CONSTRUCTION AND USE OF A SCIENCE ATTITUDE SCALE FOR APPLICATION AT THE HIGH SCHOOL LEVEL

A THESIS

SUBMITTED TO THE DEPARTMENT OF

BIOLOGY AND THE GRADUATE COUNCIL OF THE KANSAS STATE

TEACHERS COLLEGE OF EMPORIA IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

By

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AREA OF RESEARCH AND THE PROBLEM

The research area. Attitudes are a part of every individual's personality. The psychologists have shown that attitudes are learned as one matures. It is difficult to ascertain just when, where, or how attitudes are formed, but evidence indicates that attitudes begin forming when one is very young. They probably begin being learned during the early pre-school years. Attitude growth is usually very subtle. All the factors of our environment help to shape one's attitudes toward various psychological objects or situations. Needless to say, environmental factors can be complex as well as numerous.

Attitudes are learned and are subject to modification as the individual matures. Some authorities believe that attitudes are never lost, but are only displaced by newer, stronger attitudes. Little is known concerning the modification of attitudes as the maturation process proceeds. Attitudes have an emotional basis and cause an individual to react a certain way upon the presentation of some psychological object or situation which is predictable within certain limits. One cannot always be certain of the degree

or intensity of an individual's reaction to a given psychological object or situation.

This writer prefers to define an attitude as a feeling or sentiment toward some psychological object or situation that has been learned somewhere in an individual's past experiences and is subject to modification in the form of intensifying the attitude or changing the degree to which overt behavior is affected.

Workers in the social sciences have been active in attempting to measure attitudes of various kinds. Attitudes toward war, religion, sex, money, racism, and others have been studied extensively. There has been, however, very little work done on the analysis of attitudes toward science. There is some indication that interest is being renewed in this area probably due to the current national interest being expressed in scientific and technological education. This national interest is apparently being felt most keenly at the high school level although the elementary and college levels are also being affected.

It is generally agreed that teachers on any academic level should possess desirable attitudes toward their special field. High school science teachers are no exception to the preceding statement. The high school science teacher should have some idea about what attitudes toward science one can expect typical high school students to possess. No

satisfactory method for measuring a high school student's attitudes toward science has yet been devised. If a science teacher can not objectively measure positive or negative attitudes toward science he should certainly be able to recognize some obviously undesirable, as well as desirable, attitudes. He should have the ability to strengthen recognizable positive attitudes and to displace, if only in a small way, the undesirable ones.

A reliable method of measuring attitudes toward science could be very valuable to a high school science teacher or guidance counselor. It would enable the teacher to select classroom experiences and use instructional techniques that would tend to intensify or displace old attitudes to the best advantage. It also might be of value to the guidance counselor in the placement of students in certain science courses. A good science attitude scale might also find some application in predicting success of an individual in a scientific career. The success attained and personal satisfaction derived in any occupation is, at least partly, dependent upon one's attitudes toward that occupation. Such a scale might also have some value at the elementary school level in determining the type of science instruction that should be given.

The problem. The problem was as follows:

(1) To construct a scale to measure attitudes toward science.

(2) To test the scale for reliability and discrimination.

(3) To assume some validity for the scale in order to attempt to answer the following questions:

a. Is there any change in attitude toward science by high school students over a period of several months?

b. Is there any relationship between scores made on the science attitude scale and (1) number of science courses taken and being taken, (2) age, and (3) intelligence quotient?

c. Is there any relationship between scores made on the science attitude scale and the following sections of the Iowa Test of Educational Development: (1) reading in natural science, (2) background in natural science, and (3) general achievement?

It was expected that the science attitude scale would be far from a final answer to the problem of science attitude measurement. The suggestions for improvement that appeared as the experiment progressed are probably as valuable as the results obtained from the study.

REVIEW OF THE LITERATURE

The more attitudes are studied the more varied their definitions and interpretations become. Noll (1935) implied that attitudes and habits are synonymous because both are more or less automatic depending upon how well they have been learned. A few years later Noll said that attitudes are "acquired or emotional action patterns that motivate human social behavior and are based on habits of thinking or responding which can be modified." (Noll, 1939). Crow and Crow (1948) state that attitudes are by-products of one's experience and are causes as well as results of behavior. Crow and Crow (1948) state rather definitely that attitudes are not habits, but may become similar to habits, that is, habitual. Nelson (1939) listed twenty-three terms to define or describe attitudes but preferred that they be called habits because it was felt this was a more descriptive term.

Woodworth (1940) said an attitude is a readiness, inclination, or tendency to act toward some psychological object. The extent of the readiness, inclination, or tendency depends upon how familiar the individual is with the psychological object concerned. Essentially the same definition was given by Jordan (1953), but the term "attitude" was extended to include a set or disposition to act either favorably or unfavorably toward some object, process,

situations, institution, or person. In addition, Taylor (1954), felt that attitudes should also include expectations, intuitions, wishes, desires, purposes, principles, and ideals.

An attitude is an emotion attached to a specific object or relation was the definition preferred by Anderson (1949). Anderson (1949) also said that attitudes include positive or negative feelings or sentiments. Taylor (1954) listed a number of sentiments which were believed to be attitudes. Taylor (1954) also defined an attitude as a mixed emotional reaction. Sherman (1941) listed only four types of attitudes - imitative, pressure, conflicts, and traumatic. Shaffer (1956) stated that an attitude is an organization of motives involving, basically, either acceptance or rejection of certain psychological objects. Shaffer (1956) also stated that attitudes are definite factors in the determination of what an individual perceives, learns, or believes. Edwards (1957) and Sartain (1958) agreed when they said that attitudes vary in direction, either positively or negatively, degree, and intensity. Ferguson (1939) spoke of the "acceptance value of a belief" whether that belief is true or false. This was similar to Sartain (1958) who said that attitudes involve beliefs, and beliefs involve attitudes. Seeley (1953) left the impression that

attitudes may be related to morale since he defined morale in terms of feelings toward psychological objects.

One can see from the preceding that there are many ways of explaining attitudes. This author's definition of an attitude, as it pertains to science, would include the feeling one has toward all the aspects of science. This would encompass feelings toward the personality traits of scientists, the work of scientists, the laboratory equipment involved, the outcomes of research, and the methods of science. The definition given by this writer must be understood in order to properly interpret this study.

As far as attitude change is concerned, the authorities are in more agreement. Sherman (1941) stated that young individuals have attitudes much more pliable than adults and that they become more fixed and intense as one matures. Sherman (1941) also said that attitudes in a younger person are mostly imitations of the individual's family and close friends. As the individual's world expands to include more people with whom he becomes identified, his attitudes change rapidly. According to Anderson (1949), the home, the school, and the community are responsible for the development and modification of attitudes. This position was similar to that of Sartain (1958) who believed attitudes are formed and modified by specific experiences with other people involving group pressure, and

influence of persons with prestige. Smith and Smith (1958) simply stated that the acquiring of new attitudes is merely the breaking of old habits and the formation of new ones. Sherman (1941), however, said that in a mature, or nearly mature, person attitudes change only under unusual circumstances with the presence of a strong emotional tone. This author believes that Nelson (1939) made a good generalization when he said that attitudes are acquired "through the integration of specific experiences into a general emotional set."

It was interesting to note a statement made by Mayhew and Hill (1950) to the effect that knowledge of facts in academic subjects are relatively unimportant as far as attitude development is concerned. Sherman (1941) said that learning more about something does not necessarily change one's attitude toward it. Intelligence apparently has little to do with the development of attitudes. Sherman (1941) also made the statement that the use of coercion in attempts to change an attitude only results in intensifying the attitude in which change was sought. Sartain (1958) believed that one is not fully aware of their attitudes. From the foregoing it can be seen that attitudes are basically emotional and that attempts to change attitudes must likewise be placed on an emotional basis. This writer agrees with Sherman (1941) when he said that a teacher with

a great deal of personality and prestige can be successful in changing the attitudes of students. It would seem, then, that as far as attitude development is concerned, the ability of a teacher to develop or modify attitudes is just as important as the ability to infuse knowledge of subject matter. It might even be assumed that if a teacher is successful in developing or changing undesirable attitudes into desirable ones, learning of subject matter would be enhanced.

Morgan (1946) said that in addition to certain skills and capacities, attitudes are very important in the selection of a vocation or profession. If one assumes, therefore, that this nation is in great need of scientists and technologists, then it becomes imperative that anyone who teaches science at any level becomes concerned with attitude development toward science.

The lack of suitable measuring instruments are at present the greatest barrier to adequate attitude determination. Sherman (1941) said the problem of measuring attitudes has never been satisfactorily solved. Palmer (1957) stated that present attitude tests have little relative value as far as vocations are concerned. The development of a suitable device with which to measure attitudes toward science on the high school level was one of the objectives of this study.

The literature available does not offer a great deal of assistance since there has been little work done in this particular area. Sartain (1958) furnished some good illustrations of the various kinds of attitude scales or tests. Those mentioned by Sartain (1958) include the Thurstone-type in which the individual marks the statement with which he agrees. Each statement, then, has a certain numerical value as determined by the test writer through a technical process. The Likert-type was discussed by Sartain (1958) in which the examinee is offered five choices of agreement or disagreement with each statement on the test. The projective-type was also mentioned by Sartain (1958) which involves an indefinite or unstructured stimulus situation, but the details of its construction were not given. Sartain (1958) pointed out, however, that in attitude tests, like most other tests, the individual can purposely falsify or distort responses and thereby give an inaccurate score. Aalto (1956) developed a seventy item questionnaire to measure certain attitudes in which one-half of the statements were positive opinions, and one-half were negative. The Likert-type of response was used and the test was found to have high reliability. In addition, Alberty, et al (1938), furnished a check list for determining the presence of desirable attitudes in an individual. It was offered as a compromise between anecdotal records and the direct

statement questionnaire. Anecdotal records and questionnaires as they may be used to measure attitudes was discussed fairly well by Jordan (1953). The use of opinion surveys may be helpful in measuring attitudes. This was suggested in the work of Wilson (1954) who used the latter to measure students understanding of the place of science in society. Bradfield and Moredock (1957) offered some suggestions for attitude scale construction but their ideas were not clearly explained. Some help may be found in Mayhew and Hill (1950) who discussed an attitude test common to seven basic fields at Michigan State College in 1944. Edwards (1957) was an excellent source for finding material related to item selection and the mechanics of attitude scale construction.

For the purposes of this study the statement type of test was used with the assumption that the statements carried emotional connotations. The responses were the "pleasing-no feeling-not pleasing" type similar to those used by Novak (1957) and Spohn (1958).

One may see that there is a good amount of literature available that relates to attitudes in general or to various social areas. There is, however, a strikingly small amount that is related specifically to science.

METHODS

Construction of the scale. The statement type of item was selected for use in the attitude scale. It was felt that if the statements were constructed so as to evoke an emotional response, the items would provide a significant sampling of attitudes. The statements were adapted from Spohn (1958) with others supplied by the author taken from Russell (1931), French (1952), Stakman (1952), Williams (1952), Read (1955), and Conant (1951). Approximately one-half the statements were reworded so as to be antagonistic to the original meaning. All the statements were rewritten and shortened with as little loss of meaning as possible. This was done in order to bring the statements down to what, in the author's opinion, was the average high school student's understanding and reading ability.

The criteria for attitude statements as determined by Edwards (1957) were followed. Those criteria were:

1. Avoid referral to the past.
2. Avoid factual material or anything that may be interpreted as factual.
3. Avoid statements with multiple interpretations.
4. Avoid statements that are irrelevant to the psychological object under consideration.
5. Avoid statements that are likely to be universally agreeable or disagreeable.
6. Select statements that are believed to cover the entire range of the affective scale of interest.
7. Use simple, clear, and direct language.

8. Statements should never exceed twenty words.
9. Each statement should contain only one thought.
10. Avoid use of universals such as "all, always, and never."
11. Words such as "only, just, merely" and others should be used with care.
12. Use simple sentences whenever possible.
13. Use words that will be understood by those to whom the scale is to be administered.
14. Avoid use of double negatives.

Criteria numbers 1, 2, and 6 were probably not adhered to as closely as they should have been, but it was felt that the statements which violated those criteria did so only slightly. The author emphasized criteria numbers 5, 7, 8, 10, 12, and 13. A few statements on the scale exceeded the twenty word limit by two or three words. The grammar and punctuation was carefully checked by the author and another person. The completed scale was composed of eighty-five items.

The "pleasing-no feeling-not pleasing" type of response was used similar to Novak (1957) and Spohn (1958).

A "personal data" section was included on the first page of the scale. There were spaces for entry of name, date of birth, age, sex, year in school, science and mathematics courses in which the student was currently enrolled, and science and mathematics courses taken prior to the administration of the attitude scale. The scale was then duplicated for use (see Appendix, p. 89). After the scale had been administered for the first time, the author found that many of the students had done little more than fill in

their names on the scales. The remainder of the information had to be obtained from the students permanent school records in order to achieve any amount of useful information.

Validation of responses. In order to determine the "correct" responses, a group of persons assumed to be well-trained in science was used. It was also assumed that the validation group had desirable attitudes toward science. A copy of the science attitude scale and an explanatory letter (see Appendix, p. 87), along with a stamped, self-addressed envelope, was mailed to each of thirty-five college professors on 28 and 29 July 1958. Sixteen of them were from Fort Hays Kansas State College, Hays, Kansas, and the remaining nineteen were from Kansas State Teachers College, Emporia, Kansas. Sixteen of the college teachers were biologists, five were chemists, seven were physicists, and seven were mathematics teachers. All of the college teachers selected had a Master's degree or above. Most of them had a doctorate in their special fields. They were asked to mark their own responses to the items on the science attitude scale and return it to the author. Twenty-seven scales were returned as requested for approximately a 77 per cent return.

If a particular response was made by more than 10 per cent of the validation group, that response was assumed to be correct. If, for example, three or more of the 27

respondents to the scale gave a certain answer, that response was assumed to be correct. Whenever the number of responses was divided equally between the three responses choices, that item was considered to be invalid. If there was reasonably even division between two choices, both responses were considered valid. Forty-four statements were eliminated leaving 41 that were considered to be valid. These 41 statements were then administered as will be explained later in this paper.

Administration of the scale. In order to test the scale, it was first administered to the entire student body of the Caldwell High School, Caldwell, Kansas, on 12 September 1958. It was administered again on 23 April 1959. Approximately 180 students participated in each of the two administrations. On the first administration, 42 were freshmen, 46 were sophomores, 45 were juniors, and 43 were seniors. On the second administration, 42 were freshmen, 46 were sophomores, 47 were juniors, and 40 were seniors. The scale was given on the same day of the week both times and during the same class periods. The scale was given in classes in which one teacher would have all the students of a particular grade sometime during the day. For example, all the freshmen took general science so the general science teacher administered the test to the freshmen; all the

sophomores took English so the sophomore English teacher administered the test to the sophomores; all the juniors took English so the junior English teacher gave the juniors the test; and all the seniors took constitution so the social science teacher administered the scale to the seniors. The same plan was followed when the scale was given the second time.

Each teacher was given a written set of instructions (see Appendix, p. 88) and was asked to read them to the class before giving the test. The test required from fifteen to twenty minutes to complete, depending upon the student.

Statistical determination of the significance of difference between means. Snedecor's F test of homogeniety of variance was used in determining the statistical significance of differences between the variance for each pair of the four groups for each administration of the scale. Fisher's t test was used to find the statistical significance of the difference between the mean of the first administration and the mean of the second administration for each group. It was then possible to find the significance of any change in attitude between the two administrations of the scale. It was assumed that the distribution was normal therefore the variances were estimated

by the method given in Dixon and Massey (1951). The formula was as follows:

$$s^2 = \frac{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}{N - 1}$$

where s^2 is the variance, X represents each score of the sample, and N is the number of individuals in the group. After calculating the variance for each group to be analyzed, the larger of the two variances is divided by the smaller to obtain the value of F, which is called the variance ratio. From Snedecor's table of F (Snedecor, 1956), it can be found whether the difference in variances is statistically significant.

Bartlett's test of homogeniety of variance as described in Snedecor (1956) was then calculated. The purpose of this test was to determine whether or not the variances of the classes studied would produce essentially the same results as the variances of all the students taken together. In other words, a test to see if the variances were similar where the sample groups differ in size. Bartlett's test was not essential in this particular study since only four groups were involved. Adequate data concerning homogeniety of the variances was obtained from Snedecor's F test between each class and every other class studied. Bartlett's test becomes necessary when numerous sample groups are compared for differences between means by

by the use of analysis of variance. See Appendix, page 83, for details of the Bartlett test.

The 5 per cent level was used in determining the statistical significance of the variance ratio in each case. If the variance of the two groups did not differ significantly, Fisher's t test of significance of mean difference could then be applied. When considering the means of two different groups, the formula for t was:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{N_1} + \Sigma X_2^2 - \frac{(\Sigma X_2)^2}{N_2}}{N_1 + N_2 - 2}\left(\frac{N_1 + N_2}{N_1 N_2}\right)}}$$

where $\bar{X}_1$ is the larger mean, N_1 is the number of persons in the group having the larger mean, X_1 is the scores of that same group; $\bar{X}_2$ is the smaller mean, N_2 is the number of persons in the group having the smaller mean, and X_2 is the scores of that group. The 5 per cent level of significance of difference between the means was used with the t test.

Changes in attitude over a period of several months while attending school. In order to answer the question, "Is there any change in attitude toward science by high school students over a period of several months?" as measured by the scale, a null hypothesis was first stated. The null hypothesis was: "There is no change in attitude toward

science by high school students over a period of several months." This hypothesis was then tested by means of the F and t test.

Variance between individuals and test reliability. The completed science attitude scales were scored by means of strips of manila paper with rectangular notches cut on one edge. The correct, lined-out responses would then appear in the notches. The items were scored according to the responses of the validation group. The mean scores and variances were calculated for each class and the student body as a whole. The Hoyt method utilizing analysis of variance as described by Johnson (1949) was used to find the reliability of the scale and to find how well it discriminated between individuals. See pages 95 and 96 of the Appendix for a presentation of the Hoyt method.

Relationship of attitude scale scores with other data. The next question, as previously stated, was: "Is there any relationship between scores made on the science attitude scale and (1) number of science courses taken or being taken, (2) age, and (3) intelligence quotient?" In order to answer this question, it was first broken down into several parts. A null hypothesis, "There is no relationship between scores made on the science attitude scale and number of science courses taken or being taken" was stated. This

null hypothesis was tested by application of a Chi-square formula. See Appendix, page 93, for details of the calculation of Chi-square.

To determine the relationship that might exist between scores on the science attitude scale and age, correlation coefficients for ungrouped data were calculated for each administration of the scale. The formula used was:

$$r = \frac{N \Sigma X Y - (\Sigma X)(\Sigma Y)}{\sqrt{\left[N\Sigma X^2 - (\Sigma X)^2\right]\left[N\Sigma Y^2 - (\Sigma Y)^2\right]}}$$

where N is the number of individuals in the sample group, X is the scores of the group, and Y is the factor to be correlated with X. (Wert, Neidt, and Ahmann, 1954).

The t test of significance of the correlation coefficient "r" was then calculated according to the formula:

$$t = \frac{r\sqrt{f}}{\sqrt{1 - r^2}}$$

where r is the coefficient of correlation, and f is n - 2 where n is the size of the sample (Johnson, 1959). The significance of the correlation coefficient may then be found from a t table using n - 1 degrees of freedom.

To find the relationship between scores made on the science attitude scale and intelligence quotient, correlation coefficients were calculated in the same manner as was done in answering the preceding question. The significance of the correlation coefficient was also calculated.

The last question to be answered was: "Is there any relationship between the scores made on the science attitude scale and the following sections of the Iowa Test of Educational Development: (1) reading in natural science, (2) background in natural science, and (3) general achievement?" The following null hypotheses were stated: "There is no relationship between the scores made on the science attitude scale and reading in natural science; there is no relationship between the scores made on the science attitude scale and background in natural science; and there is no relationship between scores made on the science attitude scale and general achievement." Each of these hypotheses were tested by the Chi-square formula.

Item analysis. It was felt that if some form of item analysis was carried out a better picture could be drawn regarding the relative difficulty of each item on the science attitude scale. In the method used, the per cent of students in each group studied having each item correct was calculated. The per cent of students passing an item is referred to as the difficulty of the item. The number of students from each group having each item correct was taken from the analysis of various data. The item difficulty was determined for each test item for each group. The item analysis was done only for the first administration of the scale.

DESCRIPTION OF THE SAMPLE GROUPS STUDIED

The students involved in this study included the entire student body of a southern Kansas high school located in a community in which agriculture is the principle occupation. The town in which the high school is situated has a population of approximately 1800 people.

Table I and II show the number, sex, and mean ages of the groups taking both administrations of the science attitude scale. Table I shows that out of 176 students, 97 were boys and 79 were girls. Table II shows that out of 175 students taking the second administration of the scale, 97 were boys and 78 were girls. No comparison was made concerning the differences in scores between boys and girls. The number of students in each group studied for both administrations was almost constant, but there was some change of individual students. Some were absent for the first administration, but present for the second administration and vice versa. Some groups had lost one or more students, or had gained one or more thereby keeping the number constant. This type of situation did not occur often and it was felt that it had only slight, if any, effect on the total outcome of the study.

All of the students in this high school take the Henmon-Nelson Test of Mental Ability sometime during their

TABLE I

Number, Sex, and Mean Ages of the Groups Used in the Study

First Administration

Group	No. of Students	Number Males	Number Females	Mean Age
Freshmen	42	23	19	14 yrs, 3 mos (171 mos)
Sophomores	46	24	22	14 yrs, 11 mos (179 mos)
Juniors	45	24	21	16 yrs, 8 mos (200 mos)
Seniors	43	26	17	17 yrs, 2 mos (206 mos)
Total	176	97	79	

TABLE II

Number, Sex, and Mean Ages of the Groups Used in the Study

Second Administration

Group	No. of Students	Number Males	Number Females	Mean Age
Freshmen	42	22	20	14 yrs, 10 mos (178 mos)
Sophomores	46	24	22	15 yrs, 7 mos (187 mos)
Juniors	47	25	22	16 yrs, 11 mos (203 mos)
Seniors	40	26	14	17 yrs, 10 mos (214 mos)
Total	175	97	78	

school career usually during their freshman year. All the students also take the Iowa Test of Educational Development published by Science Research Associates, Chicago, Illinois, during their freshman year and again during their junior year. This battery of tests measures the student's background in social studies, background in natural science, correctness in expression, quantitative thinking, reading social studies, reading natural science, reading literature, general vocabulary, and use of sources of information. The completed battery gives a raw score and percentile rank for each area of each student based on national norms. A composite raw score and composite percentile rank is also given for each student. It was the student's raw scores and percentile ranks on those portions of the battery involving (1) reading natural science, (2) background in natural science, and (3) general achievement that were used in this study.

RESULTS

Scores on the science attitude scale. It may be seen from Table III that the score ranges were nearly uniform over the groups studied for the first administration of the scale. The most narrow score range, 22 to 37, was made by the senior class and the widest, 22 to 38, was made by the junior class. Over the entire student body the range was 21 to 39. For comparison, Table IV shows that for the second administration of the scale, the most narrow range, 22 to 38, was shared by the sophomore and junior classes. The overall range was 19 to 40 for the second administration. The widest range was 19 to 38 and was made by the senior class.

It was interesting to note that on the first administration the highest score, 39, was made by a freshman boy, and the lowest, 23, was tied between a sophomore girl and a junior girl. On the second administration, the same freshman boy made the highest score which was forty. The lowest score on the second administration was 19 and it was made by a senior boy.

Table III also shows that for the first administration the median scores ranged from 30.0 to 32.0. For the second administration, Table III shows that the median scores ranged from 29.0 to 32.0. The small change in the medians between

TABLE III

Score Ranges, Medians, Standard Deviations, and Means of the Groups Studied on the Science Attitude Scale

First Administration

Group	No. of Students	Score Ranges	Median Scores	Standard Deviation	Mean Scores
Freshmen	42	23 to 39	31.5	3.655	31.17
Sophomores	46	21 to 37	30.0	4.183	29.80
Juniors	45	21 to 38	32.0	4.294	30.55
Seniors	43	22 to 37	30.0	3.827	29.70
All students	176	21 to 39	30.0	4.016	30.34

TABLE IV

Score Ranges, Medians, Standard Deviations, and Means of the Groups Studied on the Science Attitude Scale

Second Administration

Group	No. of Students	Score Ranges	Median Scores	Standard Deviation	Mean Score
Freshmen	42	22 to 40	31.0	3.950	31.36
Sophomores	46	20 to 36	30.5	4.062	30.24
Juniors	47	22 to 38	32.0	3.672	31.68
Seniors	40	19 to 38	29.0	5.074	27.70
All students	175	19 to 40	31.0	4.429	30.30

the first and second administrations of the scale would suggest that there was no change in attitude. This will be discussed in more detail later in this paper. One might also note that the means and the medians were very much alike on both administrations of the scale. The only place where they differed much was for the junior class on the first administration and for the senior class on the second administration.

Figures 1, 2, 3, and 4 show the per cent of students from each class that received each score on the scale for both administrations. None of these four polygons show any apparent normal distribution. No significant gain in attitude between administrations is apparent from the figures. The statistical significance of this aspect will be discussed later. All four classes, except perhaps the senior class, appear to have tendencies toward a bimodal distribution which will be discussed on page 51.

Figure 5 shows the per cent of the student body that made each score on the scale for both administrations. The smoothing effect was probably due to the larger number of individuals involved. A bimodal tendency again appears, but the distribution was not statistically tested to see if it would fit a normal distribution.

From Table V one can see that for the classes studied, there was no significant difference between the variances.

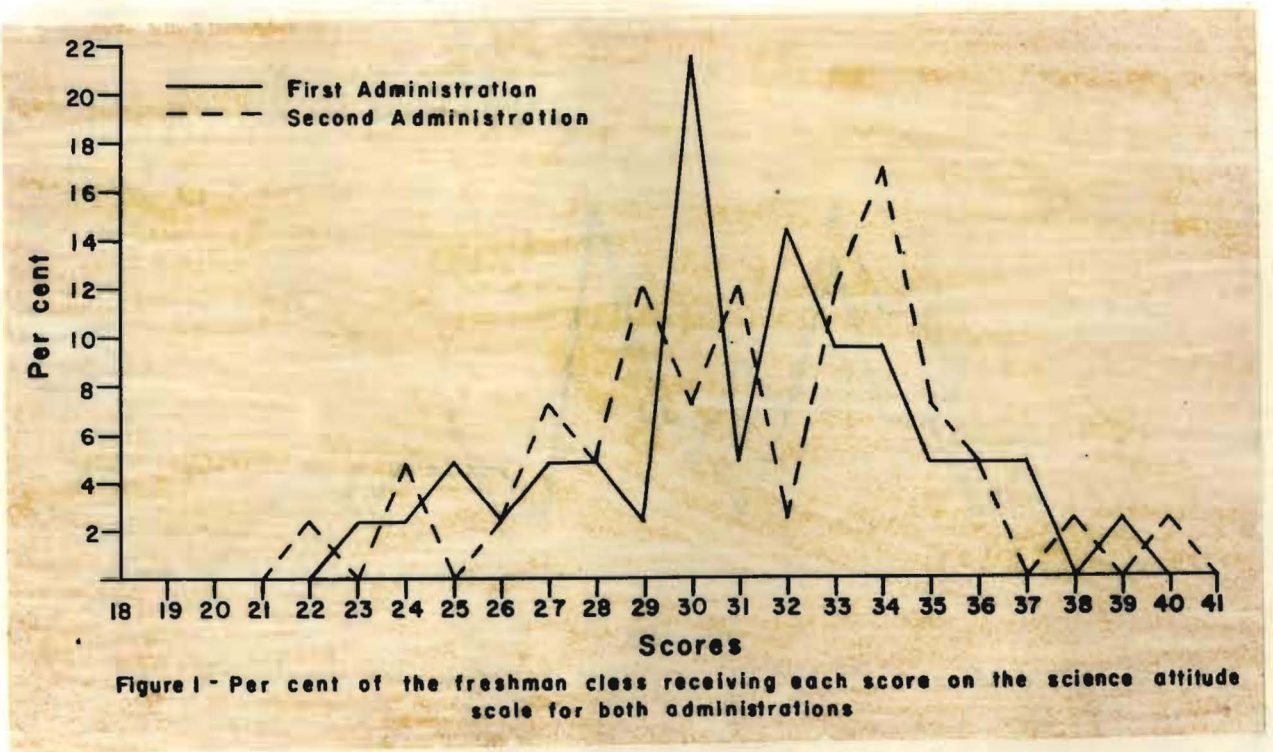

Figure I - Per cent of the freshman class receiving each score on the science attitude scale for both administrations

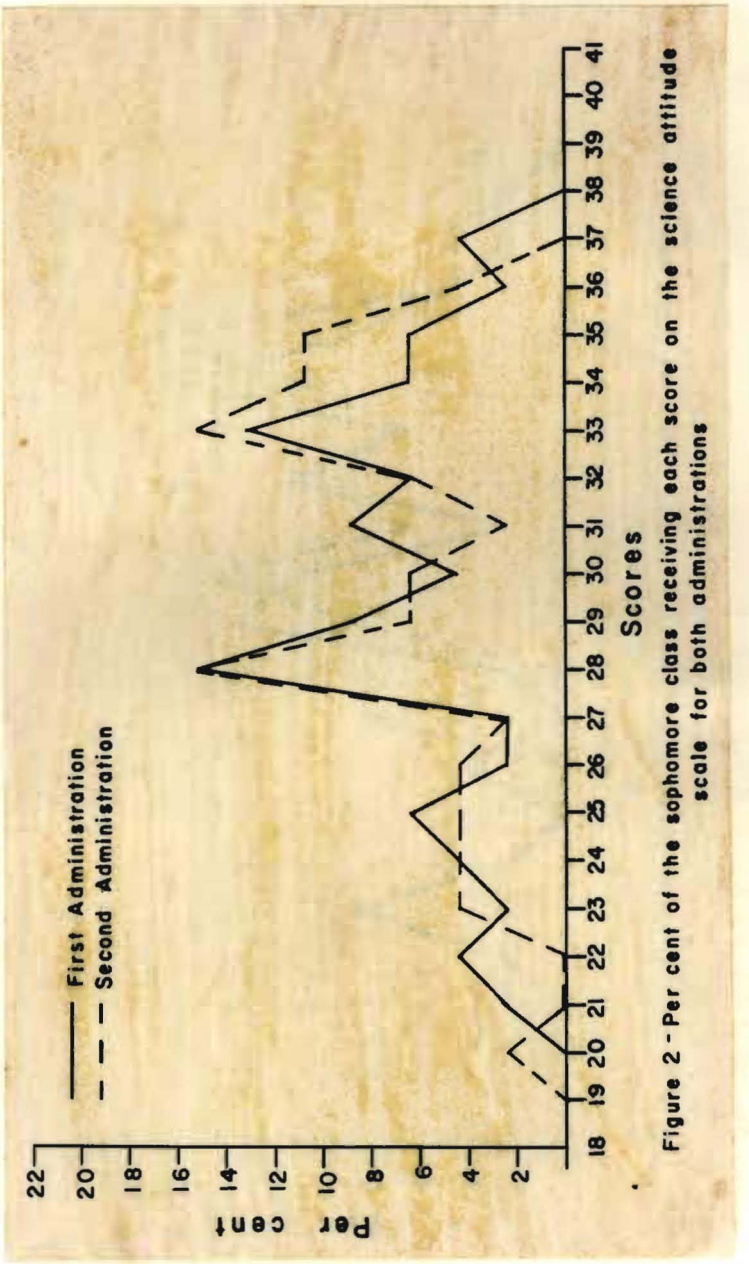

Figure 2 - Per cent of the sophomore class receiving each score on the science attitude scale for both administrations

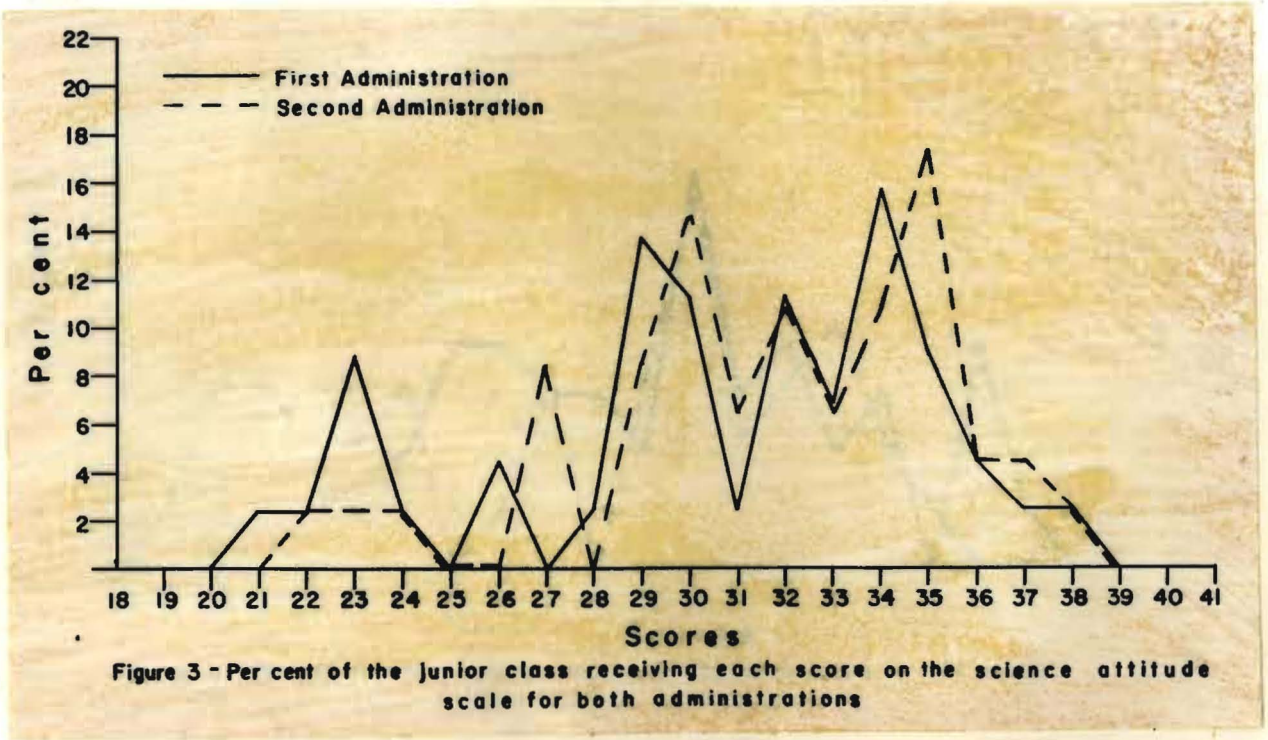

Figure 3 - Per cent of the junior class receiving each score on the science attitude scale for both administrations

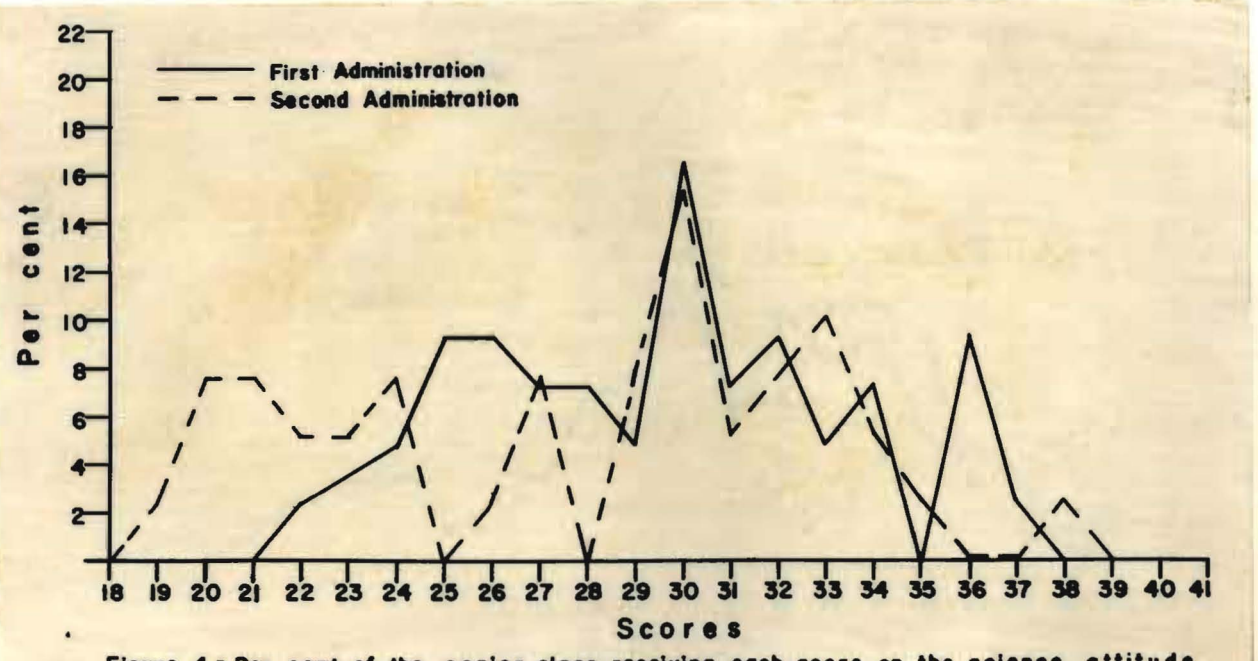

Figure 4 - Per cent of the senior class receiving each score on the science attitude scale for both administrations

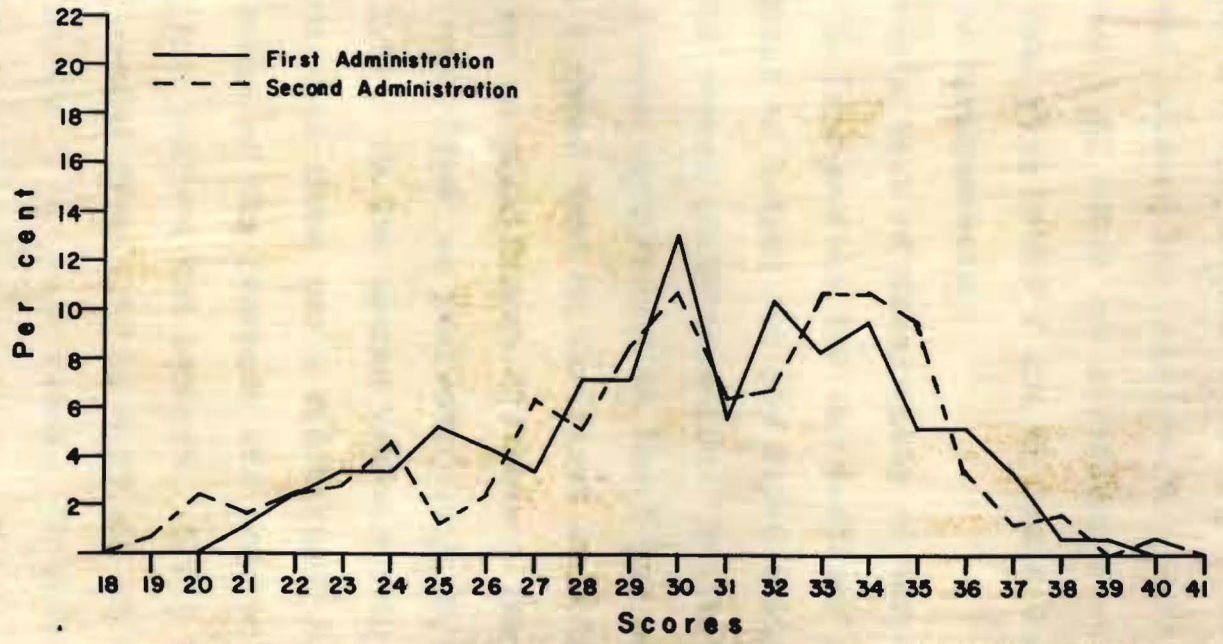

Figure 5 - Per cent of the student body receiving each score on the science attitude scale for both administrations

The values for F ranged from 1.05 to 1.38 all of which were not significant at the 5 per cent level. On the second administration the only significant difference between variances occurred between the junior and senior classes where the F value was 1.91 which was significant at the 5 per cent level. The data from Table V and VI would indicate that the variances were homogeneous.

Bartlett's test of homogeniety of variance showed the variances to be homogeneous for the combined groups with a Chi-square value of 1.4204 for the first administration and 5.0506 for the second administration. Neither of these Chi-square values were significant at the 5 per cent level.

Table V shows that on the first administration of the scale there was no significant difference between the means at the 5 per cent level as indicated by t values ranging from .12 to 1.81. On the second administration, however, Table VI shows that there was a significant difference between the means of the freshmen and seniors, sophomores and seniors, and juniors and seniors. The t values for these groups ranged from 1.79 to 4.23 all of which were significant at the 5 per cent level. By referral to Figure 4, one can see how this situation could have arisen. Apparently some of the seniors either were not cooperating or else their attitude had declined causing the mean of the

TABLE V

Significance of Differences between the Variances and Mean Scores on the Science Attitude Scale for the Groups Studied - First Administration

Group	Number of Students	Mean Score	Variance	Difference between Means	t	F	P
Freshmen	42	31.17	13.362	1.37	1.63		>.05
Sophomores	46	29.80	17.494			1.31	>.05
Freshmen	42	31.17	13.362	.62	.72		>.05
Juniors	45	30.55	18.434			1.38	>.05
Freshmen	42	31.17	13.362	1.47	1.81		>.05
Seniors	43	29.70	14.645			1.10	>.05
Sophomores	46	29.80	17.494	.75	.84		>.05
Juniors	45	30.55	18.434			1.05	>.05
Sophomores	46	29.80	17.494	.10	.12		>.05
Seniors	43	29.70	14.645			1.19	>.05
Juniors	45	30.55	18.434	.85	.98		>.05
Seniors	43	29.70	14.645			1.26	>.05

TABLE VI

Significance of Differences between the Variances and Mean Scores on the Science Attitude Scale for the Groups Studied - Second Administration

Group	Number of Students	Mean Score	Variance	Difference between Means	t	F	P
Freshmen	42	31.36	15.601	1.12	1.31		>.05
Sophomores	46	30.24	16.497			1.06	>.05
Freshmen	42	31.36	15.601	.32	.40		>.05
Juniors	47	31.68	13.482			1.16	>.05
Freshmen	42	31.36	15.601	3.66	3.65		<.05
Seniors	40	27.70	25.750			1.65	>.05
Sophomores	46	30.24	16.497	1.44	1.79		>.05
Juniors	47	31.68	13.482			1.22	>.05
Sophomores	46	30.24	16.497	2.54	2.58		<.05
Seniors	40	27.70	25.750			1.56	>.05
Juniors	47	31.68	13.482	3.98	4.23		<.05
Seniors	40	27.70	25.750			1.91	<.05

class to drop to such a point that it became significantly different than that for other classes.

Change in attitude. The F and t tests were again utilized in testing the significance of the difference between the means of each group on the first and second administrations of the scale. The F and t values were calculated in order to test the hypothesis: "There is no change in attitude toward science by high school students over a period of several months." The results of the F and t tests are given in Table VII. A value for F of 1.17 and a value for t of 1.47 was obtained for the freshmen class between the first and second administrations of the scale. Thus, neither the change in variance nor the change in mean score was significant for the freshman class at the 5 per cent level. The F value for the sophomore class was 1.06 which indicated that the change in variance was not significant at the 5 per cent level. The t value, however, for the sophomore class was 3.43 which indicated that the mean difference was significant at the 1 per cent level. The junior class followed the same pattern as that of the sophomores. An F value of 1.37 was obtained which indicated that the change in variance was not significant at the 5 per cent level. For the junior class, a value for t of 9.10 was

TABLE VII

Significance of the Difference between Mean Scores of the First and Second Administration of the Science Attitude Scale for the Groups Studied

	No of Stdnts	Mean Score	Variance	Difference between Means	t	F	P
Freshmen							
First Adm.	42	31.17	13.362	.19	1.47		>.05
Second Adm.	42	31.36	15.601			1.17	>.05
Sophomores							
First Adm.	46	29.80	17.494	.44	3.43		<.01
Second Adm.	46	30.24	16.497			1.06	>.05
Juniors							
First Adm.	45	30.55	18.434	1.13	9.10		<.01
Second Adm.	47	31.68	13.482			1.37	>.05
Seniors							
First Adm.	43	29.70	14.645	2.00	12.89		<.01
Second Adm.	40	27.70	25.750			1.76	*
All Students							
First Adm.	176	30.34	16.129	.04	1.17		>.05
Second Adm.	175	30.30	19.613			1.22	>.05

*For this group: $.01 < P < .05$

obtained which indicated that the difference between means was significant at the 1 per cent level. The F value for the senior class was 1.76 which was significant between the 5 per cent and 1 per cent levels for the change in variance. The t value for the senior class was 12.89 which was significant at the 1 per cent level indicating a significant change in mean scores. When all the groups were taken together the F value was 1.22 and the t value was 1.17. This showed that for all the classes taken together there was no significant change in variance or mean scores at the 5 per cent level. One can see from Table VII that there was essentially no change in the mean scores for the freshman class, some increase in mean score for the sophomore and junior classes, and some decline in mean score for the senior class. On the basis of the information supplied by the F and t tests it was concluded that there was a significant change in attitude by the groups studied. The hypothesis was, therefore, rejected.

Reliability of the scale. From Table VIII one can see that the reliabilities were satisfactory although they were not outstandingly high. The lowest reliability, .50, was found in the senior class on the first administration of the scale. On the second administration, however, the senior class scores were the highest with a reliability of .70. The reliabilities of the entire student body taken

together were probably the more accurate ones since more individuals were involved.

In all the groups studied, the variance due to differences between individuals was significant at the 5 per cent level. It was concluded, then, that the science attitude scale discriminated sufficiently between individuals. Further data from the analysis of variance are given in Appendix Tables, I, II, III, IV, and V which are for the first administration, and Appendix Tables VI, VII, VIII, IX, and X which are for the second administration.

TABLE VIII

Reliabilities of Both Administrations of the Attitude Scale for the Groups Studied*

Group	Reliability First Administration	Reliability Second Administration
Freshmen	.54	.52
Sophomores	.61	.61
Juniors	.68	.55
Seniors	.50	.70
All students	.60	.78

*Variance due to difference between individuals significant at the 5 per cent level in all cases.

Relationship of attitude scale scores to other data. Previously stated was the null hypothesis: "There is no relationship between scores made on the science attitude scale and number of science courses taken and being taken." The hypothesis was tested by means of Chi-square calculations for both administrations of the scale. Further data from the calculation of Chi-squares is given in Tables XI to XVIII of the Appendix.

Table IX shows that a correlation coefficient of .15 was obtained between the science attitude scale scores and number of science courses taken and being taken for the first administration of the scale. A correlation coefficient of .27 was obtained for the second administration. A *t* value of 2.00 indicated that on the first administration the significance of the correlation was between the 1 per cent and 5 per cent levels. On the second administration the correlation was not significant at the 5 per cent level having a *t* value of 3.66. Chi-square values did not show any significant relationship at the 5 per cent level for either administration of the scale concerning the relationship between attitude scale scores and number of science courses taken or being taken. On the basis of the preceding results the null hypothesis was not rejected. A comparison of correlations of science attitude scale scores

TABLE IX

Significance of the Correlations between Attitude Scale Scores and Number of Science Courses Taken by All the Students

	Correlation Coefficient	t	P	Chi-square
First Administration	.15	2.00	.01<P<.05	>.05
Second Administration	.27	3.66	>.05	>.05

with courses taken and being taken for both administrations of the scale can be seen in Figure 6.

The student's ages were converted from years to months for purposes of correlating age with the attitude scale scores. As indicated in Table X, the correlations for both administrations of the scale were low. The correlation coefficients varied from .15 to minus .28. The t value of 2.00 showed that for the first administration the correlation was significant between the 1 per cent and 5 per cent levels. The correlation coefficient was not significant at the 5 per cent level on the second administration having a t value of .28. It probably could be concluded that there was no distinct relationship between age and scores attained on the scale. A comparison can be seen concerning the correlations between the scores and ages for both administrations of the scale in Figure 6.

Correlation coefficients were calculated to find if any relationship existed between scores on the science attitude scale and intelligence quotient. Table XI shows somewhat acceptable correlation coefficients of .42 and .41 were obtained for the first and second administrations respectively. The t value for the significance of the correlation on the first administration was 6.09 and was not significant at the 5 per cent level. On the second administration the t

TABLE X

Significance of the Correlations between Attitude Scale Scores and Age in Months

	Correlation Coefficient	t	P
First Administration	.15	2.00	.01<P<.05
Second Administration	.28	3.79	>.05

TABLE XI

Significance of the Correlations between Attitude Scale Scores and Intelligence Quotient

	Correlation Coefficient	t	P
First Administration	.42	6.09	>.05
Second Administration	.41	5.84	>.05

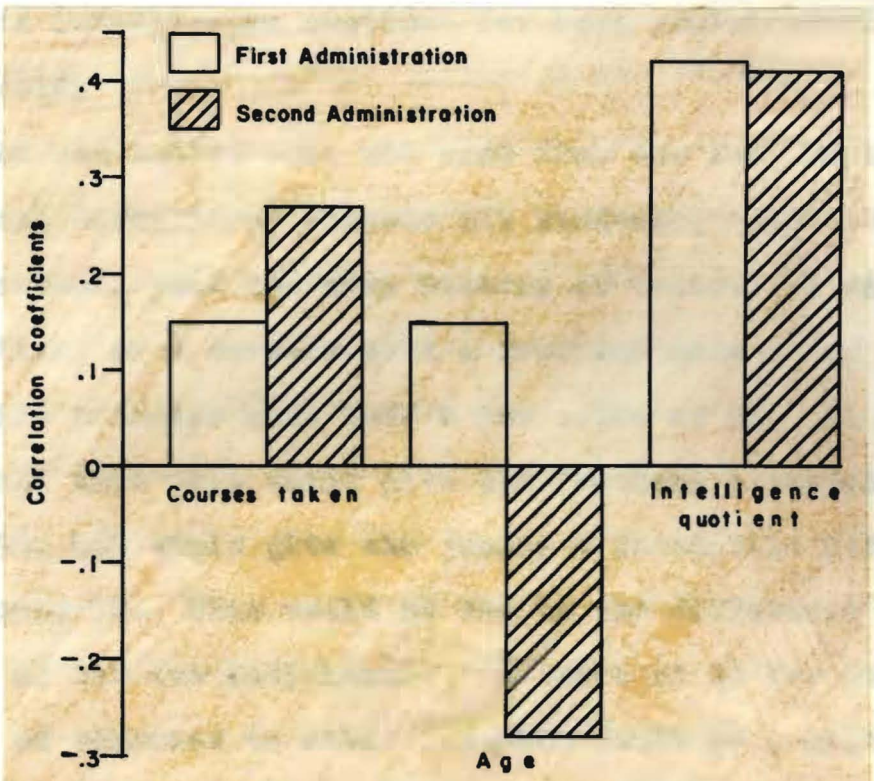

Figure 6 - Correlation of science attitude scores with other data for both administrations

value was 5.84 and also was not significant at the 5 per cent level. The conclusion was that probably there was little, if any, relationship between scores made on the attitude scale and intelligence quotient. Figure 6 shows a comparison of the correlation between the attitude scale scores and intelligence quotient for both administrations of the scale.

The raw scores were not used from the Iowa Test of Educational Development because all students, regardless of year in school, took the same battery of tests. As an illustration, on a certain test a freshman made a raw score of 20 while a junior also made a raw score of 20. It could be possible that this would give the freshman a percentile rank of 90, but would give the junior a percentile rank of perhaps only 70. This would be due to the difference in maturity of the two individuals. A score of 20 for the freshman as compared to other freshmen would be a high score whereas 20 would be a lower score for a junior compared to other juniors.

The percentile ranks of the individual students were used in attempting to find the degree of relationship between science attitude scale scores and (1) reading in natural science, (2) background in natural science, and (3) general achievement. The hypotheses, as previously

stated were: "There is no relationship between the scores made on the science attitude scale and reading in natural science; there is no relationship between the scores made on the science attitude scale and background in natural science; and there is no relationship between scores made on the science attitude scale and general achievement." Each of these hypotheses was tested by the Chi-square method for both administrations of the scale. All of the Chi-square values showed a significance beyond the 1 per cent level indicating a highly significant positive relationship between percentile ranks on these tests and scores on the science attitude scale. Further data relevant to the calculation of the Chi-square values may be found on pages 73 to 80. The aforementioned hypotheses were all rejected. It was concluded, then, that there was a high degree of relationship between the scores made on the science attitude scale and reading in natural science, background in natural science, and general achievement.

Item Analysis. The number of correct responses and per cent of correct responses (item difficulty) for each group on each item of the scale is given in Table XIX of the Appendix. The item difficulties ranged from a high of 96 to a low of 21. The lowest item difficulty was unusual,

however, since the nearest one above it was 34. More than one-half of the science attitude items had difficulties of 75 or above.

DISCUSSION

The polygons in Figures 1, 2, 3, 4, and 5, seem to suggest that the groups studied were not normally distributed with respect to science attitude scores. Some speculation might arise at this point concerning the likelihood of a normal distribution in something as intangible as attitudes. One could easily assume that a person either possesses or does not possess a certain attitude. If that assumption was true then one would expect a bimodal distribution of the scores. Proving or disproving this point is beyond the scope of this paper. The peculiar polygon for the senior class in Figure 5 for the second administration of the scale is most likely due to lack of cooperation from some of the students. The second administration of the scale was done about three weeks before the seniors were to be graduated. Some of them simply were no longer interested in school or the things connected with it.

It was interesting to note the significant difference between the means of the freshmen and seniors, sophomores and seniors, and juniors and seniors on the second administration of the scale. This probably is due also to the factors mentioned in the paragraph above. It appeared fairly obvious to the writer that some of the senior students were not putting forth an honest effort.

There was some change in attitude between the two administrations of the scale. The freshmen apparently did not improve their attitude toward science. A scale with a higher reliability, however, might have been able to detect a change. This would apply to the other classes also. A more reliable scale would probably result in more significant differences. The reliability of the scale was not high, but neither was it extremely low.

No relationship was expected between the scores made on the scale and number of science courses taken and being taken. It was also expected that there would be no relationship between scores made on the scale and age and intelligence quotient. This bears out some of the statements made by several authorities in the area of attitude measurement. (Mayhew and Hill, 1950; Sherman, 1941).

This writer believes it was highly significant that a definite relationship existed between the scores made on the scale and reading in natural science, background in natural science, and the composite scores on the Iowa Test of Educational Development. These are the things that apparently mold the individual's attitudes into certain patterns. It is the writer's opinion that attitudes toward science are already determined before a student enters high school. It becomes the task of the high school science teacher to

attempt to displace the undesirable attitudes that the student may have toward science.

The item analysis seems to indicate that the statements were fairly easy since over one-half of the items had difficulties of 75 or above.

SUMMARY

1. A forty-one statement science attitude scale was constructed using the "pleasing-no feeling-not pleasing" type of response.

2. The science attitude scale was validated by a group of college science professors who were assumed to possess desirable attitudes toward science.

3. Approximately 180 students in the Caldwell High School, Caldwell, Kansas, were given the scale early in the school year and were given it again about seven months later.

4. There was no significant differences between the variances of the classes studied on the first administration of the scale.

5. There was no significant differences between the variances of the classes studied on the second administration of the scale, except for a significant difference in variances between the junior and senior classes.

6. There was no significant differences between the means of the groups studied on the first administration of the scale.

7. There was a significant difference between means of the freshmen and seniors, sophomores and seniors, and juniors and seniors for the second administration of the scale.

8. No change in attitude could be detected in the freshman class.

9. There was a slight improvement in the attitude of the sophomores and juniors over the seven month period.

10. The senior class did significantly worse on the second administration than they did on the first administration of the scale.

11. The reliabilities for the scale ranged from a low of .50 for the senior class on the first administration of the scale to a high of .78 for all the students on the second administration.

12. Analysis of variance indicated that the scale discriminated significantly between individuals.

13. No significant correlation was found to exist between the scores made on the scale and number of science courses taken or being taken.

14. No significant correlation was found to exist between the scores made on the scale and age.

15. No significant correlation was found to exist between the scores made on the scale and intelligence quotient.

16. Significant positive relationships were found to exist between the scores made on the scale and reading in natural science, background in natural science, and general achievement.

17. Item analysis seemed to indicate that the statements were fairly "easy."

RECOMMENDATIONS

As a result of working with this study, the writer would like to recommend that high school science teachers try, to the limits of their resources, to determine what kind of attitudes their students possess toward science. Unfortunately, no method for accomplishing this can be suggested until a good science attitude scale can be devised. The high degree of relationship between the scores made on this science attitude scale and reading in natural science and background in natural science was particularly striking to the author. These are well within the realm of the science teacher. It is the obligation of the science teacher to provide those classroom experiences which will give a student the broadest possible training in reading and interpreting scientific literature and broadening the student's scientific background. If these things are important to the development of desirable attitudes toward science, then it behooves the science teacher to do something about them.

In addition the author would like to recommend the following points for further exploration:

1. Try a different response scheme on the science attitude scale such as five, six, or seven response choices ranging from "strongly disagree" to "strongly agree."

2. Try using extremely short sentences perhaps only phrases. Give the examinee the basic thought with as little verbage as possible. The hope of this would be to evoke an emotional response as soon as possible before the person being tested has had time to change his mind or mask his true response.

3. Use a much larger group of scientists for validation purposes. Use many kinds of scientists. Do not limit it to college science teachers.

4. Make certain the statements are as emotionally toned as possible by discussing them with many other people before using them on the scale. Get the emotional reactions of people other than scientists, but make the most use of scientifically trained people.

5. When the scale is given to the same group more than once try to keep the environmental conditions as nearly identical as possible each time.

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APPENDIX

TABLE I

Analysis of Variance Table for the Reliability of the Science Attitude Scale for the Freshman Class

First Administration

Source of Variation	D.F.	Sums of Squares	Mean Squares	F
Between individuals	41	13.3618	.3259	2.1698*
Between items	40	54.3043	1.3576	9.0386
Error	1640	246.2811	.1502	
Total	1721	313.9472		

*Significant at the 5 per cent level.

TABLE II

Analysis of Variance Table for the Reliability of the Science Attitude Scale for the Sophomore Class

First Administration

Source of Variation	D.F.	Sums of Squares	Mean Squares	F
Between individuals	45	18.1405	.4031	2.1698*
Between items	40	74.7243	1.8681	11.9444
Error	1800	281.5070	.1564	
Total	1885	374.3718		

*Significant at the 5 per cent level.

TABLE III

Analysis of Variance Table for the Reliability of the Science Attitude Scale for the Junior Class

First Administration

Source of Variation	D.F.	Sums of Squares	Mean Squares	F
Between individuals	44	20.6482	.4693	3.0794*
Between items	40	59.9057	1.4976	9.8268
Error	1760	268.2407		

*Significant at the 5 per cent level.

TABLE IV

Analysis of Variance Table for the Reliability of the Science Attitude Scale for the Senior Class

First Administration

Source of Variation	D.F.	Sums of Squares	Mean Squares	F
Between individuals	42	14.3778	.3423	2.0018*
Between items	40	50.3789	1.2595	7.3655
Error	1680	287.2694	.1710	
Total	1762	352.0261		

*Significant at the 5 per cent level.

TABLE V

Analysis of Variance Table for the Reliability of the Science Attitude Scale for all the Students

First Administration

Source of Variation	D.F.	Sums of Squares	Mean Squares	F
Between individuals	175	69.7515	.3986	2.5276*
Between items	40	216.8851	5.4221	34.3824
Error	7000	1104.0418	.1577	
Total	7215	1390.6784		

*Significant at 5 per cent level.

TABLE VI

Analysis of Variance Table for the Reliability of the Science Attitude Scale for the Freshman Class

Second Administration

Source of Variation	D.F.	Sums of Squares	Mean Squares	F
Between individuals	41	14.6858	.3582	2.0923*
Between items	40	16.4518	.4113	2.4025
Error	1640	280.7190	.1712	
Total	1721	311.8566		

*Significant at the 5 per cent level.

TABLE VII

Analysis of Variance Table for the Reliability of the Science Attitude Scale for the Sophomore Class

Second Administration

Source of Variation	D.F.	Sums of Squares	Mean Squares	F
Between individuals	45	18.1066	.4024	2.5468*
Between items	40	62.4952	1.5624	9.8886
Error	1800	284.4804	.1580	
Total	1885	365.0822		

*Significant at the 5 per cent level.

TABLE VIII

Analysis of Variance Table for the Reliability of the Science Attitude Scale for the Junior Class

Second Administration

Source of Variation	D.F.	Sums of Squares	Mean Squares	F
Between individuals	46	15.1271	.3289	2.2451*
Between items	40	53.8485	1.3462	9.1891
Error	1840	269.4686	.1465	
Total	1926	338.4442		

*Significant at the 5 per cent level.

TABLE IX

Analysis of Variance Table for the Reliability of the Science Attitude Scale for the Senior Class

Second Administration

Source of Variation	D.F.	Sums of Squares	Mean Squares	F
Between individuals	39	24.5848	.6304	3.3284*
Between items	40	38.9476	.9737	5.1410
Error	1560	295.5402	.1894	
Total	1639	359.0726		

*Significant at the 5 per cent level.

TABLE X

Analysis of Variance Table for the Reliability of the Science Attitude Scale for all the Students

Second Administration

Source of Variation	D.F.	Sums of Squares	Mean Squares	F
Between individuals	174	82.1110	.4719	4.6447*
Between items	40	180.8050	4.5201	44.4892
Error	6960	707.3414	.1016	
Total	7174	1384.0622		

*Significant at the 5 per cent level.

TABLE XI

Chi-square Calculation for
Attitude Scale Scores and Percentile Rank
in Reading in Natural Science

First Administration

		Scores 19-25	26-32	33-39	Totals
%-tile rank	1-33	8	10	4	22
in Reading	34-66	8	43	12	63
in Nat. Sci.	67-99	8	34	39	81
	Totals	24	87	55	166

%-tile Rank	Reciprocals of row totals	Squared frequencies .041667	.100494	.018182		
1-33	.045455	64	100	16	4.107000	.186684
34-66	.015873	64	1849	144	26.537302	.421227
67-99	.012346	64	1156	1521	43.608574	.538391

Total - 1.146302

$$x^2 = N\left\{\Sigma\left[f^2(1/T_r)(1/T_c)\right] - 1\right\}$$

$$x^2 = 166(1.146302 - 1)$$

$x^2 = 24.286132$ Significant at the 5 per cent level.

TABLE XII

Chi-square Calculation for
Attitude Scale Scores and Percentile Rank
in Reading in Natural Science

Second Administration

		Scores			
		14-22	23-31	32-40	Totals
%-tile rank	1-33	5	13	4	22
in Reading	34-66	6	33	22	61
in Nat. Sci.	67-99	1	32	49	82
	Totals	12	78	75	165

%-tile rank	Reciprocals of row totals	Squared frequencies .083333	.012821	.013333		
1-33	.045455	25	169	16	4.463402	.202884
34-66	.016393	36	1089	484	23.415229	.383846
67-99	.012195	1	1024	2401	45.224570	.551514

Total - 1.138244

$$x^2 = N\left\{\Sigma\left[f^2(1/T_r)(1/T_c)\right] - 1\right\}$$

$$x^2 = 165(1.138244 - 1)$$

$x^2 = 22.810260$ Significant at the 5 per cent level.

TABLE XIII

Chi-square Calculation for
Attitude Scale Scores and Percentile Rank
in Background in Natural Science

First Administration

		Scores			
		19-25	26-32	33-39	Totals
%-tile rank in Bkgnd. in Nat. Sci.	1-33	11	15	2	28
	34-66	8	29	14	51
	67-99	5	42	39	86
	Totals	24	86	55	165

%-tile rank	Reciprocals of row totals	Squared frequencies .041667	.011628	.018182		
1-33	.035714	121	225	4	7.730735	.276095
34-66	.019608	64	841	196	16.009508	.313914
67-99	.011628	25	1764	1521	49.208289	.572193

Total - 1.162202

$$x^2 = N\left\{\Sigma\left[f^2(1/T_r)(1/T_c)\right] - 1\right\}$$

$$x^2 = 165(1.162202 - 1)$$

$x^2 = 26.763330$ Significant at the 5 per cent level.

TABLE XIV

Chi-square Calculation for
Attitude Scale Scores and Percentile Rank
in Background in Natural Science

Second Administration

		Scores			
		14-22	23-31	32-40	Totals
%-tile rank	1-33	7	17	3	27
in Bkgnd.	34-66	2	27	20	49
in Nat. Sci.	67-99	3	33	52	88
	Totals	12	77	75	164

%-tile rank	Reciprocals of row totals	Squared frequencies .083333	.012987	.013333		
1-33	.037037	49	289	9	7.956557	.294687
34-66	.020408	4	729	400	15.134055	.308856
67-99	.011364	9	1089	2704	50.945272	.578942

Total - 1.182485

$$x^2 = N\left\{\Sigma\left[f^2(1/T_r)(1/T_c)\right] - 1\right\}$$

$$x^2 = 164\ (1.182485 - 1)$$

$x^2 = 29.927540$ Significant at the 5 per cent level.

TABLE XV

Chi-square Calculation for
Attitude Scale Scores and Percentile Rank
in Composite Score

First Administration

		Scores 19-25	26-32	33-39	Totals
%-tile rank in Composite Score	1-33	14	17	3	34
	34-66	6	38	11	55
	67-99	5	30	41	76
	Totals	25	85	55	165

%-tile rank	Reciprocals of row totals	Squared frequencies .040000	.011765	.018182		
1-33	.029412	196	289	9	11.403723	.335406
34-66	.018182	36	1444	121	20.628682	.375071
67-99	.013158	25	900	1681	42.152442	.554642

Total - 1.265119

$$x^2 = N\left\{\Sigma\left[f^2(1/T_r)(1/T_c)\right] - 1\right\}$$

$$x^2 = 165(1.265119 - 1)$$

$x^2 = 43.744635$ Significant at the 5 per cent level.

TABLE XVI

Chi-square Calculation for
Attitude Scale Scores and Percentile Rank
in Composite Score

Second Administration

		Scores 19-29	30-40	Totals
%-tile rank in Composite Score	1-33	24	8	32
	34-66	26	28	54
	67-99	11	67	78
	Totals	61	103	164

%-tile rank	Reciprocals of row totals	Squared frequencies .016393	.009709		
1-33	.031250	576	64	10.063744	.314492
34-66	.018519	676	784	18.693524	.346185
67-99	.012821	121	4489	45.567254	.584218

Total - 1.244895

$$x^2 = N\left\{\Sigma\left[f^2(1/T_r)(1/T_c)\right] - 1\right\}$$

$$x^2 = 164\ (1.244895 - 1)$$

$x^2 = 40.162780$ Significant at the 5 per cent level.

TABLE XVII

Chi-square Calculation for
Attitude Scale Scores and Number of Science
Courses Taken and Presently being Taken

First Administration

		Scores 19-29	30-40	Totals
No. of Sci. Courses Taken	0	6	8	14
	1	31	57	88
	2	24	29	53
	3-4	5	20	25
Totals		66	114	180

No. of Sci. Courses Taken	Reciprocals of row totals	Squared frequencies .015152	.008772		
0	.071429	36	64	1.106880	.079063
1	.011364	961	3249	43.061300	.489349
2	.018868	576	841	16.104804	.303865
3-4	.040000	25	400	3.887600	.155504

Total - 1.027781

$$x^2 = N\left\{\Sigma\left[f^2(1/T_r)(1/T_c)\right] - 1\right\}$$

$$x^2 = 180\ (1.027781 - 1)$$

$x^2 = 5.000580$ Not significant at the 5 per cent level.

TABLE XVIII

Chi-square Calculation for
Attitude Scale Scores and Number of Science
Courses Taken and Presently being Taken

Second Administration

		Scores 19-29	30-40	Totals
No. of	0	6	7	13
Sci. Courses	1	32	53	85
Taken	2	23	35	58
	3-4	5	14	19
	Totals	66	109	175

No. of Sci. Courses Taken	Reciprocals of row totals	Squared frequencies .015152	.009174		
0	.076923	36	49	.994998	.076538
1	.011765	1024	2809	41.285414	.485723
2	.017241	529	1225	19.253558	.331951
3-4	.052632	25	196	2.176904	.114575

Total - 1.008787

$$x^2 = N\left\{\Sigma\left[f^2(1/T_r)(1/T_c)\right] - 1\right\}$$

$$x^2 = 175(1.008787 - 1)$$

$x^2 = 1.537725$ Not significant at the 5 per cent level.

Bartlett's Test of Homogeneity of Variance* for the Science Attitude Scale First Administration

Sample	Σx^2	D.F. n - 1	Reciprocal 1/n-1	Mean Square s^2	log s^2	(n-1)log s^2
Fr.	547.8334	41	.02439	13.36179	1.125867	46.1605
Soph.	787.2392	45	.02222	17.49420	1.242895	55.9403
Jr.	811.1112	44	.02273	18.43435	1.265630	55.6877
Sr.	615.0698	42	.02381	14.64452	1.165676	48.9584
a=4	2761.2536	172	.09315		$\Sigma(n-1)(\log s^2)$ = 206.7369	
	Σx^2	$\Sigma(n-1)$	$\Sigma 1/n-1$			

$\bar{s}^2 = \Sigma x^2/\Sigma(n-1) = 2761.2536/172 = 16.0538$

$(\log \bar{s}^2)\Sigma(n-1) = (1.20558)(172) = 207.35976$

$x^2 = 2.3026 \left[(\log \bar{s}^2)\Sigma(n-1) - (n-1)(\log s^2)\right]$

$x^2 = 2.3026 \left[207.35976 - (206.7369)\right]$

$x^2 = 2.3026 \left[.62286\right]$ where $\Sigma x^2 = \Sigma X^2 - (\Sigma X)^2/n$

$x^2 = 1.4342$

X = Total scale scores per class

Correction factor $C = 1+1/3(a-1)(\Sigma 1/n-1 - 1/\Sigma(n-1))$

$C = 1+1/(3)(3)(.09315 - 1/172)$

$C = 1.00970$

Corrected $x^2 = 1.4342/1.00970$

$x^2 = 1.4204$ Not significant at the 5 per cent level.

*Adapted from Snedecor (1956) page 287

Bartlett's Test of Homogeneity of Variance* for the Science Attitude Scale Second Administration

Sample	Σx^2	D.F. n - 1	Reciprocal 1/n-1	Mean Square s^2	log s^2	(n-1)log s^2
Fr.	639.6429	41	.02439	15.60105	1.193149	48.9191
Soph.	742.3696	45	.02222	16.49710	1.217405	54.7832
Jr.	620.2128	46	.02174	13.48289	1.129782	51.9700
Sr.	1004.4000	39	.02641	25.75384	1.410845	55.0230
a=4	3006.6253 Σx^2	171 $\Sigma(n-1)$	.09476 $\Sigma 1/n-1$		$\Sigma(n-1)(\log s^2)$ =	210.6953

$\bar{s}^2 = \Sigma x^2 / \Sigma(n-1) = 3006.6253/171 = 17.5826$

$(\log \bar{s}^2)\ \Sigma(n-1) = (1.24509)(171) = 212.91039$

$x^2 = 2.3026\ [(\log \bar{s}^2)\ \Sigma(n-1) - (n-1)(\log s^2)]$

$x^2 = 2.3026\ [(212.91039 - 210.6953)]$

$x^2 = 2.3026\ [2.21509]$ where $\Sigma x^2 = \Sigma X^2 - (\Sigma X)^2/n$

$x^2 = 5.1005$

X = Total scale scores per class

Correction factor $C = 1+1/3(a-1)\left(\Sigma 1/n-1 - 1/\Sigma(n-1)\right)$

$C = 1+1/(3)(3)(.09476 - 1/171)$

$C = 1.00988$

Corrected $x^2 = 5.1005/1.00988$

$x^2 = 5.0506$ Not significant at the 5 per cent level.

*Adapted from Snedecor (1956) page 287

TABLE XIX

Number Passing each Item and Item Difficulty for each Class and for All Classes Combined on the Science Attitude Scale

Item No.	Groups								
	Freshmen		Sophomores		Juniors		Seniors		
	Number Correct	Item Difficulty	Number Correct	Item Difficulty	Number Correct	Item Difficulty	Number Correct	Item Difficulty	Mean Difficulty
1	33	79	38	83	34	76	28	65	76
2	28	67	24	52	26	58	25	58	59
3	29	69	32	70	26	58	32	75	68
4	40	95	45	98	40	89	39	91	93
5	40	95	42	91	33	73	38	88	87
6	32	76	34	74	36	80	38	88	80
7	39	93	43	94	44	98	38	88	93
8	36	86	26	57	36	80	30	70	73
9	39	93	42	91	43	96	37	86	91
10	38	91	41	89	42	93	38	88	90
11	36	86	42	91	38	85	40	93	89
12	35	83	33	72	31	69	34	79	76
13	30	71	17	37	27	60	23	54	55
14	25	60	35	76	36	80	28	65	70
15	41	100	42	91	45	100	39	91	95
16	7	17	7	15	12	27	10	23	21
17	33	79	38	83	32	71	29	68	75
18	29	69	30	65	36	80	33	77	73

TABLE XIX (Continued)

Item No.	Groups: Freshmen Number Correct	Freshmen Item Difficulty	Sophomores Number Correct	Sophomores Item Difficulty	Juniors Number Correct	Juniors Item Difficulty	Seniors Number Correct	Seniors Item Difficulty	Mean Difficulty
19	36	86	40	87	38	85	30	70	82
20	39	93	41	89	37	82	38	89	88
21	31	74	42	91	33	73	31	72	78
22	36	86	35	76	34	76	36	84	80
23	31	74	25	54	25	56	26	61	61
24	36	86	43	93	39	87	33	77	86
25	20	48	25	54	26	58	24	56	54
26	33	79	43	93	41	91	36	84	87
27	15	36	15	33	18	40	18	42	38
28	29	69	32	70	34	76	35	81	74
29	34	81	31	67	38	85	28	65	74
30	40	95	39	85	44	98	36	84	90
31	22	52	16	35	18	40	19	44	43
32	33	79	36	76	36	80	35	81	80
33	29	69	34	74	35	78	32	75	74
34	31	74	28	61	30	67	26	61	65
35	35	83	35	76	38	85	29	68	78
36	15	36	18	39	15	33	12	28	34
37	37	88	36	78	40	89	35	81	84
38	39	93	44	96	44	98	42	98	96
39	31	74	31	67	33	73	26	61	69
40	27	64	27	59	23	51	32	75	62
41	40	95	44	96	42	93	39	91	94

28 July 1958

Dear Sir:

Attached is an experimental science attitude scale which is to be given this fall to the students of Caldwell High School, Caldwell, Kansas. This scale is to be used in the development of a thesis problem at Kansas State Teachers College, Emporia, Kansas. The statements in the scale are either in agreement with, or antagonistic to, ideas presented by such well-known scientists and educators as Bertrand Russell, James B. Conant, and J. Robert Oppenheimer. Most of the statements have been shortened and the wording altered in an attempt to make them more understandable to high school students.

It would be greatly appreciated if you would complete this scale. The results of your responses to the items will be used in constructing a key to analyze the responses of high school students. In other words, you are asked to be part of the validating group. You are considered to be one of the best qualified individuals available to indicate the responses that science-minded persons would give on a test of this type.

There has been very little research where feelings are used as a basis for response in attitude measurement. This is particularly true in the field of science. It is felt that research in the identification of students who have, or do not have, a desirable attitude toward science could be significant in regard to the teaching of science.

Your cooperation in completing and returning this scale is essential to the development of the thesis problem. It should not take much time to complete. Remember to not be concerned whether a statement is true or false. Your feeling toward it is the objective. Completion and return within fourteen days would be greatly appreciated. Please use the enclosed envelope to return the completed form.

Thank you for your cooperation,

Ardon Brandyberry

Ardon Brandyberry
Science Instructor
Caldwell High School
Caldwell, Kansas

INSTRUCTIONS FOR ADMINISTERING THE SCALE

You no doubt realize the tremendous importance of science to our modern
ay living. In the past year or so science has become even more significant.
uch work is now being done to improve high school and college science courses.
he opinion survey which you are about to take is a small part of the effort
eing made to improve high school science.

Most tests try to find out how much you know about something. This is more
f an opinion survey. It is not concerned with how much you know, or don't
now, about science. It only wants you to show how you feel about the state-
ents it contains. Don't worry about whether a statement is right or wrong.
n many of them you are not expected to know whether they are true or false.
imply indicate how you feel about the statement. Be sure to read the
irections and follow them carefully.

You no doubt realize the tremendous importance of science to our modern
ay living. In the past year or so science has become even more significant.
uch work is now being done to improve high school and college science courses.
he opinion survey which you are about to take is a small part of the effort
eing made to improve high school science.

Most tests try to find out how much you know about something. This is
ore of an opinion survey. It is not concerned with how much you know, or
on't know, about science. It only wants you to show how you feel about the
tatements it contains. Don't worry about whether a statement is right or
rong. On many of them you are not expected to know whether they are true or
alse. Simply indicate how you feel about the statement. Be sure to read the
irections and follow them carefully.

SCIENCE ATTITUDE SCALE

Personal Data
(Fill all the blanks)

AME _____ DATE OF BIRTH _____
(Last) (First) (Middle) (Month) (Day) (Year)

GE _____ SEX _____ YEAR IN SCHOOL _____
(M or F)

cience or Mathematics courses you are taking now _____

ther Science or Mathematics courses you have taken in high school _____

DIRECTIONS
(Please follow carefully)

This is NOT a test. These pages contain a series of statements on ifferent ideas about science. You are asked to show how you feel about each tatement. Do not be concerned about whether a statement is true or false. o not leave any statements blank. Do not hurry, you have plenty of time.

If the statement appears pleasing to you, draw a line through the word Pleasing".

If you have absolutely no feeling about the statement, draw a line through he phrase "No feeling".

If the statement is not pleasing to you in any way, draw a line through he phrase "Not pleasing".

Example:

~~Pleasing~~ It is bad to tell lies.
No feeling
Not pleasing

---

1. ~~Pleasing~~ Nature has unity; therefore the various branches of science
No feeling are dependent on each other and have no definite boundaries.
Not pleasing

2. Pleasing When most people think of scientific advancement they think
~~No feeling~~ first of machines.
~~Not pleasing~~

3. Pleasing No sharp line can be drawn between scientific techniques
~~No feeling~~ and ordinary arts and crafts.
~~Not pleasing~~

4. ~~Pleasing~~
No feeling
Not pleasing
New ideas arise from experiments and observations, and the new ideas in turn lead to further experiments and observations.

5. Pleasing
No feeling
~~Not pleasing~~
We have reached such a point of human well-being that much of the scientific research of today is not necessary.

6. Pleasing
~~No feeling~~
~~Not pleasing~~
Science is the only line of work about which the public knows only those things which affect them directly.

7. ~~Pleasing~~
~~No feeling~~
Not pleasing
Scientific wonders can provide as much enjoyment as entertainment.

8. Pleasing
No feeling
~~Not pleasing~~
The majority of scientific research should be stopped because too much of it is for destructive purposes.

9. Pleasing
~~No feeling~~
~~Not pleasing~~
The discussion of moral issues in science classes is not important.

10. ~~Pleasing~~
~~No feeling~~
Not pleasing
Science cannot do its full share toward human progress until people better understand scientific research and the scientific method.

11. Pleasing
~~No feeling~~
~~Not pleasing~~
Attitudes toward science are determined by religious traditions.

12. ~~Pleasing~~
No feeling
~~Not pleasing~~
We have a poor science of human relations and only a few scientists are concerned about improving it.

13. Pleasing
No feeling
~~Not pleasing~~
The scientist sometimes unintentionally places great destructive powers in the hands of reckless men.

14. ~~Pleasing~~
No feeling
~~Not pleasing~~
The general public is often fooled when misunderstood scientific terms are used in the advertising of commercial products.

15. ~~Pleasing~~
~~No feeling~~
Not pleasing
A specialist in any scientific field is surrounded by an increasing amount of scientific reading material in many different forms.

16. Pleasing
No feeling
~~Not pleasing~~
America should be more secret with scientific discoveries as hostile countries might use many of them in war against us.

17. ~~Pleasing~~
~~No feeling~~
It is possible that world-wide disaster may not be the cause of the end of the human race.

18. Pleasing ~~No feeling~~ ~~Not pleasing~~ — Social sciences rather than natural sciences hold the keys to the future, because social sciences care more about mankind's welfare.

19. ~~Pleasing~~ No feeling Not pleasing — An understanding of science may give one something which can be helpful in solving a problem in an unfamiliar area.

20. Pleasing ~~No feeling~~ ~~Not pleasing~~ — The scientific habits of thought and points of view cannot be transferred to any other human activities.

21. ~~Pleasing~~ ~~No feeling~~ Not pleasing — Scientists of the past had as much difficulty explaining certain things as scientists have today with more complicated research.

22. ~~Pleasing~~ No feeling ~~Not pleasing~~ — The scientist can get a direct answer to any simple question about nature by using a carefully designed experiment.

23. Pleasing No feeling ~~Not pleasing~~ — Science is a difficult subject and only "brains" can do very well in scientific careers.

24. Pleasing ~~No feeling~~ ~~Not pleasing~~ — The enriching of emotional and artistic experience is a greater goal of science than that of providing useful products.

25. Pleasing ~~No feeling~~ ~~Not pleasing~~ — Whenever a completely new scientific discovery is made, the general reaction of people is usually suspicion and disbelief.

26. ~~Pleasing~~ ~~No feeling~~ Not pleasing — Natural events repeating themselves under the same conditions may be said to be an illustration of the uniformity of nature.

27. Pleasing No feeling ~~Not pleasing~~ — A very highly developed scientific defense program could make a nation completely safe from attack from another nation.

28. ~~Pleasing~~ No feeling ~~Not pleasing~~ — Modern science is so complicated that often many of its social and cultural values are hidden.

29. Pleasing ~~No feeling~~ ~~Not pleasing~~ — Science is the cause of much of the evil in the world today because of weapon inventions.

30. Pleasing ~~No feeling~~ ~~Not pleasing~~ — The social effects of discoveries and inventions are of little concern to the scientist.

31. Pleasing No feeling — When two theories are presented to explain something, the incorrect one should be immediately forgotten to avoid

32.	~~Pleasing~~ ~~No feeling~~ Not pleasing	People usually think scientific discoveries are sensible, and realize they result from careful, exact work and are for society's benefit.
33.	Pleasing No feeling ~~Not pleasing~~	It appears that we have almost reached the limit of scientific advancement that is possible for human minds to attain.
34.	Pleasing ~~No feeling~~ ~~Not pleasing~~	Scientific experiments came from earlier experiments done for practical purposes, and not from pure scientific curiosity.
35.	Pleasing ~~No feeling~~ ~~Not pleasing~~	The actions of the surroundings upon living things are less important than actions of living things to change their surroundings.
36.	Pleasing No feeling ~~Not pleasing~~	The main value of science is its practical benefits; therefore scientific research should be aimed at meeting society's immediate needs.
37.	~~Pleasing~~ ~~No feeling~~ Not pleasing	One of the areas in which scientific approach can be of great value is in decreasing prejudice.
38.	~~Pleasing~~ ~~No feeling~~ Not pleasing	How realistic an idea seems depends upon how well one understands the principles surrounding the idea.
39.	~~Pleasing~~ No feeling Not pleasing	Differences of theories and opinions in research have been of more help than harm to the scientific understanding of knowledge.
40.	Pleasing ~~No feeling~~ ~~Not pleasing~~	Persons who know nothing of science realize their ignorance more than those who are well-trained in science.
41.	~~Pleasing~~ ~~No feeling~~ Not pleasing	Exact and impartial investigation has probably been one of the necessary conditions for scientific advances since the beginnings of science.

Calculation of Chi-squares*

In the method used for the calculation of chi-square a block similar to the one below must be constructed. One set of data is grouped into a frequency distribution which forms the columns. The other set of data is grouped into a frequency distribution so as to form the rows. The cells are then filled in such a manner that no cells has a number less than four if at all possible. For illustrative purposes a 3 by 3 square is shown.

		Grouped data in columns 1	2	3	Row Totals
Grouped data in rows	4	x_1	y_1	z_1	a
	5	x_2	y_2	z_2	b
	6	x_3	y_3	z_3	c
Column totals		d	e	f	N

A worksheet similar to the following is then made:

Column data	Reciprocals of row totals	Squared frequencies 1/d	1/e	1/f	X	Y
4	1/a	x_1^2	y_1^2	z_1^2		
5	1/b	x_2^2	y_2^2	z_2^2		
6	1/c	x_3^2	y_3^2	z_3^2		
					Total	Y

$X = \Sigma\left[f^2(1/T_c)\right] = \left[(1/d)(x_1^2)\right] + \left[(1/e)(y_1^2)\right] + \left[(1/f)(z_1^2)\right]$ for each space under X in the worksheet.

$Y = \Sigma\left[f^2(1/T_c)(1/T_r)\right] = (1/a)(X)$ for each space under Y; for example the last space under Y would be equal to $(1/c)(X)$.

The complete formula for x^2 is:

$$x^2 = N\left\{\Sigma\left[f^2(1/T_r)(1/T_c)\right] - 1\right\}$$

where N is the number in the sample group; f is the frequency in any cell; T_r is row total; and T_c is column total. From the information given from the worksheet the formula becomes:

$$x^2 = N(\text{total } Y) - 1$$

The degrees of freedom in chi-square is the number of columns minus 1 added to the number of rows minus 1. From appropriate tables of chi-square the significance of the relationship between two sets of data can be determined.

*From Wert, Neidt, and Ahmann (1954) page 159

Hoyt's Method for Determining Reliability*

Tabulation of data

Individual	Item					Score
	1	2	. . . . .		k	
1	X_{s1}		.....		X_{s1}	ΣX_{s1}
2			.....			ΣX_{s2}
.						
.						
n	X_{s1}		.....		X_{s1}	$\sum_s X_{sn}$
Total	$\sum_i X_{1i}$	$\sum_i X_{2i}$	.....		ΣX_{ki}	$\sum_s \sum_i X_{si}$

s = 1, 2, ...k; i = 1, 2, ... n; k is the number of items; n is the number of individuals; X_{si} denotes the score of the ith individual on the sth item, which would be 1 or 0.
N = nk

The sum of squares between individuals is:

$$\frac{\sum_i (\sum_s X_{si})^2}{K} - \frac{(\sum_s \sum_i X_{si})^2}{N}$$

The sum of squares between items is:

$$\frac{\sum_s (\sum_i X_{si})^2}{n} - \frac{(\sum_s \sum_i X_{si})^2}{N}$$

The total of sum of squares is:

$$\frac{n_1 n_2}{N}$$

where $n_1 = \sum_s \sum_i X_{si}$ and n_2 = number of incorrect responses $(N-n_1)$

*From Johnson (1949) page 134-136

Reliability Worksheet*

Source of Variation	Degrees of Freedom	Sums of Squares(s.s.)	Mean Square		F
Between Individuals	n - 1	s.s.between individuals	$\frac{\text{s.s.(ind)}}{\text{D.F.}(n-1)}$	(a)	$\frac{a}{c}$
Between Items	k - 1	s.s.between items	$\frac{\text{s.s.(items)}}{\text{D.F.}(k-1)}$	(b)	$\frac{b}{c}$
Error	$(N-1) - [(n-1)] + [(k-1)]$	Total s.s. - s.s.(ind) - s.s.(items)	$\frac{\text{s.s.(error)}}{\text{D.F.(error)}}$	(c)	
Total	N - 1				

$$\text{Reliability} = \frac{a - c}{a}$$

*From Johnson (1949) page 134-36