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ABSTRACT

The factor structure and reliability of an instrument for measuring attitudes of preservice teachers toward science were studied as part of a 5-year project at the University of Wyoming (Laramie) to improve the teaching of science at the elementary school level. The Attitudes towards Science and Scientists Scale (ATSSS) of J. R. Cummings (1969) was administered to preservice elementary school teachers in 1989 and 1990. The ATSSS consists of 67 Likert-type items intended to measure seven facets of attitudes about science. Items for a revised scale were chosen based on factor analyses and the results of item analysis. The revised version, the Inventory of Science Attitudes (ISA), was administered to 72 preservice elementary education majors taking mathematics, science, and music methods courses over the summer session in 1990. Factor analyses and measures of reliability indicated that the revised version was more valid and reliable than was the ATSSS. Two tables present the rotated factor pattern for Promax rotation and the distribution of scores on the ISA. The 30-item ISA is included. (SLD)

How Do Teachers Feel About Science?:

Measurement of Attitudes Towards Science

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ABSTRACT

A major problem in preparing elementary education majors to teach science is that many of these students have negative attitudes toward science. This problem is being addressed directly in a 5-year project at the University of Wyoming, where a need to measure attitude toward science has arisen. In this study, the factor structure and reliability of an instrument to measure attitude toward science, Attitude towards Science and Scientists, (Cummings, 1969) were examined. A revised version of the instrument with fewer items was constructed based on the results. This revised instrument should be more useful in measuring attitudes toward science among pre-service teachers.

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A major problem in preparing elementary education majors to teach science is that many of these students have negative attitudes toward science (Stepans & McCormack, 1986). This is among the important factors which contribute to poor teaching of science in elementary classrooms. The NSF-sponsored Experimental Teacher Education Project in Elementary Science at the University of Wyoming is attempting to improve the teaching of science in the elementary schools through an integrated approach to undergraduate science education. Since a change in attitude toward science is a key goal of the project, (McClurg, Stepans & Beiswenger, 1988), it has been necessary to validly and reliably measure this construct.

Measurement of attitudes in science is a popular yet poorly defined area of research in science education (Schibeci, 1984). Haladyna and Shaughnessy (1982) consider the research to be disorganized and chaotic. According to Blosser (1984), one of the problems with studying attitudes in science education is the lack of a clear definition for science attitudes. Attitude toward science is not a clearly defined construct and can mean different things to different people in different contexts (Munby, 1983a).

Attitude toward science studies encompass a wide range of concepts including attitude toward scientists, attitude toward specific curricula, and scientific interests among others (Blosser, 1984). As a result of this variety of attitude constructs, many instruments are considered inadequate because of poorly defined constructs, inappropriate item structure, or items that do not relate to the construct purportedly being measured (Blosser, 1984).

Until greater attention is paid to these concerns, Munby (1983b) and Zeidler (1984) do not feel that much confidence can be placed in many of the existing scales.

Besides a more adequate definition of the constructs being investigated with science attitude scales, there is a need for the verification or establishment of reliability and validity of the instruments (Munby, 1983a; Pearl, 1974; Schibeci, 1984). Blosser (1984) and Munby (1983a) found limited reliability and validity information available for many of the existing science attitude scales. Suggestions for improving the reliability and validity of instruments include the estimation of test-retest reliabilities, the use of factor and cluster analysis to empirically validate subscales, separate scores for conceptually distinct subscales, more careful wording of items, and preliminary trials on the instrument on the population for whom the use is intended (Munby, 1983a; Pearl, 1974; Schibeci, 1984).

Despite this inadequacy, it is not necessary to discard all the poorly designed attitude scales. Thompson and Shrigley (1986) advise modifying them rather than beginning anew. Their suggestions for the revision process include salvaging valid existing items along with the writing of new items related to the construct, sampling the target population with the new instrument, and retaining those items that consistently measure the identified construct. Germann (1988) emphasizes the need for defining the construct, describing the construct within a larger theoretical

framework of relevant variables, and demonstrating the reliability and validity of the instrument being used to measure it.

After a search to find the best available instrument for use in the current pre-service teacher education project, Cummings' Attitudes toward Science and Scientists (1969) scale was chosen. Munby (1983a, 1983b) found this scale to be one that had potential usefulness for its identified audience, but that the subscales would need further investigation before the instrument could be considered satisfactory.

Cummings (1969) reported a KR-20 reliability estimate of .915 for the total scale. Evidence for construct validity of the instrument was provided by administering it to two groups expected to have different attitudes toward science. One group consisted of 24 science and mathematics teacher from the NSF Academic Year Institute at Ohio State University. The other was an elementary science methods group comprised of 349 students from the University of Texas, University of Houston, Indiana University and Ohio State University. The Institute group scored significantly higher ($p < .001$) on the instrument that did the methods students. This is presented as evidence of construct validity.

However, the instrument needed revision. The KR-20 reliability estimate in our sample was much lower than .915. Seven subscales are named and discussed for the original instrument, but only total scores are reported and there is no subscale reliability and validity information reported. Also, factor analysis indicated that the scale was factorially complex and that the intended

subscale structure was not reflected empirically. With these validity and reliability concerns in mind, the Cummings Attitude toward Science and Scientists instrument was critically examined and revised.

Method

The Cummings instrument consists of 67 Likert-type items intended to measure 7 facets of attitude toward science. This instrument was administered to preservice elementary school teachers in the Spring of 1989 and 1990. Some of these students were participants in the experimental project and some were in regular science methods courses of the teacher education program. First, item statistics were calculated for the sample. Then, exploratory factor analysis was used to investigate the construct validity of the scale. Principal axes factor analysis was conducted with squared multiple correlations as initial communality estimates. Items for the final scale were chosen based on this factor analysis and results from item analysis.

Analysis and Results

Item means and standard deviations showed that some items were of low quality and were candidates for modification or deletion because of their adverse effect on the reliability of the scales. Exploratory factor analysis was conducted to determine the number of separate factors measured by the instrument. Examination of the 11 eigenvalues of the reduced correlation matrix greater than one (15.0, 4.4, 3.7, 2.2, 1.9, 1.6, 1.5, 1.4, 1.3, 1.2, 1.0) indicated that three or four separate factors accounted well for the inter-

item correlations. The factor pattern matrices for a three-factor and four-factor oblique rotation were examined in making the decision to retain three subscales from the instrument. We have named these factors Interest in Science (I), Value of Science to Society (II), and Perceptions of Scientists and Their Work (III). Ten items for each subscale were chosen based on item statistics and factor pattern loadings.

The final version, the Inventory of Science Attitudes, was administered to 72 pre-service elementary education majors taking math, science and music methods courses during the summer session, 1990. This sample was comparable to the original sample except that there were more nontraditional students in this second sample. Factor analysis was again conducted. In this sample, Factors I and II correlated .39, Factors I and III correlated 0.32, and Factors II and III correlated 0.40. Table 1 contains the factor pattern matrix of the Promax oblique rotation. All items aligned with their anticipated factor except for items 7 and 22. Future administrations of the instrument will help determine whether this anomaly is sample-specific or a characteristic of the instrument. Cronbach alpha estimates of internal consistency were .94, .84, and .84, respectively, for the three subscales.

Although the instrument must be administered to many more subjects in order for stable norms to be established, we present a table of percentiles, together with scale means and standard deviations based on our sample, in Table 2. In this sample, the

correlation of scale I with II was .44; scale I with III was .48; and scale II with III was .56.

Scoring the Instrument

The final version, Inventory of Science Attitudes, is found in Appendix A. Subjects respond on a 5-point Likert Scale ranging from Strongly Agree to Strongly Disagree. A response of Strongly Agree is scored 5. Instead of a total score for the instrument, 3 subscale scores should be calculated. Scale I, Interest in Science is comprised of items 2, 5, 8, 11, 14, 17, 20, 23, 26, and 29. Scale II, Value of Science to Society is comprised of items 3, 6, 9, 12, 15, 18, 21, 24, 27, and 30. Scale III, Perceptions of Scientists and Their Work includes the remaining items 1, 4, 7, 10, 13, 16, 19, 22, 25, and 28. For scales I and II, the score is simply the sum of items comprising each scale, after reversing items 8, 14, 20, and 29. Since the items on scale III reflect a negative perception of scientists and their work, the sum of items from that scale must be subtracted from 60 to make the score reflect degree of positive attitude toward scientists and their work. Missing values must be assigned the average of the completed responses for the appropriate subscale. Alternatively, if missing values are numerous, the average of completed items for each subscale can be multiplied by 10 to arrive at total score estimates.

Conclusion

As a result of this study, we now have a shorter, more valid and reliable measure available to measure interest in science, perceptions of the value of science to society, and perceptions of scientists and their work for elementary education majors. At the present time, norming of the revised attitude instrument is proceeding with elementary education majors enrolled in methods courses at the University of Wyoming. Validity studies using groups assumed to have different attitudes towards science are planned.

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Table 1

Rotated Factor Pattern for Promax Rotation

Item	Factor I	Factor 2	Factor 3
2	0.84353	-0.00907	0.16174
5	0.85977	0.09033	0.13620
9*	-0.80388	0.12022	0.24441
11	0.82765	0.07829	0.00951
14*	-0.71609	0.13152	-0.00486
17	0.76444	0.03905	-0.09916
20*	-0.77191	-0.01637	-0.08693
23	0.78321	0.08256	-0.12555
26	0.76253	0.06923	-0.18830
29*	-0.62933	-0.10543	0.10470
3	-0.29678	0.34754	-0.33742
6	0.16309	0.71580	0.22211
9	0.12874	0.58169	0.11671
12	0.06168	0.42985	-0.32952
15	-0.10602	0.64486	-0.01105
18	0.29131	0.33188	-0.07116
21	-0.21838	0.58284	-0.20142
24	0.13901	0.77114	-0.00404
27	0.13325	0.65446	0.03142
30	0.02169	0.47078	-0.11802
1	-0.08314	-0.03858	0.56743
4	0.01469	0.04882	0.76202
7	-0.19979	-0.53039	-0.06893
10	-0.33180	0.11185	0.57945
13	-0.24488	0.06818	0.38748
16	0.07177	-0.47961	0.53494
19	-0.01951	0.13517	0.80847
22	-0.22125	-0.30428	0.10901
25	-0.17004	-0.19676	0.55695
28	0.20043	-0.31744	0.36880

* Reversed Item

Table 2

Distribution of Scores (N=72)

Score	Percentiles I	II	II
50	94	99	99
49	92	93	
48	88	92	96
47	86	90	94
46	79	85	
45	72	78	89
44	67	74	85
43	62	62	83
42	57	54	81
41	64	42	76
40	51	33	67
39	46	29	58
38	39	22	43
37	31	21	40
36	29	15	36
35	25	12	35
34	15	10	24
33	12	6	15
32	10		14
31			
30	8	4	10
29	7		6
28			4
27	6	3	3
26			
25		1-	
24	4		
23			
22			1
21			
20			
19			
18	3		1-
17			
16			
15			
14			
13			
12			
11	1-		
10			
Mean	28.97	30.56	27.20
S.D.	8.05	5.30	5.87

INVENTORY OF SCIENCE ATTITUDES

INSTRUCTIONS: Please give your reaction to the following list of statements regarding science, scientists, and scientific careers. Work rapidly. Record your first impressions -- the feeling that comes to mind as you read the item.

Please circle your answer for each item. Be sure to erase completely if it is necessary to change your response.

PLEASE MARK:
SD if you strongly disagree with the item
D if you disagree
N if you are neutral
A if you are in agreement
SA if you strongly agree

EXAMPLE:
Scientists are apt to be more rational in solving problems outside their field than are other professinals. (Since A is marked, this indicates you are in agreement.) SD SD N A SA

SD - strongly agree D - disagree N - neutral A - agree SA - strongly agree

1.	The majority of scientists are irreligious.	SD	D	N	A	SA
2.	I am very attracted to scientific activities.	SD	D	N	A	SA
3.	Scientists have a potent influence oversignificant economic, political and social processes.	SD	D	N	A	SA
4.	Most scientists make few friends other than their fellow scientists.	SD	D	N	A	SA
5.	I am enthusiastic about learning more scientific information.	SD	D	N	A	SA
6.	An education in science is imperative in present-day society.	SD	D	N	A	SA
7.	Educators attach too much importance to the study of science.	SD	D	N	A	SA
8.	Scientific work is boring.	SD	D	N	A	SA
9.	Science appears to be necessary in our present-day society.	SD	D	N	A	SA
10.	Scientists are often eccentric in their personal behavior.	SD	D	N	A	SA
11.	Science is a very fascinating subject.	SD	D	N	A	SA
12.	An education in science contributes toward good citizenship.	SD	D	N	A	SA
13.	Scientific truths are normally discovered by individuals seeking financial gain.	SD	D	N	A	SA

SD - strongly agree D - disagree N - neutral A - agree SA - strongly agree

14.	Scientific knowledge is hard for me to understand.	SD	D	N	A	SA
15.	The study of science benefits people socially.	SD	D	N	A	SA
16.	The majority of scientists are not interested in the practical value of scientific information.	SD	D	N	A	SA
17.	I enjoy solving problems in the school laboratory.	SD	D	N	A	SA
18.	A comprehension of the significance of science is necessary to thoroughly appreciate present-day society.	SD	D	N	A	SA
19.	The nation's top scientists are mainly interested in their own current of thought.	SD	D	N	A	SA
20.	To me science classes are very uninteresting.	SD	D	N	A	SA
21.	Great improvement in all areas of human endeavor could be accomplished by the application of the scientific method.	SD	D	N	A	SA
22.	Science is chiefly a program of action for originating new gadgets.	SD	D	N	A	SA
23.	I enjoy scientific investigations.	SD	D	N	A	SA
24.	A comprehension of science is essential for my everyday living.	SD	D	N	A	SA
25.	In pursuit of their interests, scientists often consent to sacrifice the well-being of others.	SD	D	N	A	SA
26.	I enjoy doing science laboratory experiments.	SD	D	N	A	SA
27.	An education in science frequently helps one make more logical decisions.	SD	D	N	A	SA
28.	The advancement of science makes possible the control of our lives by a few people.	SD	D	N	A	SA
29.	I would prefer not to take college science courses.	SD	D	N	A	SA
30.	Public interest in science is necessary for the continuance of scientific research.	SD	D	N	A	SA

END

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