in Science," *Science Education*, XLVI (March, 1962), 115-27.
rate science fields represented in the camp in terms of the following categories: (1) social prestige, (2) intellectual complexity, (3) popular interest, and (4) contributions to human welfare. The campers rated strongest preferences for physics and chemistry and lowest preferences for anthropology and oceanography.\(^49\)

**Charen's laboratory method.** In an effort to determine the effect of laboratory methods on the building of scientific attitudes, Charen devised the experiment described below. Using a sample of 268 high school students at five high schools, three in Denver, Colorado and two in New Jersey, he compared the attitudes of students using traditional experiments and the Manufacturing Chemists' Association Experiments. The traditional experiments were deductive in which previously presented facts and principles were confirmed and the MCA experiments were inductive and open-ended.

Through the use of an open-ended questionnaire, he discovered that more than half the students favored the open-ended experiments. In conclusion the author states:

Since attitudes are equal to, if not more important than the specific information pupils acquire and then probably soon forget, the results of this study indicates the superiority

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Klopfer and Cooley's HOSC Instruction Method. A study concerned with the development of student understanding of science and scientists was reported by Klopfer and Cooley. They developed a high school series of history of science cases which conveyed important ideas about science and scientists. These materials contained historical narrative, quotations, experiments and exercises used as instructional units in high school biology, chemistry and physics. The authors evaluated the effectiveness of these cases in changing students' understanding of science and scientists. The History of Science Cases Instruction Method required about sixteen class periods during the experimental period from October to March.

Using three-way analysis of variance design, with covariance adjustments for scholastic aptitude and initial achievement, the investigators compared fifty-three experimental with fifty-five control schools, with respect to understanding of science, scientists, and achievement in science. The sample of 108 classes was considered to be representative of high school biology, chemistry, and physics in the United States. The investigators concluded

the following:

The KOSC Instruction Project clearly demonstrates that the KOSC Instruction Method is definitely effective in increasing student understanding of science and scientists... with little or no concomitant loss of achievement. 51

Karth's instrument to measure the social aspects of science. An attempt to measure high school seniors' attitudes toward the social aspects of science was performed by Karth. He developed an instrument to measure high school seniors' understanding of the social aspects of science based upon the assertions below:

1. Science and technology interact with each other and with society.

2. The scientific enterprise is an internally regulated social institution.

3. The changes in society resulting from advanced science and technology may produce social, economic, and political problems which must be managed through appropriate social and political processes. 52

The instrument contained 52 statements arranged in a Likert-type scale. The reliability of the scale was calculated to be .71. The instrument was administered to 1,493 high school seniors to assess their understanding of science.


the relationship between science, technology, and society. The investigator compared science-oriented students and non-science oriented students with respect to their understanding of the social aspects of science.

Based upon the data, the investigator drew the following conclusions:

1. In general, science oriented students show a more positive attitude toward science, a better understanding of the nature of the scientific enterprise, and a more realistic conception of the characteristics of sciences.

2. The most pronounced differences between the two groups were in the areas of understanding the nature of science and the characteristics of scientists.

3. The evidence reveals that science oriented students lack understanding of some of the important aspects of science.

4. Many high school seniors confuse science with technology.

5. Many high school seniors lack understanding of the nature of scientific knowledge and tend to think of science as the development of materials products. 53

Wickline's study of motivational films. Wickline conducted an investigation to determine the effect of motivational films on attitude development of high school students. A 122 member experimental group consisted of six sections, two classes in each of physics, chemistry, and biology. The control group was composed of 138 stu-

53Ibid.
dents enrolled in classes in physics, sociology, chemistry
and American History. The Allen Attitude Scale and The
Facts About Science Test were administered as pre-tests
and post-tests to all students. The experimental group
viewed ten Horizon of Science Films, one a week.

Based upon the data collected from these instru-
ments, Wickline drew the following conclusion:

Results of this study indicate that the films
produced no appreciable changes in the experi-
mental group's responses on the Allen Attitude
Scale or on the Facts About Science Test.

Boeck's experiment. The purpose of a study con-
ducted by Boeck was to compare experimentally the learn-
ings of students instructed by means of an inductive-
deductive approach with the learnings of students instructed
through the use of the deductive-descriptive approach in
the high school chemistry laboratory.

The investigation was carried out using two classes
selected at random during the 1948-49 academic year at the
University of Minnesota High School. Seven additional
classes from schools of similar enrollment in the State of
Minnesota were selected randomly to take part in some of
the evaluations. These classes were ascertained to be

54Lee E. Wickline, The Use of Motivational Films
to Favorably Change the Attitudes of High School Students
toward Science and Scientists (Title VII, Project No.729
National Defense Education Act of 1958; West Virginia:
of the deductive-descriptive type through interviews, visitation, and examination of teaching materials. Teaching in the experimental classes progressed from the particular to the general through use of laboratory problems providing data which could be generalized to provide basic principles in chemistry. In general, in the control groups the laboratory experiments were illustrative or verifications of already discussed principles. Few attempts were made in the control groups to develop generalizing ability.

All the examinations administered in the study were constructed by the researcher. Achievement examinations were administered as pre-tests to measure status on the non-laboratory objectives. The Terman-McNemar Test of Mental Ability was used to obtain intelligence quotients for each student. At the end of the nine months school term, an achievement examination was administered to the students. Also, an examination to check on retention was given four months after completion of the course. The groups were compared with respect to relative attainment of the following four objectives as well as total achievement in all four areas: (1) knowledge of basic facts and principles of chemistry; (2) application of the principles of chemistry to new situations; (3) knowledge of and ability to use the scientific method with an accompanying scientific attitude; and (4) ability to perform in the laboratory
with resourcefulness using sound techniques.

Results were analyzed by analysis of variance and covariance in which adjustments were made for inequalities in mental ability and initial status among the experimental and control groups. In the University High School students taught in the inductive-deductive class showed significantly better achievement than those in the deductive-descriptive class. In addition, significant differences in average achievement were found in favor of the inductive-deductive class relative to identifying proper laboratory techniques. Retention examinations showed differences in mean scores in favor of the inductive-deductive class. Analysis of data which compared deductive descriptive classes from other schools with the university inductive-deductive class revealed significant advantage in favor of the inductive-deductive class in knowledge of facts and principles, applications of principles, and scientific methods and attitudes.

Based upon the findings discussed above, the experimenter concluded the following:

The inductive-deductive class did as well or better than the deductive-descriptive class in the attainment of the general outcomes of a high school course in chemistry and was significantly superior with respect to the crucial problem of attaining knowledge of and ability in the use of the methods of science with and accompanying scientific attitude.55

55 Clarence H. Boeck, "Teaching Chemistry for
Tartars' supplementary reading experiment. The purpose and basic hypothesis of an experiment conducted by Tartars are stated below:

...to determine the effect of a supplementary reading program of selected fiction about the scientist on certain high school seniors. The basic hypothesis...novels which present a positive image of the scientist will have a measurable effect on the readers by changing their ideas about the scientist toward a more positive direction.  

The subjects of the experiment, two control and two experimental English classes of approximately thirty students each, were randomly selected from the Charles Evans Hughes High School. The students had reading scores of approximately their grade placement and I.Q.'s from 90-110 and above. The experimental and control groups were equated on basis of (1) sex, (2) grade level, (3) I.Q. score, (4) reading score, (5) chronological age, (6) class grades in English and science, (7) interests, (8) extracurricular activities, and (9) backgrounds. At the beginning of the experiment, both groups completed Allen's Questionnaire and Mead and Metraux's Questionnaire. Four novels presenting a positive image of the scientist were required supplementary reading for the experimental group.

Scientific Method and Attitude Development," Science Education, XXXVII (March, 1953), 84.

At the end of the experiment, one term later, the pre-test questionnaires were again administered to both groups. The data obtained was analyzed by means of t-ratio and Pearson product moment coefficient of correlation.

The findings of the study tended to show that the reading of selected fiction about the scientist changed the students' ideas concerning scientists in a more positive direction. The results showed that there was no significant relationship between the students' I.Q. scores and their responses to the reading. The analysis revealed that skill in reading appears to be independent of what a student thinks about scientists. In addition, science grades were shown to have no significant relationship to students' responses. Girls attitudes changed significantly more than the boys' attitudes.\textsuperscript{57}

\textbf{Methods of changing attitudes of college students and adults.}

Science magazine articles, a physical science course, motion pictures, and various media are among the methods described in this section to change college students' and adults' attitudes.

\textbf{Robinson's study involving a physical science course.}

The purpose of an investigation conducted by Robinson was to determine the effects of reading and discussing popular

\textsuperscript{57}Ibid., pp. 5-9
science articles as a part of a general education course in physical science. The following hypotheses were proposed as outcomes of the experiment:

(1) better development of students' science reasoning...concerned with scientific problems, information, hypotheses, conclusions, and attitudes; (2) better development of students' understanding of how scientific discoveries are made and how they affect people's lives and beliefs; (3) stimulation of students' interest in reading popular science articles on their own initiative; (4) improvement of students' attitudes toward the course; and (5) better learning of science subject matter during normal course activities due to increased interest and better attitudes.58

The experiment was conducted in a one year, eight hour course titled: "Man's Physical World" and was designed for freshmen majoring in non-technical fields. In general the experimental subjects were determined to be average in general scholastic ability, but somewhat deficient in reading as determined by the ACE Examination and Reading, Speed of Comprehension Test. In addition, most of the students had poor high school backgrounds in science and mathematics. In 1956-57, 220 freshmen, who were assigned to experimental and control sections randomly, participated in the experiment. The experimental groups were assigned to read and study fifteen science articles, mostly from Scientific American, which were selected on the basis of usefulness for teaching science reasoning and science understanding, Robinson, "Effect of Teaching with Science Articles," Science Education, XLVII (February, 1963), 74.

as well as, being understandable and interesting to non-science students. Special recitation sessions of 25 students were arranged to discuss informally the facts, interpretations, and opinions of these articles.

Pre-test and post-test data was obtained through use of the following measurement devices: (1) Science Reasoning Test, (2) Science Understanding Questionnaire, (3) ACE (scholastic aptitude) Examination, (4) Man's Physical World I Examination, and (5) Scale on Interest in Science Articles. Data from the above measurement devices were analyzed by analysis of covariance and the Kolmogarov-Smirnov Test.

Analysis revealed no significant differences between groups in learning science subject matter as a result of the use of science articles. Negative results were obtained from analysis of data concerning science reasoning ability. Significant differences between groups in science understanding in favor of the experimental group were revealed at the .001 level by analysis of covariance. Relative to increased interest in science articles, the K-S Test revealed a significance between the .1 and .05 levels in favor of the experimental sub-group of women without high school chemistry. With respect to attitudes toward Man's Physical World, subgroups of experimental and control men who had taken high school chemistry yielded significant differences between .05 and .02 levels by the K-S Test.
From the data the investigator concluded: (1) that science articles were not effective in the development of science reasoning; (2) that both the experimental and control groups had gained significantly in science understanding, but that the experimental group had gained significantly more; (3) that teaching with science articles did succeed in stimulating greater interest in such articles; and (4) that reading and discussion of science articles, favorably effected the men students having chemistry in their high school backgrounds toward the course Man's Physical World.  

Diehl's dissertation. Diehl's dissertation was concerned with the development and evaluation of a physical science course for non-science majors. His major concern was to measure change in attitudes toward science of pre-service elementary teachers resulting from instruction in physical science. The attitudes of particular interest were open-mindedness toward science and understanding the role of science in contemporary society.

The sample for the study was pre-service elementary teachers at Miami University. Two 25 member sections of pre-service elementary teachers were used, one as a control group and one as an experimental group. During one 1966 trimester the experimental group was exposed to many more and longer laboratory experiences using Physical Science for

59Ibid., pp. 73-83
the Non-Scientist materials; whereas, the control group pursued the conventional course taught at Miami University. Measuring instruments used in a pre-test and post-test design were Rokeach's Dogmatism Scale, Facts about Science Test, and the Natural Science Test from the American College testing program.

Based upon the data obtained from the use of the above instruments, the following conclusions were given:

1. There was no significant differences between the experimental and control groups with respect to open-mindedness as measured by Rokeach's Scale.

2. There was no significant differences between experimental and control groups with respect to understanding the role of science in society as measured by the Facts About Science Test.

DeProspo's study of selected motion pictures. A study of the effect of selected motion pictures on the development of scientific attitudes was conducted by DeProspo. The sample for the study was composed of 240 students enrolled in General Biology I and General Science at Seton Hall University. The students were randomly divided into three sections designated as Experimental Group (X), Film

Control Group (FC) and No Film Control Group (NFC). Three films *Madame Curie*, *Yellow Jack* and *The Scientific Method* were selected by the investigator and a panel to be the most useful for developing the attitude of suspended judgment. The NFC Group experienced the usual routine class work, the FC Group viewed the three films and the X Group was made aware of the object of the experiment, identified problem solving skills and discussed them.

An instrument to measure suspended judgment was prepared containing 55 statements of opinion from various sources. Forty-six of the statements were retained after review by a panel. Forty well-trained science educators rated the items on a one to nine Thrustone-type scale. Twenty of the items were retained for the final form which had a reliability coefficient of .88. This scale was used as a pre-test and post-test and also six weeks later to measure retention. In addition, to the instrument described above, measures of scholastic aptitude, science preference, and attitudes toward the scientist were obtained.

The following conclusions were drawn from the study:

1. The X Group and the FC Group showed significant gains in suspended judgment abilities, but the NFC Group showed negligible gains.

2. The gains of the X Group and the FC Group were insignificantly different.
3. Change in suspended judgment ability was not related to scholastic aptitude.

4. There was a moderate negative relationship between suspended judgment ability and attitudes toward scientists.

5. The change in suspended judgment ability was slightly related to preference for science.

6. After a period of six weeks, the suspended judgment abilities had diminished appreciably.

**Tichenor's study of the communication of science knowledge.** A study of the communication of science knowledge and attitudes through various media was conducted by Tichenor. The data for the study was obtained from a secondary analysis of public opinion polls.

Among the conclusions drawn from the study concerning science knowledge were the following:

1. Exposure to science knowledge in printed media is positively related with sex, occupational status and education.

2. Science knowledge tends to be positively related

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61Nicholas D. DeProspo, "Developing Scientific Attitudes by Responding Actively to Motion Pictures: A Study to Determine if Responding Actively to Selected Motion Pictures by Identifying the Problem-Solving Skills they Portray Reinforces or Develops a Scientific Attitude in College Freshmen," (Ph.D. dissertation, New York University, 1957; Abstract: Dissertation Abstracts, XVIII, 1957), pp. 521-22.
with the extent of exposure to science news.

3. Science knowledge is positively related with preference for media with science content.

4. Science knowledge is most highly associated with reading magazines for science contents.

With respect to attitudes toward science, the following conclusions were drawn: (1) attitudes are more favorable for people with more education; and (2) attitudes are positively associated with scientific knowledge.  

Summary

Selected research studies relevant to the writer's study have been presented in this chapter. Studies concerned with the following topics were reviewed: (1) Components of scientific attitudes and attitudes toward science; (2) Techniques of attitude scale construction; and (3) The effectiveness of various methods in the development of attitudes toward science and scientific attitudes.

Chapter III presents the design of the study. The procedures are described through discussion of the following aspects of the study: (1) The item pool; (2) First refinement of the scale; (3) Attitude Item Rating Scale; (4) Second refinement of the scale; and (5) Construct validity of the scale.

CHAPTER III
DESIGN OF THE STUDY

In this chapter the procedures, for the development and validation of the instrument to measure attitudes of pre-service elementary science methods students toward science and scientists, will be presented. The chapter will be organized in the following sections:

I. The Item Pool

II. First Refinement of the Scale
   A. Administration of the scale
   B. Item and factor analysis of the scale

III. Attitude Item Rating Scale
   A. Development of the rating scale
   B. Evaluation of the rating scale
   C. Analysis of the rating scale

IV. Second Refinement of the Scale
   A. Second administration of the scale
   B. Second item analysis of the scale

V. Construct Validity of the Scale

The Item Pool

In order to obtain an item pool, permission was sought to use selected items from existing scales as models.\(^1\) This permission was granted; and through use of attitude item criteria, approximately 150 items were selected as

\(^1\)See page 7.
models from these scales. The items were modified using a thesaurus for similar terms. Close attention was given to attitude item criteria to create 139 new items. The attitude item criteria used were as follows:

1. Avoid statements that refer to the past rather than to the present.

2. Avoid statements that are factual or capable of being interpreted as factual.

3. Avoid statements that may be interpreted in more than one way.

4. Avoid statements that are irrelevant to the psychological object under consideration.

5. Avoid statements that are likely to be endorsed by almost everyone or by almost no one.

6. Select statements that are believed to cover the entire range of the affective scale of interest.

7. Keep the language of the statements simple, clear and direct.

8. Statements should be short, rarely exceeding 20 words.

9. Each statement should contain only one complete thought.

10. Statements containing universals such as all, always, none, and never often introduce ambiguity and should be avoided.

11. Words such as only, just, merely and others of a similar nature should be used with care and moderation in writing statements.

12. Whenever possible, statements should be in the form of simple sentences rather than in the form of compound or complex sentences.
13. Avoid the use of words that may not be understood by those who are to be given the completed scale.

14. Avoid the use of double negatives.\(^2\)

The new items were placed randomly into two scales of 70 and 69 items.

**First Refinement of the Scale**

**Administration of the scale**

Dr. Languis, Co-ordinator of Elementary Science Methods Instruction at The Ohio State University, suggested that arrangements be made with the instructors of the science methods classes for administration of the scales. The two scales were administered in early December 1968 to two groups each of approximately 65 elementary science methods students in the College of Education at The Ohio State University.

**Item and factor analysis of the scale**

Item analysis was performed using an IBM 1620 computer program written by Goode of The Ohio State University Center for Human Resources Research. The computational methods used in the item analysis program are described below:

The calculations are based on the L-factor, the

concept of the total load of variation. The computational formulas using the L-factor are as follows:

\[ L(T) = N\varepsilon T^2 - (\varepsilon T)^2 \]

\( T \) = The normal sum of item responses

\( N \) = The number of observations

The following sequence of calculations is performed for each item in turn:

\[ L(X) = N\varepsilon X^2 - (\varepsilon X)^2 \]

\( X \) = The item response

\[ L(X, T) = N\varepsilon XT - (\varepsilon X)(\varepsilon T) \]

\[ L(X, Y) = L(X, T) - L(X), \text{ where } Y = T - X \]

\[ L(Y) = L(T) - L(X, T) - L(X, Y) \]

\[ B = L(X, Y)^2/L(Y) \]

A running value of the numerator for the Kuder-Richardson reliability coefficient is calculated by adding "B" and subtracting "L(X)" for each item. In addition, the following statistics are calculated and are provided as outputs on each item:

Average \( X = \frac{\varepsilon X}{N} \)

Variance \( X = \frac{L(X)}{N^2} \)

Standard Deviation \( X = \sqrt{\text{Variance } X} \)

Reliability of \( X \), \( r_{x,y} = \sqrt{L(X, Y)^2/(L(X)L(Y))} \)

Furthermore, the following statistics for the scale as a unit are calculated and are outputed:

Average \( T = (\varepsilon T)/N \)
Standard Deviation of Average $T = \sqrt{\frac{L(T)}{N}}$

Variance $T = \frac{L(T)}{N}$

Standard Deviation $T = \sqrt{\text{Variance } T}$

Kuder-Richardson Scale Reliability Coefficient $= \frac{L(T) - \sum L(X) + \sum (LX,Y)^2/L(Y)}{3}$

Scale scores for each respondent on Scale A and Scale B were calculated by summing values of 0 - 4 for positive item responses strongly disagree, disagree, neutral, agree, and strongly agree respectively and values 0 - 4 for negative item responses strongly agree, agree, neutral, disagree, and strongly disagree respectively. Negative and positive items for the first refinement were determined from internal consistency item reliabilities. Those items with positive item reliabilities were considered positive and those items with negative reliabilities were considered negative.

The data obtained from the item analysis of Scale A and Scale B are given in Table 1 and Table 2 (pages 84-84).

Factor analysis was performed using an IBM 7094 computer program developed by Wherry of The Ohio State University Psychology Department. Evaluation of the

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3 Omar S. Goode, "Item Analysis" (Columbus, Ohio: The Ohio State University Center for Human Resources Research, 1967), pp. 16-18. (Mimeographed.)

4 Robert J. Wherry, "Hiearchical Factor Analysis" Columbus, Ohio: The Ohio State University, 1968. (Computer program.)
factor analysis data revealed that the factor structure was too complicated to be useful in further refinement of the scale.

**Attitude Item Rating Scale**

**Development of the rating scale**

Based upon internal consistency and item reliabilities, 99 items were selected for further refinement. These items were sorted into the following categories based upon their content:

1. Attitude toward the Scientist
2. Attitude toward Science in General
3. Attitude toward the Value of Science
4. Attitude toward Science as a School Subject
5. Attitude toward Science's Impact on Society
6. Attitude toward the Nature of Science
7. Attitude toward Society's Impact on Science

The 99 items were arranged by category in the Attitude Item Rating Scale which is given in Appendix C. This scale contained three rating classes—(1) relevancy, (2) unambiguity, and (3) attitude.

**Evaluation of the scale**

A jury of seven scientists and eight science educators was selected through consultation with the writer's advisor. The science educators included professors with
scientific interests in physical, biological and earth sciences. The group of scientists was composed of two chemists, two physicists, and three biological scientists. Twelve of the fifteen Attitude Item Rating Scales, which were given to the scientists and science educators, were returned. Of the scales returned, six were from the scientists and six were from the science educators.

Table 3 (pages 87-93) shows the ratings of the items on a two-point scale for the relevancy and unambiguity rating classes. In the relevancy rating class 2, 1, and 0 values were assigned respectively to highly relevant, somewhat relevant, and irrelevant. Similarly, in the unambiguity rating class 2, 1, and 0 values were assigned respectively to unambiguous, fairly clear, and ambiguous.

In order to determine which items were positive and negative attitude responses, strongly agree, agree, neutral, disagree and strongly disagree were assigned values 4, 3, 2, 1, and 0 respectively. Positive and negative items were determined by averaging the responses of the jury. Averages for attitude items between 0 - 2 were considered negative and averages between 2.1 - 4.0 were considered positive. Once positive and negative items were determined, values were assigned from 0 to 4 respectively for positive items for responses strongly disagree, disagree, neutral, agree and strongly agree. Similarly,
values of 0 to 4 were assigned respectively to negative items for responses strongly agree, agree, neutral, disagree, and strongly disagree.

The criterion for retention of items, with respect to relevancy, was an average rating of between 1 and 2 indicating the item was rated at least "somewhat relevant" or higher. Those items which rated high, with respect to ambiguity, were discarded or revised in an attempt to remove the ambiguities. After discarding irrelevant items and either discarding or revising ambiguous items, there were 87 items remaining.

Second Refinement of the Scale

Second Administration of the Scale

The sample for the second administration of the attitude instrument was composed of elementary science methods students enrolled at the following universities: 124 at The Ohio State University, 130 at the University of Houston, 64 at Indiana University, and 31 at the University of Texas. At The Ohio State University, which operates on a quarter system, the attitude scale was administered between February 25 and March 5. At the other universities participating, which operate on a semester system, the attitude scale was administered during the week of March 24 to March 28.
Second item analysis of the scale

Item analysis (page 96) from this sample was used to select the final scale of 67 items.  

Construct Validity of the Scale

In an attempt to obtain a measure of construct validity, the attitude scale was administered to 24 science participants in the National Science Foundation Academic Year Institute at The Ohio State University. It is postulated that this group has more positive attitudes toward science and scientists than the group of elementary science methods students. To obtain a measure of construct validity, the Academic Year Institute participants were compared with the elementary science methods students on the items which showed high internal consistency item reliabilities for both groups.

Summary

In this chapter the procedures for development and validation of the attitude scale have been presented.

In Chapter IV the results of the analyses performed in the development and validation of the attitude scale will be presented.

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5 See Appendix E
CHAPTER IV

RESULTS

In this chapter the results of the analyses performed will be organized in the following manner:

I. Results of the First Refinement of the Scale
II. Results from the Attitude Item Rating Scale
III. Results from the Second Refinement of the Scale
IV. Results of the Construct Validity Measure

Results of the First Refinement

In an attempt to select the best items from the 139 item pool, the items were randomly placed into two scales of 69 and 70 items. Each scale was administered to a group of approximately 65 pre-professional elementary science methods students. Based upon the item analyses data shown on Table 1 and Table 2 (pages 84 and 85), several items were discarded because of low internal consistency item reliabilities.

Observation of Table 1 and Table 2 reveals that item reliabilities range from .0994 to .7169. Those items with item reliabilities lower than .1801 were considered not to be sufficiently reliable and were therefore discarded. In
TABLE 1

ITEM RELIABILITIES OF SCALE A

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Scale Reliability 0.8499
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**ITEM RELIABILITIES OF SCALE B**

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<td>36</td>
<td>0.2108</td>
<td>58</td>
<td>0.4021</td>
</tr>
<tr>
<td>13</td>
<td>0.1599</td>
<td>37</td>
<td>0.4259</td>
<td>59</td>
<td>0.7169</td>
</tr>
<tr>
<td>14</td>
<td>0.2719</td>
<td>38</td>
<td>0.5630</td>
<td>60</td>
<td>0.2388</td>
</tr>
<tr>
<td>15</td>
<td>0.6223</td>
<td>39</td>
<td>0.4402</td>
<td>61</td>
<td>0.4771</td>
</tr>
<tr>
<td>16</td>
<td>0.2331</td>
<td>40</td>
<td>0.6285</td>
<td>62</td>
<td>0.3660</td>
</tr>
<tr>
<td>17</td>
<td>0.5644</td>
<td>41</td>
<td>0.4488</td>
<td>63</td>
<td>0.1746</td>
</tr>
<tr>
<td>18</td>
<td>0.3278</td>
<td>42</td>
<td>0.2075</td>
<td>64</td>
<td>0.5313</td>
</tr>
<tr>
<td>19</td>
<td>0.2946</td>
<td>43</td>
<td>0.2816</td>
<td>65</td>
<td>0.4333</td>
</tr>
<tr>
<td>20</td>
<td>0.2271</td>
<td>44</td>
<td>0.1384</td>
<td>66</td>
<td>0.4388</td>
</tr>
</tbody>
</table>

**Scale Reliability 0.9141**
addition, a few items which were essentially duplicate of other items were also eliminated.

Results from the Attitude Item Rating Scale

The remaining 99 items were arranged in the Attitude Item Rating Scale. The rating scale was evaluated by a group of six science educators and six scientists who rated each item with respect to relevancy, unambiguity and also gave their attitude toward the item. The results of this attempt to insure content validity, eliminate item ambiguities, and determine the positiveness and negativeness of the items are shown on Table 3 (pages 87-93).

The values assigned to each item in the relevancy and unambiguity classes were based upon averages of a 0 to 2 point scale. Attitude values were assigned upon a 0 to 4 point scale with strongly agree, agree, neutral, disagree, strongly disagree receiving 4, 3, 2, 1, and 0

1See Appendix C
TABLE 3

ITEM RATINGS

<table>
<thead>
<tr>
<th>Item</th>
<th>Relevance</th>
<th>Unambiguity</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. <strong>Attitude toward the Scientist</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The majority of scientists are irreligious.</td>
<td>1.3</td>
<td>1.6</td>
<td>.82</td>
</tr>
<tr>
<td>2. Very often scientists meddle in matters which are inappropriate for scientific methods.</td>
<td>.92</td>
<td>.83</td>
<td>2.0</td>
</tr>
<tr>
<td>3. Scientists make few friends other than their fellow scientists.</td>
<td>1.3</td>
<td>1.5</td>
<td>.9</td>
</tr>
<tr>
<td>4. Girls who are not mechanically inclined should not contemplate becoming scientists.</td>
<td>1.4</td>
<td>1.4</td>
<td>.7</td>
</tr>
<tr>
<td>5. Would you want to be a scientist?</td>
<td>1.6</td>
<td>1.4</td>
<td>3.6</td>
</tr>
<tr>
<td>6. Scientists are more apt to hear out both positions of a controversy than are most other persons.</td>
<td>1.5</td>
<td>1.6</td>
<td>2.2</td>
</tr>
<tr>
<td>7. Creative people should not pursue science as a vocation.</td>
<td>1.6</td>
<td>1.5</td>
<td>.18</td>
</tr>
<tr>
<td>8. With respect to issues not related to science, scientists are apt to be more radical than non-scientists.</td>
<td>1.3</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>9. Most scientific research is conducted by scientists who have little concern for their own personal welfare.</td>
<td>1.5</td>
<td>1.4</td>
<td>.9</td>
</tr>
<tr>
<td>10. Most scientists are very creative thinkers.</td>
<td>1.7</td>
<td>1.5</td>
<td>2.3</td>
</tr>
<tr>
<td>11. Scientists are prompt to acknowledge their errors when they are made aware of them.</td>
<td>1.6</td>
<td>1.4</td>
<td>2.1</td>
</tr>
<tr>
<td>12. Scientists are more apt to have mental problems than other occupational groups.</td>
<td>1.1</td>
<td>.7</td>
<td>.45</td>
</tr>
</tbody>
</table>
TABLE 3--Continued

<table>
<thead>
<tr>
<th>Item</th>
<th>Relevance</th>
<th>Unambiguity</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Scientists are reactionaries.</td>
<td>1.2</td>
<td>1.0</td>
<td>.36</td>
</tr>
<tr>
<td>14. Scientists are apt to be impartial and unprejudiced in other areas of activity as well as in science.</td>
<td>1.6</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>15. Scientists are unbiased and objective in reporting their experimental results because they know other scientists will examine their work.</td>
<td>1.4</td>
<td>1.2</td>
<td>2.4</td>
</tr>
<tr>
<td>16. Scientists are fundamentally magicians.</td>
<td>.91</td>
<td>1.5</td>
<td>.10</td>
</tr>
<tr>
<td>17. Scientists do not have strong patriotic feelings.</td>
<td>.83</td>
<td>.92</td>
<td>.67</td>
</tr>
<tr>
<td>18. The scientist is little concerned about the consequences of his research findings.</td>
<td>1.4</td>
<td>1.5</td>
<td>1.7</td>
</tr>
<tr>
<td>19. Scientists are &quot;oddballs.&quot;</td>
<td>1.2</td>
<td>1.4</td>
<td>.6</td>
</tr>
<tr>
<td>20. Scientists should be viewed with suspicion.</td>
<td>1.1</td>
<td>1.6</td>
<td>.2</td>
</tr>
<tr>
<td>21. Scientists are peculiar people.</td>
<td>1.2</td>
<td>1.3</td>
<td>.5</td>
</tr>
<tr>
<td>22. The majority of scientists are not interested in the practical value of scientific information.</td>
<td>1.6</td>
<td>1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>23. The nation's top scientists are mainly interested in their own current of thought.</td>
<td>1.8</td>
<td>1.1</td>
<td>1.5</td>
</tr>
<tr>
<td>24. Scientists possess great amounts of factual knowledge.</td>
<td>1.5</td>
<td>1.4</td>
<td>2.9</td>
</tr>
<tr>
<td>25. In pursuit of their interests, scientists frequently consent to sacrifice the well-being of others.</td>
<td>1.5</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>26. Developments such as the atomic bomb reveal that scientists have little consideration for mankind.</td>
<td>1.5</td>
<td>1.3</td>
<td>.27</td>
</tr>
<tr>
<td>27. Scientific truths are normally discovered by individuals seeking financial reward.</td>
<td>1.6</td>
<td>1.5</td>
<td>.9</td>
</tr>
</tbody>
</table>

II. Attitude toward Science in General

28. I am enthusiastic about learning more scientific information                                                                           | 1.3       | 1.4         | 3.1      |
TABLE 3—Continued

<table>
<thead>
<tr>
<th>Item</th>
<th>Relevance</th>
<th>Unambiguity</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>29. I am very strongly attracted to scientific activities.</td>
<td>1.6</td>
<td>1.7</td>
<td>3.4</td>
</tr>
<tr>
<td>30. Because science repudiates some religious teachings, it is immoral.</td>
<td>1.1</td>
<td>1.2</td>
<td>.36</td>
</tr>
<tr>
<td>31. Science problems are intriguing.</td>
<td>1.3</td>
<td>1.4</td>
<td>3.5</td>
</tr>
<tr>
<td>32. Science is very hard for me to understand.</td>
<td>1.2</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>33. I wouldn't pursue the study of science independently.</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>34. Science classes are very uninteresting.</td>
<td>1.3</td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td>35. To me science is boring.</td>
<td>1.5</td>
<td>1.6</td>
<td>.46</td>
</tr>
<tr>
<td>36. I enjoy doing science investigations.</td>
<td>1.5</td>
<td>1.6</td>
<td>3.3</td>
</tr>
<tr>
<td>37. I enjoy doing science experiments.</td>
<td>1.5</td>
<td>1.5</td>
<td>3.2</td>
</tr>
</tbody>
</table>

III. Attitude toward the Value of Science

<table>
<thead>
<tr>
<th>Item</th>
<th>Relevance</th>
<th>Unambiguity</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>38. Science is much commotion about nothing.</td>
<td>.75</td>
<td>.92</td>
<td>.20</td>
</tr>
<tr>
<td>39. The study of science enables one to reason more clearly in other subject areas.</td>
<td>1.5</td>
<td>1.7</td>
<td>2.5</td>
</tr>
<tr>
<td>40. Too much importance is attached to the study of science.</td>
<td>1.6</td>
<td>1.6</td>
<td>1.0</td>
</tr>
<tr>
<td>41. Science is little related to everyday living.</td>
<td>1.7</td>
<td>1.8</td>
<td>.27</td>
</tr>
<tr>
<td>42. Scientists' attempts to solve problems of everyday life are typically unrealistic.</td>
<td>1.4</td>
<td>1.0</td>
<td>.88</td>
</tr>
<tr>
<td>43. Scientific questioning should not be used in matters of religion and morals.</td>
<td>1.2</td>
<td>1.0</td>
<td>1.4</td>
</tr>
<tr>
<td>44. The troublesomeness involved in learning science exceeds its usefulness.</td>
<td>1.2</td>
<td>.75</td>
<td>.6</td>
</tr>
<tr>
<td>45. Money should be expended only for scientific research of practical value.</td>
<td>1.4</td>
<td>1.4</td>
<td>.4</td>
</tr>
<tr>
<td>46. A scientific education will certainly help one make more logical decisions.</td>
<td>1.4</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Item</td>
<td>Relevance</td>
<td>Unambiguity</td>
<td>Attitude</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-----------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>IV. Attitude toward Science as a School Subject</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47. Science will enable me to think more clearly in other subject areas.</td>
<td>1.5</td>
<td>1.5</td>
<td>2.3</td>
</tr>
<tr>
<td>48. Science learned in school isn't genuine science.</td>
<td>1.5</td>
<td>1.2</td>
<td>2.4</td>
</tr>
<tr>
<td>49. Science is a very fascinating subject.</td>
<td>1.7</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>50. High school science ought to be compulsory only for those students who wish to become scientists.</td>
<td>1.8</td>
<td>1.8</td>
<td>0.8</td>
</tr>
<tr>
<td>51. I receive gratification from solving science problems.</td>
<td>1.7</td>
<td>1.4</td>
<td>3.6</td>
</tr>
<tr>
<td>52. Science subjects which are not related to school work frequently interest me.</td>
<td>1.8</td>
<td>1.7</td>
<td>3.6</td>
</tr>
<tr>
<td>53. Science is chiefly a program of action for originating new gadgets.</td>
<td>1.5</td>
<td>1.3</td>
<td>0.2</td>
</tr>
<tr>
<td>54. Science is not as important as other subjects.</td>
<td>1.5</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>55. Science is less fascinating than almost any other subject.</td>
<td>1.5</td>
<td>1.7</td>
<td>0.6</td>
</tr>
<tr>
<td>56. I would not recommend the study of science to anyone.</td>
<td>1.3</td>
<td>1.7</td>
<td>0.3</td>
</tr>
<tr>
<td>57. More science should be taught in the elementary school.</td>
<td>1.8</td>
<td>1.8</td>
<td>3.5</td>
</tr>
<tr>
<td>58. I don't want to study any more science.</td>
<td>1.3</td>
<td>1.6</td>
<td>0.2</td>
</tr>
<tr>
<td>59. Science can be pursued profitably only by students of better than average ability.</td>
<td>1.6</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>V. Attitude toward Science's Impact on Society</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60. Science has been mainly responsible for the eradication of ignorance and disease in our society.</td>
<td>1.4</td>
<td>1.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Item</td>
<td>Relevant</td>
<td>Unambiguity</td>
<td>Attitude</td>
</tr>
<tr>
<td>------</td>
<td>----------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>61. Science will find the solutions to our social problems such as mental illness and crime.</td>
<td>1.4</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>62. Science is primarily responsible for our swift economic progress.</td>
<td>1.8</td>
<td>1.1</td>
<td>3.0</td>
</tr>
<tr>
<td>63. Anarchy will likely result from the scientist's disposition to repudiate traditional beliefs.</td>
<td>0.83</td>
<td>0.93</td>
<td>0.6</td>
</tr>
<tr>
<td>64. Science enhances society by utilization of recent scientific information to develop new industries.</td>
<td>1.5</td>
<td>1.2</td>
<td>2.7</td>
</tr>
<tr>
<td>65. A scientific education contributes to good citizenship.</td>
<td>1.6</td>
<td>1.3</td>
<td>3.0</td>
</tr>
<tr>
<td>66. Science has caused chaos in our world.</td>
<td>1.2</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>67. Science is irrelevant in present-day society.</td>
<td>1.3</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>68. Scientists have excessive power in our society.</td>
<td>1.5</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>69. Scientists exert a potent influence over the significant economic, political and social processes.</td>
<td>1.7</td>
<td>1.4</td>
<td>2.3</td>
</tr>
<tr>
<td>70. The utilization of scientific information for the development of weapons has caused much of the evil on the international scene today.</td>
<td>1.4</td>
<td>1.2</td>
<td>0.78</td>
</tr>
<tr>
<td>71. Science causes our mode of living to change too rapidly.</td>
<td>1.3</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>72. Science has not been very beneficial to the average citizen.</td>
<td>1.8</td>
<td>1.4</td>
<td>0.80</td>
</tr>
<tr>
<td>73. Science appears to be a necessary evil in present-day society.</td>
<td>1.2</td>
<td>1.0</td>
<td>0.70</td>
</tr>
<tr>
<td>74. The advancement of science makes possible the control of our lives by a few people.</td>
<td>1.3</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>75. The study of science benefits people socially.</td>
<td>1.4</td>
<td>1.2</td>
<td>2.7</td>
</tr>
</tbody>
</table>
### TABLE 3--Continued

<table>
<thead>
<tr>
<th>Item</th>
<th>Relevancy</th>
<th>Unambiguity</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI. Attitude toward the Nature of Science</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76. Interpretations of scientific observations and measurements entail little possibility for error.</td>
<td>1.8</td>
<td>1.3</td>
<td>.7</td>
</tr>
<tr>
<td>77. Theories and laws of modern science are apt to remain in their present form.</td>
<td>1.8</td>
<td>1.6</td>
<td>.7</td>
</tr>
<tr>
<td>78. It is impossible to set up scientific laws of human conduct.</td>
<td>1.1</td>
<td>.92</td>
<td>1.6</td>
</tr>
<tr>
<td>79. Science aids us in comprehending our surroundings.</td>
<td>1.7</td>
<td>1.6</td>
<td>3.9</td>
</tr>
<tr>
<td>80. Science cannot hope to understand and control human behavior.</td>
<td>1.5</td>
<td>1.4</td>
<td>.9</td>
</tr>
<tr>
<td>81. Most of the science worth knowing can be read in books.</td>
<td>1.4</td>
<td>1.5</td>
<td>.8</td>
</tr>
<tr>
<td>82. Great improvement in all areas of human endeavor could be accomplished by the application of scientific methods.</td>
<td>1.3</td>
<td>1.3</td>
<td>2.2</td>
</tr>
<tr>
<td>83. The objective of science is to profit the human race.</td>
<td>1.5</td>
<td>1.3</td>
<td>1.6</td>
</tr>
<tr>
<td>84. Science will not enable the human mind to comprehend many aspects of our universe.</td>
<td>1.4</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>85. Most scientific discoveries were stumbled upon.</td>
<td>1.4</td>
<td>1.2</td>
<td>.8</td>
</tr>
<tr>
<td>86. Because of the increased use of hazardous radio-active materials scientific work is becoming less attractive.</td>
<td>1.3</td>
<td>1.3</td>
<td>.9</td>
</tr>
<tr>
<td>87. Scientists often make misjudgments which cause much wasted time.</td>
<td>1.3</td>
<td>1.1</td>
<td>2.3</td>
</tr>
<tr>
<td>88. Most discoveries are the outcome of thoughtful experimentation.</td>
<td>1.8</td>
<td>1.8</td>
<td>3.6</td>
</tr>
<tr>
<td>89. Scientific work is boring.</td>
<td>1.4</td>
<td>1.5</td>
<td>.78</td>
</tr>
<tr>
<td>90. Scientific investigations are performed in the laboratory rather than in the real world.</td>
<td>1.4</td>
<td>1.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Item</td>
<td>Relevancy</td>
<td>Unambiguity</td>
<td>Attitude</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-----------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>91. Most great discoveries of the world were found through careful observation rather than by accident.</td>
<td>1.7</td>
<td>1.8</td>
<td>2.7</td>
</tr>
</tbody>
</table>

VII. **Attitude toward Society's Impact on Science**

| 92. Science is essential in this technological age.               | 1.8       | 1.5         | 3.4      |
| 93. A scientific education is imperative in present-day society.  | 1.7       | 1.3         | 2.9      |
| 94. Social climate in the United States is antagonistic toward the cultivation of scientific talent. | 1.5       | 1.2         | 1.0      |
| 95. Presently the human race has little demand for creative scientists because more scientific knowledge is available than is being utilized. | 1.6       | 1.2         | 1.3      |
| 96. Continuance of scientific research necessitates public interest in science. | 1.7       | 1.4         | 3.0      |
| 97. A comprehension of science is essential for my everyday living. | 1.5       | 1.5         | 2.8      |
| 98. A comprehension of the significance of science is necessary to thoroughly appreciate present-day society. | 1.6       | 1.2         | 3.1      |
| 99. Government favoritism toward extraordinary scientific talent is undemocratic. | 1.3       | 1.2         | 1.3      |
Observation of Table 3 (pages 87-93) reveals that item numbers 2, 12, 13, 16, 17, 20, 30, 38, 44, 63, 78, and 87 received low relevancy ratings or high ambiguity ratings. The items with low relevancy ratings indicated that the jury believed these items to be less than "somewhat relevant;" and therefore, these items were discarded. High ambiguity ratings indicated the jury considered these items to be less than "fairly clear." Those items considered less than "fairly clear" were either discarded or modified to remove the ambiguities. In addition, a few items were discarded because they were essentially duplicate of other items. Upon completion of the preceding item selection process, 87 items remained for further refinement of the scale. This 87 item scale is shown in Appendix D.

Items with ratings in the attitude rating class of 2.0 or less were considered negative and those above 2.0 were designated as positive.

Results from the Second Refinement of the Scale

The remaining 87 item scale was administered to a total population of 349 students enrolled in elementary science methods courses—124 at The Ohio State University, 130 at the University of Houston, 64 at Indiana University, and 31 at the University of Texas.
The results from the item analysis performed on the IBM 1620 computer led to the selection of the items shown on Table 4 (page 96). Notice there are only 67 items; those items with lower than a 0.1579 item reliability were considered not to be sufficiently reliable and were discarded. Observation of Table 4 reveals that the items retained for the final scale have item reliabilities ranging from 0.1579 to 0.6048. The Kuder-Richardson reliability coefficient for the 67 item scale is 0.9150.

Results of the Construct Validity Measure

An attempt to obtain a measure of construct validity was performed using 24 science participants in the National Science Foundation Academic Year Institute for science and mathematics teachers conducted at The Ohio State University. Table 5 (page 97) shows the results of the item analysis performed upon data obtained from the Academic Year Institute participants.

Observation of Table 4 and Table 5 shows that the same 67 items were considered sufficiently reliable for the Academic Year Institute participants and the elementary science methods students. The Kuder-Richardson reliability coefficient of the 67 item scale for the Academic Year Institute participants is 0.9214.

Consultation with Dr. Whitney, Director of The Ohio

2See Appendix E
TABLE 4

ITEM RELIABILITIES OF THE FINAL SCALE

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<thead>
<tr>
<th>Item Number</th>
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Scale Reliability 0.9150
TABLE 5

ITEM RELIABILITIES FOR THE ACADEMIC YEAR INSTITUTE PARTICIPANTS

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<td>0.7479</td>
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</tbody>
</table>

Scale Reliability 0.9214
State University Statistics Laboratory, led to the method (described below) used to compare the two groups. The means of the two groups were compared by establishing confidence intervals for the mean using the following relations:

\[ \sigma_{M}^{2} = \text{Variance of the mean} = \frac{(1 - r) s^2}{n} \]

\[ r = \text{Reliability coefficient of Attitude Scale} \]

\[ s = \text{Variance of the group} \]

\[ n = \text{Number of the group} \]

\[ \sigma_{M} = \text{Standard error of the mean} = \frac{\sqrt{1 - r}}{\sqrt{n}} s \]

The 99 per cent confidence interval for the mean of the Academic Year Institute group is calculated below:

\[ \sigma_{x}^{2} = \frac{(1 - .921)(488.33)}{24} \]

\[ M = \frac{\sqrt{0.079}(22.098)}{\sqrt{24}} \]

\[ \sigma_{M} = 1.28 \]

The 99.9 per cent confidence limit is established by adding or subtracting the 3.10 standard error of the mean from the mean. Since the mean is 203.08 the confidence interval is given below:

\[ 203.08 \pm 3.10 (1.28) \]

or

\[ 199.11 \text{ to } 207.05 \]

Thus, the probability is approximately .99 that the true
value of the mean is covered by the interval 199.11 to 207.05.

Similarly the confidence interval for the mean of the elementary science methods group is calculated as follows:

\[ \sigma^2 = \text{Variance of the mean} = \frac{(1 - \rho)s^2}{n} \]

\[ \sigma_M = \text{Standard error of the mean} = \frac{(\sqrt{1 - \rho})s}{\sqrt{n}} \]

\[ \sigma^2 = (1 - .915)(498.62) \]

\[ \sigma_M = \frac{\sqrt{.085}(22.33)}{18.3} \]

\[ \sigma_M = .356 \]

The 99.9 per cent confidence interval is 183.85 ± 3.10(.356) or 182.75 to 184.95.

Note that the lower limit of the mean for the Academic Year Institute group (199.11) does not overlap the upper limit of the mean for the elementary science methods group (184.95). Therefore, observation of the means and the confidence intervals of the two groups reveals that the Academic Year Institute group scored significantly higher than the elementary science methods group on the attitude scale. This comparison confirms the assumption that the Academic Year Institute group have more positive attitudes toward science than the elementary science methods group. In addition, the comparison provides a measure of construct validity by showing that the instru-
ment validly measures the difference between the two groups.

Summary

In this chapter the results of the study have been presented. Special attention was given to the results of the following aspects of the study: (1) the first refinement; (2) the Attitude Rating Scale; (3) the second refinement; and (4) the construct validity measure.

Chapter V presents a summary of the study along with the investigator's conclusions and implications for further study.
CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Summary

Chapter V will be presented in the following manner:

I. Summary
   A. Purpose of the study
   B. Hypothesis of the study
   C. Procedures and results of the study
      1. The item pool
      2. First refinement of the scale
      3. Attitude Item Rating Scale
      4. Second refinement of the scale
      5. Construct validity of the scale

II. Conclusions
   A. Hypothesis
   B. Reliability
   C. Content validity
   D. Construct validity

III. Implications for Further Study

Purpose of the study

The purpose of this study was to develop a reliable and valid instrument to measure the attitudes toward science and scientists of students enrolled in elementary science methods courses.

Hypothesis of the study

In view of the stated purpose of the study, the
investigator hypothesized the following: an instrument can be developed which will provide reliable and valid measurements of the attitudes toward science and scientists of students enrolled in elementary science methods courses.

**Procedures and results of the study**

**The item pool.** To accomplish the purpose of this study, the investigator began by obtaining an item pool. The item pool was obtained (with constructors' permission) from other instruments designed to measure attitudes toward science and scientists. These items were modified to create 139 new items by close attention to attitude item criteria and nature of the population for which the scale was being prepared.

**First refinement.** For the initial refinement of the attitude scale, it was administered to 128 students enrolled in elementary science methods courses at The Ohio State University. Item analysis performed upon the data obtained from this sample revealed that 99 items of the 139 were sufficiently reliable to merit further refinement.

**Attitude Item Rating Scale.** To increase content validity, remove ambiguities and determine the positiveness and negativeness of items, an Attitude Item Rating Scale was developed. The Attitude Item Rating Scale contained
three rating classes—relevancy, unambiguity, and attitude.

A panel of experts, six scientists and six science educators, rated each item as follows: (1) with respect to relevancy—relevant, somewhat relevant or irrelevant; (2) with respect to unambiguity—unambiguous, fairly clear, or ambiguous; and (3) with respect to attitude—strongly agree, agree, neutral, disagree, or strongly disagree. Those items which did not rate at least "somewhat relevant" by the panel of experts were discarded. Items rating less than "fairly clear" were modified to remove ambiguities or were discarded.

Second refinement. Applying the criteria mentioned above for retention, 87 items were selected for further refinement. In order to obtain a measure of the reliabilities of the 87 items, the items were arranged randomly into a Likert-type scale. Through consultation with the writer's advisors, samples of elementary science methods students were selected from the University of Texas, the University of Houston, Indiana University and The Ohio State University. The scale was administered to each group of students during the eighth or ninth week of the course in elementary science methods. Results of the item analysis performed upon the data received from this group of 349 students, revealed that 67 items were sufficiently reliable to be retained for the final scale.
Construct validity. Having selected reliable items and items with content validity, the investigator attempted to obtain a measure of construct validity. The investigator postulated that the group of science participants in the National Science Foundation Academic Year Institute for science and mathematics teachers conducted at The Ohio State University would have more positive attitudes toward science and scientists than would the elementary science methods students. In order to obtain a measure of construct validity, the scale was administered to 24 members of the Academic Year Institute. The item analysis of this data revealed the same 67 items out of the 87 item scale were sufficiently reliable for this sample.

In Chapter IV the means of the Academic Year Institute group and the elementary science methods group were compared using 99.9 per cent confidence intervals about the means. The 99.9 per cent confidence limits of the means for the Academic Year Institute group and the elementary science methods group are respectively 199.11 to 207.05 and 182.75 to 184.95. Since the lower limit (199.11) for the Academic Year Institute group does not overlap the upper limit of the mean (184.95) for the elementary science group, the investigator concluded that the two groups were significantly different at the .001 level. Therefore since we have shown the responses of the two groups are
different at the .001 level and that the Academic Year Institute mean is higher than the elementary science methods group mean, the writer concludes that the Academic Year Institute group scored significantly higher on the attitude scale than the elementary science methods group.

In view of the nature of the two groups, one would expect the Academic Year Institute group to score higher than the elementary science methods group. Since the instrument did measure a significant difference between the two groups in favor of the Academic Year Institute group, the investigator concludes the instrument validly measures the difference between the two groups. Therefore, the writer concludes that the instrument has a measure of construct validity.

Conclusions

Several conclusions can be drawn from the data presented in Chapter IV relative to the hypothesis stated below.

Hypothesis

An instrument can be developed which will provide reliable and valid measurement of the attitudes toward science and scientists of students enrolled in elementary science methods courses.

Reliability

Concerning the reliability of the attitude scale, it can be stated that a reliability of 0.9150 is sufficient to provide a reliable measurement of the attitudes of elementary
science methods students toward science and scientists.

Content validity

With respect to the question of content validity, the judgments of the panel of six scientists and six science educators provided sufficient data to reject those items which were irrelevant. Therefore, it can be stated that the instrument has sufficient content validity to measure validly the attitudes of elementary science methods students toward science and scientists.

Construct validity

Since it has been shown that the instrument measures the expected difference between the Academic Year Institute group and the elementary science group, the investigator concludes the instrument has a measure of construct validity.

In summation of the above conclusions, it can be stated that a reliable and valid instrument to measure elementary science methods students' attitudes toward science and scientists can be developed by the methods used in this study.

Implications for Further Study

Since this study was rather limited in scope, there are several implications for further study. Among the implications for further study are the following:

1. A follow-up of this study should be conducted using random sampling procedures to develop norms which would be applicable to a large population of elementary,
2. A study defining the components of a generalized attitude toward science and scientists which could be used to help insure content validity of a scale to measure attitudes toward science and scientists.

3. A study identifying the relative importance of the various components of a generalized attitude toward science.

4. A study to identify the behaviors of instructors of courses in elementary science methods which are positively associated with positive growth of elementary science methods students' attitudes toward science and scientists.

5. Studies in which the various methods of changing attitudes are evaluated to determine their effectiveness in promoting the development of positive attitudes toward science and scientists.

6. Studies to evaluate the effects of teachers' attitudes toward science and scientists on children at various school levels.

7. Studies evaluating the differences in perception of attitudes toward science and scientists between certain groups (scientists, science educators, science philosophers, and science teachers) which are considered to possess positive attitudes toward science and scientists.
APPENDIX A

INITIAL ATTITUDE SCALE

FORM A
ATTITUDES TOWARD SCIENCE AND SCIENTISTS

INSTRUCTIONS:

Please give your reactions to the following list of statements regarding science, scientists, and scientific careers. Work rapidly. Record your first impression—the feeling that comes to mind as you read the item. Feel free to express yourself because you have complete anonymity since you are not required to place your name on the answer sheet.

You must USE A PENCIL to mark your answer sheet and be sure to erase completely if it is necessary to change your response.

ON THE ANSWER SHEET PROVIDED, PLEASE MARK:

A if you strongly agree with the item
B if you are in agreement
C if you are neutral
D if you disagree
E if you strongly disagree

EXAMPLE:

A B C D E In the springtime Paris is more beautiful than New York. (Since B is marked, this indicates you are in agreement.)

Please designate Form A on the answer sheet.
1. Too much importance is attached to the study of science.
2. Science is boresome.
3. Science is a very fascinating subject.
4. Science is much commotion about nothing.
5. Science has caused chaos in our world.
6. Scientific knowledge contributes toward good citizenship.
7. Science undermines one's beliefs of right and wrong.
8. Most scientists are more brilliant than farmers, businessmen and lawyers.
9. The majority of scientists are irreligious.
10. Great devotion and strength of purpose are required to become a successful scientist.
11. Frequently scientists have physical deformities or handicaps.
12. Carefully designed experiments can enable scientists to answer any simple question about nature.
13. Most great discoveries of the world were found through careful observation rather than by accident.
14. The famous scientists of the past often used intuition.
15. Industrial research is frequently conducted by groups of scientists as a team.
16. Money should be expended only for scientific research of practical value.
17. I receive gratification from solving science problems.
18. I would not recommend the study of science to anyone.
19. The amount of science taught in our schools should be increased.
20. Science has not been very beneficial to the average citizen.
21. Scientific research should be designed and conducted to fulfill the current needs of society.
22. The study of science benefits people socially.
23. Most scientists are highly intelligent.
24. Very often scientists meddle in matters which are inappropriate for scientific methods.
25. A scientist cannot have a normal family and home life.
26. Would you want to be a scientist?
27. Scientific work is "humdrum."
28. Most scientific discoveries are stumbled upon by accident.
29. Experimentation is necessary in order to learn science.
30. Progress in science is comprised of the collection and organization of accurate data.
31. Most of the science worth knowing can be read in books.
32. Whatever happens, science always takes precedence.
33. Science is not as important as other subjects.
34. Science can be pursued profitably only by students of better than average ability.
35. Science appears to be a necessary evil in present day society.
36. The advancement of science makes possible the control of our lives by a few people.
37. Presently the human race has little demand for creative scientists because more scientific knowledge is available than is being utilized.
38. Scientists should be viewed with suspicion.
39. Scientists are commonly unfriendly.
40. Girls who are not mechanically inclined should not contemplate becoming scientists.
41. Imaginative and creative people should not pursue science as a vocation.

42. Physical endurance is not required for scientific work.

43. I detest small crawling things such as worms, bugs, and mice.

44. Scientists often make misjudgments which cause much wasted time.

45. Because science repudiates some religious teachings, it is immoral.

46. Science aids us in comprehending our surroundings.

47. Scientists are reactionaries.

48. A scientific education will certainly help one make more logical decisions.

49. I wouldn't pursue science independently.

50. I look forward to the study of science with great apprehension.

51. Science subjects which are not related to school work frequently interest me.

52. Social climate in the United States is antagonistic toward the cultivation of scientific talent.

53. Science has been mainly responsible for the eradication of ignorance and disease in our society.

54. Science is primarily responsible for our swift economic progress.

55. With respect to issues not related to science, scientists are apt to be more radical than non-scientists.

56. Scientists are more apt to hear out both positions of a controversy than are most other persons.

57. The university scientist has little to contribute to the practical problems of everyday living.
58. In pursuit of their interests, scientists frequently consent to sacrifice the well-being of others.

59. Science will not enable the human mind to comprehend many aspects of our universe.

60. Because of the increased use of hazardous radioactive materials scientific work is becoming less attractive.

61. Science is chiefly a program of action for originating new gadgets.

62. Great improvement in all areas of human endeavor could be accomplished by the application of scientific methods.

63. The troublesomeness involved in learning science exceeds its usefulness.

64. I am enthusiastic about learning more science.

65. Science will find the solutions to our social problems such as mental illness and crime.

66. The government should exercise control over scientific discoveries.

67. Interpretation of scientific observations and measurements entails little possibility for error.

68. The real important scientific discoveries have been fortuitous.

69. The majority of scientists desire to develop products which will improve our standard of living.

70. Scientists are peculiar people.
APPENDIX B

INITIAL ATTITUDE SCALE

FORM B
ATTITUDES TOWARD SCIENCE AND SCIENTISTS

INSTRUCTIONS:

Please give your reactions to the following list of statements regarding science, scientists, and scientific careers. Work rapidly. Record your first impression—the feeling that comes to mind as you read the item. Feel free to express yourself because you have complete anonymity since you are not required to place your name on the answer sheet.

You must USE A PENCIL to mark your answer sheet and be sure to erase completely if it is necessary to change your response.

ON THE ANSWER SHEET PROVIDED, PLEASE MARK

A if you strongly agree with the item
B if you are in agreement
C if you are neutral
D if you disagree
E if you strongly disagree

EXAMPLE:

A B C D E In the Springtime Paris is more beautiful than New York. (Since B is marked, this indicates you are in agreement.)

Please designate Form B on the answer sheet
1. A scientific education is the best education for impartial thinking.
2. I am always partial to learning more science.
3. Most scientists are very creative thinkers.
5. Scientists are timid, lonesome individuals.
6. Developments such as the atomic bomb reveal that scientists have little consideration for mankind.
7. Scientific investigations are performed in the laboratory rather than in the real world.
8. Scientific research funds should be concentrated on engineering development and the application of scientific principles to practical problems.
9. Most scientific research is conducted by scientists who have little concern for their own personal welfare.
10. Scientific research work is boring.
12. Science enhances society by utilization of recent scientific information to develop new industries.
13. Science's primary function in society is to make life more pleasant through better use of natural resources.
15. Science is less fascinating than almost any other subject.
16. A comprehension of science is essential for my everyday living.
17. Science problems are intriguing.
18. Scientific questioning should not be used in matters of religion and morals.
19. Science cannot hope to understand and control human behavior.
20. Theories and laws of modern science are apt to remain in their present form.

21. Science is little related to everyday living.

22. Science is very hard to understand.

23. More science should be taught in the elementary school.

24. Scientists are prompt to acknowledge their errors when they are made aware of them.

25. Scientists are more apt to have mental problems than other occupational groups.

26. Scientists are apt to be impartial and unprejudiced in other areas of activity as well as in science.

27. Scientists' attempts to solve problems of everyday life are typically unrealistic.

28. Scientists are unbiased and objective in reporting their experimental results because they know other scientists will examine their work.

29. It is impossible to set up scientific laws of human conduct.

30. Numerous discoveries in science are contrary to the Laws of God.

31. Science is irrelevant to everyday living.

32. The objective of science is to profit the human race.

33. Scientific knowledge is accumulated by consistent step by step employment of the scientific method.

34. The federal government should finance and direct scientific research because of its importance to national survival.

35. Science's most important function in society is to extend man's control over his environment.

36. Scientists exert a potent influence over the significant economic, political and social processes.
37. The utilization of scientific information for the development of weapons has caused much of the evil on the international scene today.

38. I don't want to study anymore science.

39. Science will enable me to think more clearly in other subject areas.

40. I am very strongly attracted by science.

41. Scientists are fundamentally magicians.

42. Scientists are apt to be more rational in solving problems outside their field than are other professionals.

43. Scientists do not have strong patriotic feelings.

44. Scientific discoveries are usually the result of the perseverance and understanding of the observer.

45. The significant developments in science are the manufacture of useful consumer products.

46. Most scientific discoveries were stumbled upon.

47. I enjoy doing science investigations.

48. Most discoveries are the outcome of thoughtful experimentation.

49. Instead of developing a scientifically literate citizenry to make decisions on scientific matters, we should accept the judgment of scientists.

50. Science is irrelevant in present-day society.

51. Science causes our mode of living to change too rapidly.

52. Scientists have excessive power in our society.

53. Anarchy will likely result from the scientist's disposition to repudiate traditional beliefs.

54. Scientists are "oddballs."

55. The majority of scientists are not interested in the practical value of scientific information.
56. Because of government secrecy pertaining to certain research findings, United States scientists will soon outclass other countries in the competition of new knowledge.

57. The nation's top scientists are mainly interested in their own current of thought.

58. The study of science enables one to reason more clearly in other subject areas.

59. Science classes are very uninteresting.

60. Scientists are walking encyclopedias.

61. The scientist is little concerned about the consequences of his research findings.

62. A comprehension of the significance of science is necessary to thoroughly appreciate present-day society.

63. Continuance of scientific research necessitates public interest in science.

64. Scientific truths are normally discovered by individuals seeking financial reward.

65. High school science ought to be compulsory only for those students who wish to become scientists.

66. Science is essential in this technological age.

67. A scientific education contributes to good citizenship.

68. The actual existence of science hinges on the capacity of experimental scientists to communicate quickly with one another.

69. A scientific education is imperative in present-day society.
APPENDIX C

ATTITUDE ITEM RATING SCALE
ATTITUDE ITEM RATING SCALE

DIRECTIONS: Please circle the appropriate response in each rating class.

<table>
<thead>
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<th>Relevancy</th>
<th>Unambiguity</th>
<th>Attitude</th>
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</thead>
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<tr>
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<td>A</td>
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<td>D</td>
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<tr>
<td></td>
<td></td>
<td>SD</td>
</tr>
</tbody>
</table>

EXAMPLE: Scientists are apt to be more rational in solving problems outside their field than are professionals.

I. Attitude toward the Scientist

1. The majority of scientists are irreligious.
   - Relevancy: HR SR I
   - Unambiguity: U FC Am
   - Attitude: SA A N D SD

2. Very often scientists meddle in matters which are inappropriate for scientific methods.
   - Relevancy: HR SR I
   - Unambiguity: U FC Am
   - Attitude: SA A N D SD

3. Scientists make few friends other than their fellow scientists.
   - Relevancy: HR SR I
   - Unambiguity: U FC Am
   - Attitude: SA A N D SD

4. Girls who are not mechanically inclined should not contemplate becoming scientists.
   - Relevancy: HR SR I
   - Unambiguity: U FC Am
   - Attitude: SA A N D SD

5. Would you want to be a scientist?
   - Relevancy: HR SR I
   - Unambiguity: U FC Am
   - Attitude: SA A N D SD

6. Scientists are more apt to hear out both positions of a controversy than are most other persons.
   - Relevancy: HR SR I
   - Unambiguity: U FC Am
   - Attitude: SA A N D SD

7. Creative people should not pursue science as a vocation.
   - Relevancy: HR SR I
   - Unambiguity: U FC Am
   - Attitude: SA A N D SD

8. With respect to issues not related to science, scientists are apt to be more radical than non-scientists.
   - Relevancy: HR SR I
   - Unambiguity: U FC Am
   - Attitude: SA A N D SD
9. Most scientific research is conducted by scientists who have little concern for their own personal welfare.  
10. Most scientists are very creative thinkers.  
11. Scientists are prompt to acknowledge their errors when they are made aware of them.  
12. Scientists are more apt to have mental problems than other occupational groups.  
13. Scientists are reactionaries.  
14. Scientists are apt to be impartial and unprejudiced in other areas of activity as well as in science.  
15. Scientists are unbiased and objective in reporting their experimental results because they know other scientists will examine their work.  
16. Scientists are fundamentally magicians.  
17. Scientists do not have strong patriotic feelings.  
18. The scientist is little concerned about the consequences of his research findings.  
19. Scientists are "oddballs."  
20. Scientists should be viewed with suspicion.  
21. Scientists are peculiar people.  
22. The majority of scientists are not interested in the practical value of scientific information.  
23. The nation's top scientists are mainly interested in their own current of thought.  
24. Scientists possess great amounts of factual knowledge.  
25. In pursuit of their interests, scientists frequently consent to sacrifice the well-being of others.

<table>
<thead>
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<th>Item</th>
<th>Relevancy</th>
<th>Unambiguity</th>
<th>Attitude</th>
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<td>SA A N D SD</td>
</tr>
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<td>25</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
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</table>
## Item

26. Developments such as the atomic bomb reveal that scientists have little consideration for mankind.

27. Scientific truths are normally discovered by individuals seeking financial reward.

### II. Attitude toward Science in General

28. I am enthusiastic about learning more scientific information.

29. I am very strongly attracted to scientific activities.

30. Because science repudiates some religious teachings, it is immoral.

31. Science problems are intriguing.

32. Science is very hard for me to understand.

33. I wouldn't pursue the study of science independently.

34. Science classes are very uninteresting.

35. To me science is boring.

36. I enjoy doing science investigations.

37. I enjoy doing science experiments.

### III. Attitude toward the Value of Science

38. Science is much commotion about nothing.

39. The study of science enables one to reason more clearly in other subject areas.

40. Too much importance is attached to the study of science.

<table>
<thead>
<tr>
<th>Item</th>
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<th>Attitude</th>
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<td>36</td>
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<td>37</td>
<td>HR SR I</td>
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<td>38</td>
<td>HR SR I</td>
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<tr>
<td>39</td>
<td>HR SR I</td>
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<tr>
<td>40</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
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</tbody>
</table>
41. Science is little related to everyday living.
42. Scientists attempts to solve problems of everyday life are typically unrealistic.
43. Scientific questioning should not be used in matters of religion and morals.
44. The troublesomeness involved in learning science exceeds its usefulness.
45. Money should be expended only for scientific research of practical value.
46. A scientific education will certainly help one make more logical decisions.

IV. Attitude toward Science as a School Subject

47. Science will enable me to think more clearly in other subject areas.
48. Science learned in school isn't genuine science.
49. Science is a very fascinating subject.
50. High school science ought to be compulsory only for those students who wish to become scientists.
51. I receive gratification from solving science problems.
52. Science subjects which are not related to school work frequently interest me.
53. Science is chiefly a program of action for originating new gadgets.
54. Science is not as important as other subjects.
55. Science is less fascinating than almost any other subject.
56. I would not recommend the study of science to anyone.
57. More science should be taught in the elementary school.
58. I don't want to study any more science.
59. Science can be pursued profitably only by students of better than average ability.

V. Attitude toward Science's Impact on Society

60. Science has been mainly responsible for the eradication of ignorance and disease in our society.
61. Science will find the solutions to our social problems such as mental illness and crime.
62. Science is primarily responsible for our swift economic progress.
63. Anarchy will likely result from the scientists disposition to repudiate traditional beliefs.
64. Science enhances society by utilization of recent scientific information to develop new industries.
65. A scientific education contributes to good citizenship.
66. Science has caused chaos in our world.
67. Science is irrelevant in present day society.
68. Scientists have excessive power in our society.
69. Scientists exert a potent influence over the significant economic, political and social processes.
70. The utilization of scientific information for the development of weapons has caused much of the evil on the international scene today.
<table>
<thead>
<tr>
<th>Item</th>
<th>Relevancy</th>
<th>Unambiguity</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>71. Science causes our mode of living to change too rapidly.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
</tr>
<tr>
<td>72. Science has not been very beneficial to the average citizen.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
</tr>
<tr>
<td>73. Science appears to be a necessary evil in present day society.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
</tr>
<tr>
<td>74. The advancement of science makes possible the control of our lives by a few people.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
</tr>
<tr>
<td>75. The study of science benefits people socially.</td>
<td>HR SR I</td>
<td>U FC Am</td>
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</tr>
<tr>
<td>VI. Attitude toward the Nature of Science</td>
<td></td>
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</tr>
<tr>
<td>76. Interpretations of scientific observation and measurements entails little possibility for error.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
</tr>
<tr>
<td>77. Theories and laws of modern science are apt to remain in their present form.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
</tr>
<tr>
<td>78. It is impossible to set up scientific laws of human conduct.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>79. Science aids us in comprehending our surroundings.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>80. Science cannot hope to understand and control human behavior.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
</tr>
<tr>
<td>81. Most of the science worth knowing can be read in books.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
</tr>
<tr>
<td>82. Great improvement in all areas of human endeavor could be accomplished by the application of scientific methods.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
</tr>
<tr>
<td>83. The objective of science is to profit the human race.</td>
<td>HR SR I</td>
<td>U FC Am</td>
<td>SA A N D SD</td>
</tr>
<tr>
<td>84. Science will not enable the human mind to comprehend many aspects of our universe.</td>
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<td>U FC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>Item</td>
<td>Relevance</td>
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<td>85. Most scientific discoveries were stumbled upon.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>86. Because of the increased use of hazardous radioactive materials scientific work is becoming less attractive.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>87. Scientists often make misjudgments which cause much wasted time.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>88. Most discoveries are the outcome of thoughtful experimentation.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>89. Scientific work is boring.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>90. Scientific investigations are performed in the laboratory rather than in the real world.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>91. Most great discoveries of the world were found through careful observation rather than by accident.</td>
<td>HR SR I U PC Am</td>
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</table>

VII. Attitude toward Society's Impact on Science

<table>
<thead>
<tr>
<th>Item</th>
<th>Relevance</th>
<th>Ambiguity</th>
<th>Attitude</th>
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<tr>
<td>92. Science is essential in this technological age.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>93. A scientific education is imperative in present-day society.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
<td></td>
</tr>
<tr>
<td>94. Social climate in the United States is antagonistic toward the cultivation of scientific talent.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>95. Presently the human race has little demand for creative scientists because more scientific knowledge is available than is being utilized.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>96. A comprehension of science is essential for my everyday living.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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</tr>
<tr>
<td>97. Continuance of scientific research necessitates public interest in science.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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<tr>
<td>98. A comprehension of the significance of science is necessary to thoroughly appreciate present day society.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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</tr>
<tr>
<td>99. Government favoritism toward extraordinary scientific talent is undemocratic.</td>
<td>HR SR I U PC Am</td>
<td>SA A N D SD</td>
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APPENDIX D

SECOND MODIFICATION OF ATTITUDE SCALE
ATTITUDES TOWARD SCIENCE AND SCIENTISTS

INSTRUCTIONS:

Please give your reactions to the following list of statements regarding science, scientists, and scientific careers. Work rapidly. Record your first impression—the feeling that comes to mind as you read the item. Feel free to express yourself because you have complete anonymity since you are not required to place your name on the answer sheet.

You must USE A PENCIL to make a heavy mark on your answer sheet. Be sure to erase completely if it is necessary to change your response.

ON THE ANSWER SHEET PROVIDED, PLEASE MARK:

A If you strongly agree with the item
B If you are in agreement
C If you are neutral
D If you disagree
E If you strongly disagree

EXAMPLE:

A  B  C  D  E Scientists are apt to be more rational in solving problems outside their field than are other professionals. (Since B is marked, this indicates you are in agreement.)

Please designate Form A on the answer sheet.
1. The majority of scientists are irreligious.

2. Scientists are apt to take more extreme positions on social issues than are historians.

3. Scientists are apt to be impartial and unprejudiced in most areas of everyday living.

4. I am very strongly attracted to scientific activities.

5. Methods of scientific questioning have little value in matters of religion and morals.

6. Most science learned in school isn't real science.

7. More science should be taught in the elementary school.

8. Science has been responsible for the eradication of some diseases in our society.

9. Science has caused chaos in our world.

10. Theories and laws of modern science are apt to remain in their present form.

11. Most discoveries are the outcome of thoughtful experimentation.

12. Science is essential in this technological age.

13. Most scientists make few friends other than their fellow scientists.

14. Those girls who are not mechanically inclined should not contemplate becoming scientists.

15. Scientists are usually unbiased and objective in reporting their experimental results because they know other scientists will examine their work.

16. I am enthusiastic about learning more scientific information.

17. Educators attach too much importance to the study of science.

18. Science will enable me to think more clearly in most other subject areas.
19. Science is less interesting than most other school subjects.

20. Scientific methods will find the solutions to our social problems such as crime.

21. Science causes our way of life to change too rapidly.

22. Science aids us in comprehending our surroundings.

23. Scientific work is boring.

24. At present the human race has little demand for creative scientists.

25. I would not like to be a research scientist.

26. Scientists are more likely to hear out both sides of a social controversy than are most businessmen.

27. People possessing creative imaginations should not pursue science as a vocation.

28. Most scientists are little concerned about the harmful consequences of later applications of their research findings.

29. Scientific research problems are intriguing.

30. The study of science enables one to reason more clearly in other areas such as politics.

31. Science has not been very beneficial to the average citizen.

32. Science is a very fascinating subject.

33. High school science ought to be compulsory only for those students who wish to become scientists.

34. Science is primarily responsible for our rapid economic progress.

35. Science is irrelevant in present-day society.

36. Scientists have a potent influence over the significant economic, political and social processes.

37. It is extremely difficult to set up scientific laws of human conduct.
38. Most scientific investigations are performed in the laboratory rather than in the everyday world.

39. An education in science is imperative in present-day society.

40. Government favoritism toward extraordinary scientific talent is undemocratic.

41. Most scientific research is conducted by scientists who have little concern for their own personal physical welfare.

42. Most scientists are very creative thinkers.

43. Scientific knowledge is very hard for me to understand.

44. Science is little related to everyday living.

45. I enjoy solving science problems in the school laboratory.

46. Only students of better than average ability can be successful in school science courses.

47. Science helps society by using recently discovered scientific information to develop new industries.

48. The utilization of scientific information for the development of weapons has brought about many of the problems on the international scene today.

49. Interpretations of scientific observations and measurements entails little possibility for errors.

50. The social climate in the United States is essentially antagonistic toward the cultivation of scientific talent.

51. Most scientists are prompt to acknowledge their errors in any phase of living when they are made aware of them.

52. Scientists possess voluminous amounts of factual knowledge.

53. I wouldn't like to pursue a science research project.
54. Scientists' attempts to solve their personal problems of everyday living are often unrealistic.

55. Science information which is not related to school work frequently interests me.

56. An education in science contributes toward good citizenship.

57. The study of science benefits people socially.

58. The methods of science are not applicable to understanding human behavior.

59. The methods of science will not enable the human mind to comprehend many aspects of our universe.

60. A comprehension of the significance of science is necessary to thoroughly appreciate present-day society.

61. Scientists are often eccentric in their personal behavior.

62. Scientific truths are normally discovered by individuals seeking financial gain.

63. I enjoy doing science investigations.

64. The difficulties involved in learning science often exceed its usefulness.

65. To me science classes are very uninteresting.

66. I enjoy doing science laboratory experiments.

67. Scientists exert excessive power in our society.

68. Great improvement in all areas of human endeavor could be accomplished by the application of scientific methods.

69. Most of the science worth knowing can be read in books.

70. Most scientific discoveries were accidental.

71. A comprehension of science is essential for my everyday living.

72. The majority of scientists are not interested in the practical value of scientific information.
73. The nation's top scientists are mainly interested in their own current of thought.

74. Science is chiefly a program of action for originating new gadgets.

75. An education in science frequently helps one make more logical decisions in everyday living.

76. Science is not as important as other school subjects such as English.

77. Science appears to be necessary in our present-day society.

78. A primary objective of science is to benefit the human race.

79. Because of the increased use of hazardous radioactive materials scientific work is becoming less attractive.

80. Public interest in science is necessary for the continuance of scientific research.

81. In pursuit of their interests, scientists often consent to sacrifice the well-being of others.

82. Money should be expended only for scientific research of practical value.

83. I would not recommend high school science to beginning high school students.

84. The advancement of science makes possible the control of our lives by a few people.

85. Most great discoveries of the world were found through careful observation rather than by accident.

86. Scientists have shown their lack of consideration for the welfare of mankind by participating in such research as the development of nuclear weapons.

87. I would prefer not to take any college science courses.
APPENDIX E

FINAL ATTITUDE SCALE
ATTITUDES TOWARD SCIENCE AND SCIENTISTS

INSTRUCTIONS:

Please give your reactions to the following list of statements regarding science, scientists, and scientific careers. Work rapidly. Record your first impression—the feeling that comes to mind as you read the item. Feel free to express yourself because you have complete anonymity since you are not required to place your name on the answer sheet.

You must USE A PENCIL to make a heavy mark on your answer sheet. Be sure to erase completely if it is necessary to change your response.

ON THE ANSWER SHEET PROVIDED, PLEASE MARK:

A if you strongly agree with the item
B if you are in agreement
C if you are neutral
D if you disagree
E if you strongly disagree

EXAMPLE:

A  B  C  D  E
//  //  //  //

Scientists are apt to be more rational in solving problems outside their field than are other professionals. (Since B is marked this indicates you are in agreement.)
1. The majority of scientists are irreligious.
2. I am very strongly attracted to scientific activities.
3. More science should be taught in the elementary school.
4. Science has caused chaos in our world.
5. Theories and laws of modern science are apt to remain in their present form.
6. Science is essential in this technological age.
7. Most scientists make few friends other than their fellow scientists.
8. Those girls who are not mechanically inclined should not contemplate becoming scientists.
9. I am enthusiastic about learning more scientific information.
10. Educators attach too much importance to the study of science.
11. Science will enable me to think more clearly in most other subject areas.
12. Science is less interesting than most other school subjects.
13. Scientific methods will find the solutions to our social problems such as crime.
14. Science causes our way of life to change too rapidly.
15. Science aids us in comprehending our surroundings.
16. Scientific work is boring.
17. I would not like to be a research scientist.
18. People possessing creative imaginations should not pursue science as a vocation.
19. Most scientists are little concerned about the harmful consequences of later applications of their research findings.
20. Scientific research problems are intriguing.
21. The study of science enables one to reason more clearly in other areas such as politics.

22. Science has not been very beneficial to the average citizen.

23. Science is a very fascinating subject.

24. High school science ought to be compulsory only for those students who wish to become scientists.

25. Science is irrelevant in present-day society.

26. Scientists have a potent influence over the significant economic, political and social processes.

27. Most scientific investigations are performed in the laboratory rather than in the everyday world.

28. An education in science is imperative in present-day society.

29. Government favoritism toward extraordinary scientific talent is undemocratic.

30. Most scientific research is conducted by scientists who have little concern for their own personal physical welfare.

31. Most scientists are very creative thinkers.

32. Scientific knowledge is hard for me to understand.

33. Science is little related to everyday living.

34. I enjoy solving science problems in the school laboratory.

35. Only students of better than average ability can be successful in school science courses.

36. Science helps society by using recently discovered scientific information to develop new industries.

37. I wouldn't like to pursue a science research project.

38. Scientists' attempts to solve their personal problems of everyday living are often unrealistic.

39. Science information which is not related to school work frequently interests me.
40. An education in science contributes toward good citizenship.

41. The study of science benefits people socially.

42. The methods of science are not applicable to understanding human behavior.

43. The methods of science will not enable the human mind to comprehend many aspects of our universe.

44. A comprehension of the significance of science is necessary to thoroughly appreciate present-day society.

45. Scientists are often eccentric in their personal behavior.

46. Scientific truths are normally discovered by individuals seeking financial gain.

47. I enjoy doing science investigations.

48. The difficulties involved in learning science often exceed its usefulness.

49. To me science classes are very uninteresting.

50. I enjoy doing science laboratory experiments.

51. Great improvement in all areas of human endeavor could be accomplished by the application of scientific methods.

52. Most of the science worth knowing can be read in books.

53. Most scientific discoveries were accidental.

54. A comprehension of science is essential for my everyday living.

55. The majority of scientists are not interested in the practical value of scientific information.

56. The nation's top scientists are mainly interested in their own current of thought.

57. Science is chiefly a program of action for originating new gadgets.
58. An education in science frequently helps one make more logical decisions in everyday living.

59. Science is not as important as other school subjects such as English.

60. Science appears to be necessary in our present-day society.

61. Public interest in science is necessary for the continuance of scientific research.

62. In pursuit of their interests, scientists often consent to sacrifice the well-being of others.

63. I would not recommend high school science to beginning high school students.

64. The advancement of science makes possible the control of our lives by a few people.

65. Most great discoveries of the world were found through careful observation rather than by accident.

66. Scientists have shown their lack of consideration for the welfare of mankind by participating in such research as the development of nuclear weapons.

67. I would prefer not to take any college science courses.
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