The Scientific Attitude Inventory: A Revision (SAI II)

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Received 12 January 1995; revised 29 February 1996; accepted 8 July 1996

Abstract: The Scientific Attitude Inventory (SAI) was developed and field tested 25 years ago. It has been used extensively throughout the world, and it continues to be used. Reports of its use and suggestions for revision provide impetus for revision. The revision retains the original position statements of attitudes assessed and the original attitude statements with changes made only to improve readability and to eliminate gender-biased language. Also, in response to critical analysis, the SAI II uses a five-response Likert Scale. The new version is shorter, 40 items instead of 60 in the original. The SAI II was field tested with 557 students in Grades 6, 9, and 12. The top and bottom 27% of scorers for the total inventory were compared for the subscales. A statistically significant difference was obtained for each *t*-test comparison. Face validity for the SAI II is claimed on the basis of the original judgments of a panel of judges regarding the attitude position statements which have not been altered. A split-half reliability coefficient of .805 was computed for the entire group of 557 respondents. Cronbach's alpha reliability coefficient is .781. J Res Sci Teach **34:** 327–336, 1997.

Background

Motivation of students to be interested in science, their attitudes toward science, their views of scientists, and their desire to become scientists have been investigated by science educators for many years. Interest has grown since Noll's 1935 investigation of the measurement of scientific attitudes, and Mead and Metraux's 1957 investigation of high school students' image of scientists. More recently, science educators have been struggling with defining science attitudes (Shrigley, Koballa, & Simpson, 1988) and differentiating among attitudes, beliefs, and values (Koballa, 1988). A critical review of science attitude measurement by Munby (1983) included 30 studies that used the Scientific Attitude Inventory (SAI). Munby reported that the SAI was the most popular instrument of its type at that time, as he raised questions about its validity. The purpose of this article is to report the development, field test, and availability of a revision of the original SAI, the SAI II.

Requests for permission to use the SAI and/or this revision have been received recently from Boston University to study attitude development within a National Science Foundation (NSF) grant, from The University of Southern Mississippi to study attitude development in high

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school biology classes, from Sheffield Hallam University for a study of attitudes of first-year students of primary education toward science, from several students at Temple University studying attitude development among high school students, and from the State University of New York at Brockport for a study of the effect of a business–school partnership on students' attitudes toward science. Dimensions of the attitudes toward science addressed by the SAI are at the forefront of interest in the development of a literate citizenry. For example, the knowledge or attitudes that scientific ideas are subject to change, that science cannot answer all questions, and that scientific work requires creativity are part of the subject of this instrument and are identified as important dimensions of the nature of science by Project 2061 (American Association for the Advancement of Science [AAAS], 1990).

The Original SAI

The development of the SAI was reported in the *Journal of Research in Science Teaching* over 25 years ago (Moore & Sutman, 1970). The SAI has been used extensively throughout the world (Baker, 1985; Finson & Enochs, 1987; LaShier & Nieft, 1975; Welch, 1972). The authors are aware that it has been translated into Hebrew and Thai. A request for permission to translate it into Spanish was received, but there is no evidence of that or any additional translation.

In developing the instrument initially, the plan was to develop position statements representing the universe of content, namely, attitudes toward science. Twelve position statements, six opposing positive and negative statements, were developed. The position statements were intended to represent both intellectual and emotional attitudes. Then, a pool of attitude statements was developed for each of the position statements. The attitude items were submitted to a panel of judges who judged each attitude statement with respect to whether it represented a particular position statement. The panel of judges consisted of 4 science educators, 4 practicing scientists, and 2 liberal arts science professors. On the basis of the judges' judgments, attitude statements were selected from the pool for use in the instrument. Content validity for the SAI was claimed on the basis of the judgments of the panel of judges (Kerlinger, 1986; Gable, 1993).

The SAI consists of 60 Likert-type items. There are 5 attitude statements for each of 12 position statements, 6 opposing positive and negative statements. Each set of five statements represents a particular position statement and is referred to as a scale. Half of the position statements are positive and half are negative; thus, half of the 60 attitude statements are positive and half are negative. The SAI was field tested with three classes of 10th-grade biology students. The field test is reported in the *Journal of Research in Science Teaching* (Moore & Sutman, 1970). Scoring the original SAI was done with a FORTRAN program. A Macintosh Filemaker Pro template is now available for scoring.

Munby's (1983) report on the use of the SAI was a criticism of its use and of the validity of the instrument itself. Munby also reported conflicting reports from various researchers using the SAI. Baker (1985) stated that Munby's criticism "leaves the researcher in a quandary," noting that researchers "can spend a great deal of time developing their own instrument to assess attitudes toward science, avoiding all of the conceptual problems inherent in previous instruments, or the variable of attitude can cease to be a part of any study. Neither of these approaches seems to be realistic. At best we can hope that a better instrument will be developed and that all conclusions about attitude toward science can be regarded as tentative" (p. 105).

Nagy (1978) investigated the SAI "to look for empirical support for the distinction between 'feelings' and 'beliefs' in a scientific attitude scale" (p. 355). Assumptions underlying this investigation were stated: "Since beliefs require cognitive learning, it is reasonable to expect that feelings will correlate with achievement more strongly than beliefs unless beliefs are part of the course content" (p. 355). Nagy found that there were problems with some of the more difficult vocabulary required by the SAI: for example, the words *phenomena, objective,* and *idea-generating* seemed to be cause for concern. In addition, Nagy built a case for using a five-choice response format with an undecided or neutral category as opposed to the original four-choice format without a neutral category.

It is important to pay attention to serious criticisms and suggestions regarding vocabulary, item difficulty, and format in a revision of an instrument. This revision is an effort to do that.

Need for Revision

Many events have transpired since the SAI was developed. Many NSF-funded curricula and various projects for teachers have had various impacts upon the teaching of science. Some of these projects are in a third or fourth revision. Some of the science education work of the 1960s and 1970s has been incorporated into text series produced by different publishers. Some of the investigators of that period are still at work on extensions of those efforts. In addition, the AAAS (1990) embarked on a project to develop a scientifically literate society by the year 2061. Changes in direction and focus usually accompany changes in projects. This is a good reason to update an instrument that may be used in support of both continuing efforts and new initiatives.

A reading of the items in the SAI provides an obvious reason for revision. The words *he, him,* and *his* appear nine times, the words *she, her,* and *hers* are not used at all. Also, there are two references to *man.* This use of language reflects the thinking of the era in which the instrument was developed. It also is cause for outright rejection of the use of the instrument today. This is sufficient reason to revise the SAI. Also, as indicated above, Nagy (1978) discussed some of the vocabulary used in the original instrument, and suggested revisions which have been addressed (e.g., as noted above, items containing terms such as "idea-generating activity," "objective," and "phenomena," when used with a five-choice format, produced an inordinate number of undecided choices when compared with the remainder of the SAI).

Method

The SAI revision is referred to as the SAI II. Since there is evidence for the content validity of the items in the original instrument with respect to the 12 position statements, we decided to make as few changes as possible while responding to criticisms and suggestions. This evidence was presented in item selection and the field test of the original SAI. The primary goal for the revision was to prepare an instrument which would be as widely useful as possible and still retain the validity of the original SAI. To this end, we decided to focus on three goals: (a) to eliminate gender-biased references, (b) to eliminate words that have been criticized as difficult for readers to understand, and (c) to shorten the instrument to make it easier to use.

All 12 of the original position statements were retained to represent the universe of content, attitudes toward science. In addition, there was no attempt to generate new statements. The 60 attitude statements—five items for each of 12 position statements, 6 opposing positive and negative statements—were revised for the purpose of making them easier to read. Difficult words were eliminated, and the attitude statements were shortened when possible. After the attitude statements were edited, two attitude statements were eliminated for each scale except for the last pair of positive and negative scales, which have to do with the individual's desire to do scientific work. Thus, the SAI II has 40 Likert-type attitude statements instead of the 60 items in the original SAI. In addition, we decided to use the five-point scale in a field test of the SAI

II on the basis of suggestions by individuals who have used the original SAI. The position statements and the corresponding attitude statements for the SAI II are presented in the Appendix. The numbers by each item in the Appendix indicate the order of the items in the instrument.

Of the 60 attitude statements of the SAI, 40 were selected for use in the SAI II. Ten of the 40 statements were not changed. The 30 that were changed were changed to eliminate gender bias or make the item easier to read. The following is an example of a change to eliminate gender-biased language (the revision is read without the portion lined through):

> If one scientist says a theory is true, all other scientists will believe ~~him~~ it.

The following is a change to make the item easier to read:

> Scientific ideas ~~may be said to undergo a process of evolution in their development~~ can be changed.

Some changes met both objectives of eliminating gender bias and making the item easier to read:

> If a scientist cannot answer a question, ~~all he has to do is to ask~~ another scientist can.
> Scientific questions are answered by ~~When one asks questions in science, he gets information by~~ observing ~~natural phenomena~~ things.
> ~~One of the most important jobs of a~~ Scientists must ~~is to~~ report exactly what they observe.
> ~~his senses tell him~~.

There are 12 position statements. Six positions are positive and are labeled 1-A through 6-A. Six are negative and are labeled 1-B through 6-B. The A and B pair for each position are opposites of each other. The useful scales for analysis are 1-AB through 6-AB for each position and the positive and negative scales consisting of 1-A through 6-A and 1-B through 6-B, respectively.

Scoring

The SAI II is scored by assigning point values to each of the attitude items. Point values are assigned as shown in Table 1.

Scores for the various subscales can be determined by adding the scores for the respective items. Scores may be determined for the 12 subscales, a total for the positive items, a total for the negative items, and a total for the entire SAI II. The range of scores for each of the scales 1-A through 5-B is 3–15 (1–5 points $\times$ 3 items). The range of scores for scales 6A and 6B is

Table 1
Point values for positive items and for negative items

	Positive Items	Negative Items
Strongly agree	5	1
Mildly agree	4	2
12 neutral/undecided	3	3
Mildly disagree	2	4
Strongly disagree	1	5

5–25 (1–5 points × 5 items). The range of scores for the entire SAI is 40–200 (1–5 points × 40 items). Refer to the Appendix for the various scales. The authors handled the data for the field test entirely by machine after identification numbers were coded on students' scanner forms. An optical scanner read the data into a mainframe computer. The data were downloaded from the mainframe to a personal computer. The downloaded data had to be cleaned up to eliminate mainframe reference numbers that were of no importance to the study and to parse the data so they could be used by the scoring program. Microsoft Excel was used to remove the unwanted mainframe reference numbers and parse the data. Then the data was exported from Excel and imported into Filemaker Pro. A Filemaker Pro template was used to score each student's responses and to generate scores for each of the scales for each student. The Filemaker Pro template is available from the authors.

Field Test of the SAI II

Responses were collected from 588 students in 6th, 9th, and 12th grades in a rural/suburban middle school and high school in the same school district to determine how students at the various grade levels would respond to the revised SAI. A total of 557 of the respondents provided usable papers. The responses of the top and bottom 27% of respondents on the total instrument have been compared on the various subscales to provide evidence for the validity of the revised SAI. The rationale is that if there is a difference between the scores of the top scorers and the bottom scorers in favor of the top scores on the various subscales, those scales contribute to the instrument's ability to distinguish between those with strong attitudes toward science and those with weak attitudes toward science. This method of analyzing Likert data has been used by others for science attitude scale development (Hassan, 1984; Koballa, 1984; Misiti, 1991). This work indicates that each of the various subscales contributes positively to the total score for the instrument.

The SAI II has a score range of 40–200. The number of items in each scale, the scale mean, the scale standard deviation, the low and high score for this sample, and the score range for each of the scales in presented in Table 2.

When the top and bottom 27% of scorers on the total test are compared on each of the six subscales, scales 1-AB through 6-AB, a significant *t* was obtained in each case at the .05 level of significance. The results of these *t* tests for independent samples are presented in Table 3.

Table 2
Mean (M) standard deviation (SD), low and high score, and range for each scale of the SAI II for 557 respondents

Scale	No. of Items	*M*	*SD*	Score Low	Score High	Scale Range Range
1-AB	6	22.0	2.95	9	30	6–30
2-AB	6	23.4	3.48	12	30	6–30
3-AB	6	23.0	3.15	12	30	6–30
4-AB	6	18.3	2.56	10	28	6–30
5-AB	6	21.6	3.82	6	30	6–30
6-AB	10	31.0	8.74	10	50	10–50
Positive	20	73.5	10.00	40	96	20–100
Negative	20	67.6	8.66	36	93	20–100
Total	40	141.2	15.07	97	182	40–200

Table 3
Comparison of total score high and low scorers on subscales 1-AB through 6-AB, and positive scales, negative scales, and total score

	High		Low			
Scale	*M*	*SD*	*M*	*SD*	*t*	$p < .05$
1-AB	24.0	2.42	20.0	2.58	13.81	Yes
2-AB	25.3	2.79	21.4	3.58	10.50	Yes
3-AB	25.9	2.40	21.6	3.34	12.72	Yes
4-AB	18.9	2.67	17.8	2.65	3.47	Yes
5-AB	24.4	3.06	18.3	3.42	16.28	Yes
6-AB	41.0	5.74	23.2	5.99	26.29	Yes
Positive	83.2	5.71	62.8	7.63	26.23	Yes
Negative	76.2	5.70	59.4	7.18	22.27	Yes
Total	159.4	6.93	122.3	7.33	45.03	Yes

These data demonstrate that the instrument distinguishes between those who score high and those who score low on the total score, and are useful in establishing the validity of the SAI II.

Validity

The statements in the SAI II are essentially the same as those in the SAI. They have been revised to improve readability and eliminate gender-biased language as indicated above. Therefore, content validity is claimed on the basis of the original judgments of the panel of judges regarding the relation of the attitude items to the attitude positions. Construct validity of the SAI was demonstrated in the original field test.

An attempt was made to obtain support for the validity of the SAI II with confirmatory factor analyses of the data from the 557 respondents. One approach to the analysis involved all 40 items. In another analysis, the group of intellectual scales (1-A through 4-B) were examined separately from the emotional scales (4-A through 6-B). The resulting factor loadings were not satisfactory in any of these efforts. Exploratory factor analysis was attempted to determine a factor structure that might be supported by subsequent confirmatory factor analysis. This effort produced five scales using 30 of the 40 items in the SAI II. However, the grouping of items was not very satisfactory in terms of attempts to give meaning to the groupings. Establishing meaning for the groupings of items identified by factor loadings is an important step in establishing validity with factor analysis (Gable, 1993; Hatcher, 1994). In addition, regrouping the items would virtually eliminate the support gained by judges for the validity of the instrument. Therefore, the 40-item SAI II is being advanced as presented here without the support of factor analysis.

We have presented the results of an administration of the SAI II to 588 students (557 useful respondents), which indicates that the scales of the instrument distinguish between those who have more positive attitudes toward science and those who have less positive attitudes toward science as determined by the total score on the SAI II. The *t*-test comparisons of the high and low scorers is evidence that the various subscales contribute positively to the total score of the instrument. This is evidence that the various scales are related to each other and measure something similar. Coupled with judgments that the items of the instrument are related to the scientific attitudes it is supposed to assess, validity is claimed for the SAI II.

Considering the wide use of the SAI, it is possible that construct validity for the SAI II will be demonstrated further as it is used in a variety of studies. There have been many requests in recent years by individuals desiring to use the SAI and to modify it in various ways. There clearly is a need for a revision of this instrument to be available for continuing research regarding scientific attitudes.

Reliability

A split-half reliability coefficient was computed for the entire group of 557 respondents. Application of the Spearman Brown correction for split-half reliability to the correlation coefficient yields a reliability coefficient of .805. Cronbach's alpha reliability coefficient is .781 for this group.

Discussion

Validity support from factor analysis would have helped establish the viability of this instrument and would have been a helpful response to previous criticism. On the other hand, Lederman (1992) examined various efforts to assess both teachers' and students' attitudes toward and views about science. He noted that "science teachers do not possess adequate conceptions of the nature of science, irrespective of the instrument used to assess understandings" (p. 345). If science teachers are lacking in this area, one might expect that while scales designed to assess attitudes can distinguish among those who score high and those who score low on the total instrument, it is possible that the objects of the scales are so ill-formed in the subjects, students in this case, that we are not able to use their responses to confirm the scales as factors.

We believe this version of the SAI, the SAI II, is a significant improvement over the original. It is hoped that this update of a widely used instrument will provide additional interest in this important dimension of science, and will promote advances in assessing science attitudes and distinguishing among attitudes, values, and beliefs.

Permission to use the SAI II for research purposes may be obtained by writing to the authors. A copy of the instrument will be provided to any interested person. Please address correspondence to: Richard W. Moore, 301 McGuffey Hall, Miami University, Oxford, OH 45056; or e-mail moorerw@muohio.edu. A Macintosh Filemaker Pro template for scoring also is available from this author at no charge. A revision of the Science Teaching Attitude Scales (STAS) (Moore, 1973), which incorporates revisions in the SAI, also is available. Studies involving attitudes of both teachers and their students may find these instruments to be useful.

Appendix

Position Statements and Attitude Statements of the SAI II

These are the position statements and corresponding attitude statements of the SAI II.

The position statements are labeled with a number and a letter: for example, 1-A. The letter designates whether the position statement is positive (A) or negative (B). The position statements are in pairs, where the pair 1-A and 1-B are intended to be opposite positions regarding the same point of view. The numbers in front of each attitude statement indicates its number in the SAI II.

1-A. The laws and/or theories of science are approximations of truth and are subject to change.

4. Scientists are always interested in better explanations of things.

16. Scientific ideas can be changed.
34. Scientists believe that nothing is known to be true for sure.

1-B. The laws and/or theories of science represent unchangeable truths discovered through science.

11. When scientists have a good explanation, they do not try to make it better.
15. Scientists discover laws which tell us exactly what is going on in nature.
35. Scientific laws have been proven beyond all possible doubt.

2-A. Observation of natural phenomena and experimentation is the basis of scientific explanation. Science is limited in that it can only answer questions about natural phenomena and sometimes it is not able to do that.

10. Scientists cannot always find the answers to their questions.
19. Some questions cannot be answered by science.
33. The senses are one of the most important tools a scientist has.

2-B. The basis of scientific explanation is in authority. Science deals with all problems and it can provide correct answers to all questions.

2. Anything we need to know can be found out through science.
7. We can always get answers to our questions by asking a scientist.
26. If a scientist cannot answer a question, another scientist can.

3-A. To operate in a scientific manner, one must display such traits as intellectual honesty, dependence upon objective observation of natural events, and willingness to alter one's position on the basis of sufficient evidence.

17. Scientific questions are answered by observing things.
18. Good scientists are willing to change their ideas.
25. Scientists must report exactly what they observe.

3-B. To operate in a scientific manner one needs to know what other scientists think; one needs to know all the scientific truths and to be able to take the side of other scientists.

3. It is useless to listen to a new idea unless everybody agrees with it.
5. If one scientist says an idea is true, all other scientists will believe it.
32. Scientists should not criticize each other's work.

4-A. Science is an idea-generating activity. It is devoted to providing explanations of natural phenomena. Its value lies in its theoretical aspects.

20. A scientist must have a good imagination to create new ideas.
21. Ideas are the important result of science.
28. Science tries to explain how things happen.

4-B. Science is a technology-developing activity. It is devoted to serving mankind. Its value lies in its practical uses.

9. Electronics are examples of the really valuable products of science.
24. A major purpose of science is to produce new drugs and save lives.
31. A major purpose of science is to help people live better.

5-A. Progress in science requires public support in this age of science; therefore, the public should be made aware of the nature of science and what it attempts to do. The public can understand science and it ultimately benefits from scientific work.

12. Most people can understand science.
23. People must understand science because it affects their lives.
29. Every citizen should understand science.

5-B. Public understanding of science would contribute nothing to the advancement of science or to human welfare; therefore, the public has no need to understand the nature of science. They cannot understand it and it does not affect them.

6. Only highly trained scientists can understand science.
8. Most people are not able to understand science.
38. Scientific work is useful only to scientists.

6-A. Being a scientist or working in a job requiring scientific knowledge and thinking would be a very interesting and rewarding life's work. I would like to do scientific work.
1. I would enjoy studying science.
27. I would like to work with other scientists to solve scientific problems.
30. I may not make great discoveries, but working in science would be fun.
36. I would like to be a scientist.
40. Working in a science laboratory would be fun.

6-B. Being a scientist or working in a job requiring scientific knowledge and thinking would be dull and uninteresting; it is only for highly intelligent people who are willing to spend most of their time at work. I would not like to do scientific work.
13. The search for scientific knowledge would be boring.
14. Scientific work would be too hard for me.
22. I do not want to be a scientist.
37. Scientists do not have enough time for their families or for fun.
39. Scientists have to study too much.

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