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ABSTRACT

This information bulletin provides an overview of some of the documents that were identified as a result of limited searches of the literature related to science education attitude research and highlights some of the problems and concerns involved in this research. Major areas considered include: (1) problems of defining scientific attitudes; (2) attitudes toward science; (3) attitude measurement techniques; (4) methodological issues; (5) Hugh Munby's investigation of attitude measurements ("An Investigation into the Measurement of Attitudes in Science Education"); (6) recommendations for improving attitude research; and (7) implications. A list of references cited (with ED numbers for documents in "Resources in Education") and related references is included. (JN)

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Attitude Research in Science Education

EDITOR'S COMMENTS

Several years ago Wayne W. Welch made a presentation at a science education meeting in which he characterized the situation in science learning by saying that students were learning less science but enjoying it more. Science educators of students at varying educational levels are interested not only in their students' achievement but also in producing positive attitudes about science. This information bulletin is designed to provide readers with an overview of studies in attitude research. It was prepared by Patricia E. Blosser, Associate Director, User Services.

Introduction

Several years ago the National Science Teachers Association (NSTA) issued a position statement titled "Science-Technology-Society: Science Education for the 1980s." (1982) In this statement committee members identified some problems they felt were indicative of a crisis in science education. Among these problems were a decline in public appreciation for science, decreased support for science education, an increasing number of problems related to science-generated technology that have an impact on the quality of life, and the underrepresentation of women, minorities, and handicapped persons in "nearly all professional and technical roles in science and technology."

The committee's thesis was that scientific literacy was basic for living, working, and decision making in the 1980s and beyond. Attributes that characterize a scientifically literate person were listed. Some of these attributes were of the cognitive knowledge variety. Others related to the affective domain of science education. For example, according to the position statement,

> . . . The scientifically and technologically literate person:
>
> . . . appreciates science and technology for the intellectual stimulus they provide;
>
> . . . distinguishes between scientific evidence and personal opinion;
>
> . . . recognizes the origin of science and understands that scientific knowledge is tentative, and subject to change as evidence accumulates;
>
> . . . has a richer and more exciting view of the world as the result of science education . . . (1982)

While no teachers would quarrel with these objectives, they might ask how they were to design curriculum and instruction to lead to their attainment, and how this attainment was to be measured. Science teachers are accustomed to dealing with, and attempting to measure, cognitive objectives in their classes. Getting a handle on the affective aspects of science education appears to present some problems. Researchers in science education have attempted to deal with the affective domain primarily through the investigation of attitudes.

The Literature Base

It is easy to get an idea of the amount of material related to attitudes and science education research by doing a computer search of the ERIC data base. For example, in November 1984, a computer search of relevant descriptors resulted in the following document counts:

Descriptor	Number of Documents
attitudes	62,417
attitude measures	2,186
scientific attitudes	491
teacher attitudes	12,836
student attitudes	16,429

When the descriptors "science education" and "research" were added to further delimit the search, the new counts were:

Descriptor Combination	Number of Documents
science education + research + attitudes	962
science education + research + attitude measures	57
science education + research + teacher attitudes	213
science education + research + student attitudes	398
research + scientific attitudes	243

It would appear that the investigation of attitudes in science education has resulted in a large number of publications.

The Purpose of This Bulletin

The purpose of this information bulletin is to provide the reader with an overview of some of the documents that were identified as a result of limited searches of the literature related to science education research of attitudes and to highlight some of the problems and concerns involved in this research.

Some Problems of Definition

One of the problems in attitude research in science education is that of finding a clear definition of what is meant by "science attitudes." Some researchers appear to be investigating scientific attitudes while others are studying attitudes toward science. Gardner discussed this difference, writing that attitudes toward science always have " . . . some distinct attitude object to which the respondent is invited to react favourably or unfavourably . . . " while the scientific attitudes category is composed of traits " . . . better described as styles of thinking which scientists are presumed to display." (1975:1-2)

Scientific attitudes: In a journal article published in 1982 Gauld provided an amplified description of what constitutes the "scientific attitude:"

> The scientific attitude as it appears in the science education literature embodies the adoption of a particular approach to solving problems, to assessing ideas and information or to making decisions. Using this approach evidence is collected and evaluated objectively so that the idiosyncratic prejudices of the one making the judgment do not intrude. No source of relevant information is rejected before it is fully evaluated and all available evidence is care-

fully weighed before the decision is made. If the evidence is considered to be insufficient then judgment is suspended until there is enough information to enable a decision to be made. No idea, conclusion, decision or solution is accepted just because a particular person makes a claim but it is treated sceptically and critically until its soundness can be judged according to the weight of evidence which is relevant to it. A person who is willing to follow such a procedure (and who regularly does so) is said by science educators to be motivated by the scientific attitude. (1982:110)

Two years earlier, Gauld and Hukins published a review of the literature on scientific attitudes, using those studies fitting Gardner's definition. (The 1982 article from which the quotation was taken was a critical reappraisal of the situation.) In the 1980 article Gauld and Hukins said that philosophies of science imply different conceptions of scientific attitude, but people do not seem to realize this. As a result, there is inadequate theoretical framework in the research literature of scientific attitudes and in attitude measurement.

Gauld and Hukins considered that the concept of scientific attitude has two main dimensions: a scientific one, dealing with the nature of scientific activity, and an affective or attitudinal one.

They identified three broad groups into which components of the scientific attitude as described in the literature might be classified:

Group 1. General attitude towards ideas and information (e.g. curiosity, open-mindedness, scepticism, humility, antiauthoritarianism, creativity)

Group 2. Attitudes related to the evaluation of ideas and information (e.g. critical-mindedness - including objectivity, intellectual honesty, caution when drawing conclusions or making decisions)

Group 3. Commitment to particular (scientific) belief (e.g. loyalty to truth, belief in the understandability of nature, existence of natural cause and effect relationships, lack of foundation for superstition) (1980: 133)

Readers are probably familiar with one of the more influential publications dealing with the scientific dimension of the scientific attitude concept, the Educational Policies Commission's 1966 document entitled "Education and the Spirit of Science." In the recommendations section of this document, the writers urge that schools promote

> . . . understanding of the values on which science is everywhere based. . . . We believe that the following values underlie science.
>
> 1. Longing to know and to understand
> 2. Questioning of all things
> 3. Search for data and their meaning
> 4. Demand for verification
> 5. Respect for logic
> 6. Consideration of premises
> 7. Consideration of consequences . . . (1966:15)

The members of the Educational Policies Commission believe that ". . . the values of science are the most complete expression of one of the deepest of humane values—the belief in human dignity." (1966:16) This is one justification for the importance of developing a scientific attitude in students. Gauld and Hukins present two other reasons: such an attitude helps students have a better understanding of the nature of the scientific process by acting out the role of a scientist, and it is important for all students in their everyday lives, independent of the supposed importance of scientists, to be rational thinkers (1980: 140).

Again, questions are raised relative to instruction and evaluation. What should science teachers do? What should be done to measure success? Nay and Crocker developed an inventory of the affective attributes of scientists which they reported in an article published in 1970 in *Science Education*. They grouped selected attributes of scientists on five components considered by Krathwohl as part of the affective domain: appreciations, interests, attitudes, values and beliefs, and adjustments. Nay and Crocker's inventory is shown below:

1. *Interests*

   (The motivation for a person to become a scientist and continue to be one.)

   1.1 Understanding natural phenomena
   - 1.11 Curiosity
   - 1.12 Fascination
   - 1.13 Excitement
   - 1.14 Enthusiasm

   1.2 Contributing to knowledge and human welfare
   - 1.21 Altruism
   - 1.22 Ambition
   - 1.23 Pride
   - 1.24 Satisfaction

2. *Operational Adjustments*

   (Primary behaviours which underlie competence and success in science, and performance at recognized standards.)

   2.1 Dedication or commitment
   - 2.11 Perseverance (persistence)
   - 2.12 Patience
   - 2.13 Self-discipline
   - 2.14 Selflessness
   - 2.15 Responsibility
   - 2.16 Dependability

   2.2 Experimental requirements
   - 2.21 Systematism (methodicalness)
   - 2.22 Thoroughness
   - 2.23 Precision
   - 2.24 Sensitivity
   - 2.25 Alertness for the unexpected

   2.3 Initiative and resourcefulness
   - 2.31 Pragmatism (common-sense)
   - 2.32 Courage (daring, venturesomeness)
   - 2.33 Self-direction (independence)
   - 2.34 Self-reliance
   - 2.35 Confidence
   - 2.36 Flexibility
   - 2.37 Aggressiveness

   2.4 Relations with peers
   - 2.41 Cooperation
   - 2.42 Compromise
   - 2.43 Modesty (humility)
   - 2.44 Tolerance

3. *Attitudes or Intellectual Adjustments*

   (Intellectual behaviours which are foundational to the scientist's contribution to or acceptance of new scientific knowledge.)

   3.1 Scientific integrity
   - 3.11 Objectivity
   - 3.12 Open-mindedness
   - 3.13 Honesty
   - 3.14 Suspended judgment (restraint)
   - 3.15 Respect for evidence (reliance on fact)
   - 3.16 Willingness to change opinions
   - 3.17 Idea sharing

   3.2 Critical requirements
   - 3.21 Critical mindedness
   - 3.22 Skepticism
   - 3.23 Questioning attitude
   - 3.24 Disciplined thinking
   - 3.25 Anti-authoritarianism
   - 3.26 Self-criticism

4. *Appreciations*

   (Relative to the foundations, interactions, and dynamics of science.)

   4.1 The history of science
   - 4.11 The evolution of scientific knowledge
   - 4.12 Contributions made by individual scientists
   - 4.13 The exponential growth of science

   4.2 Science and society
   - 4.21 The social basis of the development of modern science
   - 4.22 The contribution made by science to social progress and melioration
   - 4.23 The relationship between science and technology
   - 4.24 The interaction of the "two cultures"

   4.3 The nature of science
   - 4.31 The process of scientific inquiry
   - 4.32 The tentative and revisionary character of scientific knowledge
   - 4.33 The strengths and limitations of science
   - 4.34 The value of one's own contribution and the debt owing other scientists
   - 4.35 The communality of scientific ideas
   - 4.36 The esthetics and parsimony in scientific theory
   - 4.37 The power of individual and cooperative effort
   - 4.38 The power of logical reasoning (rationality)

4.39 The casual, relativistic, and probabilistic nature of phenomena

5. *Values and/or Beliefs*

(In the realm of philosophy, ethics, politics, etc.)

5.1 Philosophy

5.11 The universe is "real"

5.12 The universe is comprehensible (knowable) through observation and rational thought

5.13 The universe is not capricious

5.2 Ethical

5.21 Science is amoral but scientists have the responsibility to interpret the consequences of their work

5.22 Humanism is the highest ideal

5.3 Social

5.31 Science must serve the needs of society

5.32 Science flourishes best in a free and democratic society

(1970:61-62)

Nay and Crocker said that the science teacher was the key to successfully promoting such affective attributes in students. The science teacher needs to have a good knowledge of the nature of the scientific enterprise and must be a good role model. Students may perform experiments or do laboratory research, or they may read science case histories. Students may also solve problems which they identify or which the teacher supplies, using the processes involved in scientific inquiry. (1970:65).

These suggestions speak to the question of instruction. What about evaluation? Problems related to the measurement of attitudes will be discussed in a later section. There are other problems to be considered relative to scientific attitudes.

Gauld (1982) said that a great deal of effort has been devoted to identifying the nature of the scientific attitude. Most of the work has involved detailed analyses of the writings of scientists, philosophers of science, and science educators. Much of the material was the work of philosophers of science who looked at science from an empiricist perspective. As a result, the concept of scientific attitude has an empiricist emphasis. Little research has been done to see if scientists do possess the affective characteristics attributed to them. Gauld cited the work of Mahoney who examined the extent to which scientists possessed the characteristics of objectivity, rationality, open-mindedness, superior intelligence, integrity, and communality. The data Mahoney obtained produced a picture of "real" scientists that was different from that in science education literature. Practicising scientists displayed both objectivity and emotionality, openmindedness and tenacity, depending on the situation (1982:112-113).

Gauld suggested that science educators need to consider Holton's distinction between "public science" and "private science." Holton said that the way in which arguments and evidence are publicly presented is not the way they were originally conceived, clarified and tested (private science). However, the public science image is that of the detached, impartial scientist. Gauld concluded that ". . . If the distinction between 'public' and 'private' science is a valid one, it means that the attitudes toward scientists held by science educators and science students can be expected to have little, if any, necessary connection with the personal characteristics of scientists." (1982:117)

Gauld argued that

> . . . development of the scientific attitude in students should be eliminated as one of the major goals of science education, and this certainly follows for the attitude as it has been formulated by science educators for the past 60 years. Teaching that scientists possess these characteristics is bad enough but it is abhorrent that science educators should actually attempt to mold children in the same false image . . . (1982:118)

Gauld has suggested that terms such as open-mindedness, objectivity, skepticism need to be clarified and the way in which they relate to scientific practice needs to be more carefully discussed so that it may be possible to develop a reformulated and more acceptable version of what is meant by scientific attitude.

This is a large task. It is not apparent from a review of the existing literature that science educators are working on it or that they are even aware of Gauld's review and criticisms. If, and when, such a task is begun, science educators need to look at the nonempiricist philosophies of science that have been published since 1960 (Gauld, 1982:117).

Perhaps we need to remember not only the Educational Policies Commission's seven values underlying science but also some of the discussion that followed the listing of these values:

> . . . like other sets of values, they have the defect that neither individually nor jointly do they provide a fully adequate guide to action; in many concrete human situations, various values, all cherished, are involved, and the choice of action involves an ethical compromise. The values of the spirit of science express the belief that the compromise is likely to be better if based on thoughtful choice; in this respect they differ from those value systems which hesitate to submit all problems to reason . . .
>
> By their very nature, these values cannot be acquired through indoctrination. . . . (1966:16)

Attitudes towards Science

When this broad category of attitudes is considered, the situation is no more encouraging. There is wide variation of topics considered to relate to this category. This is evident in Haladyna and Shaughnessy's categorization of studies they included in a meta-analysis study (1982). In reviewing resea[illegible] for this analysis, they classified stu[illegible] as relating to scientific attitudes, to attitude toward scientists, to attitudes toward a method of teaching science, to scientific interests, to attitudes toward parts of the curriculum, and attitudes toward the subject of science.

Gardner (1975) reviewed studies containing variables within the attitudes toward science category: interest, satisfaction, enjoyment. Gardner considered the relationships between attitudes to science and other personal and social variables. He separated his discussion into studies of internal or personal variables, which included other attitude variables, cognitive variables, personality and sex; and studies of external or social variables, which included such structural variables as home background, school environment variables, and curriculum and instructional variables. However, Gardner admitted that it was not always easy to classify a study into one of these two groups and that some external variables were confounded with some internal variables.

Gardner said that there was support in the literature for the idea that attitudes are not isolated personal attributes but that they form broad and coherent patterns consistent with, and outgrowths of, deeper personality structures (1975:19). It was possible to find relationships between students' attitudes to science and aspects of their personality. There was variation among studies in terms of age of students, gender, measuring instruments used, but the general picture was that ". . . students who are favourably inclined towards science tend to be relatively serious and achievement-oriented, realistic and independent, but conventional and conformist." (1975:22)

According to Gardner, "Sex is probably the single most important variable related to pupils' attitudes to science." (1975:22) Sex differences apparently arise relatively early in life. Gardner wrote that there was a "substantial body of evidence" involving upper primary and secondary school pupils that boys have greater interest in science than do girls, with the differences appearing to carry over into adulthood. The nature of boys' and girls' interests in science also tended to differ, with boys relatively more interested in physical science and girls more interested in biology and social science. These differences also persist into adulthood. (1975:23) When social forces and sex differences are concerned, these forces appear to operate through children's literature, parental interest and behavior, and expectations of teachers (1975:23). Gardner wondered if there were innate cognitive differences between males and females which might influence attitudes and enrollment patterns (1975 24).

Structural variables (geographic location, socioeconomic status) are probably proxy variables for factors such as parental, peer group, and teacher behavior. When school variables were considered, classroom climate and teacher behavior have been studied. Gardner reported a study by Walberg in which it was found that classroom characteristics associated with higher achievement were different from those associated with better attitudes. Teacher behavior studies need to be reviewed with the caution that the same teacher behavior could have different effects on different kinds of pupils (1975:26). Likewise, when looking at attitude studies involving curriculum and instruction, the reader needs to keep in mind that teacher and pupil variables may exert more powerful effects on attitudes than the curriculum and instruction variables do (1975:29).

Gardner raised the question: to what extent do instruments now available actually measure a common construct? This question has been studied and discussed in detail by Munby. Before Munby's writings are reported, it seems appropriate to consider the various techniques that are used to obtain data on attitudes.

Attitude Measurement Techniques

Persons wishing to read in more detail about measurement techniques can find additional information in an article by Gardner (1975), an occasional paper by Page and others (1975), and a review by Munby (1983). Methods for gathering attitude data vary. As Page and his colleagues wrote, one method is to ask direct or indirect questions. However, the person being questioned may be cued in providing a response by the phrasing of the question or may not wish to provide a truthful response or may decide to provide a response he/she considers socially acceptable. Another method would involve observation of the behavior of another individual and then an attempt to infer the attitudes that person holds based on the behavior exhibited. Not only is this procedure time consuming but overt behavior may not be a true indicator of attitudes (Page et al., 1975:3-4). Most attitude research involves the use of some kind of instrument.

Gardner (1975:4-11) discussed nine different techniques and/or instruments:

- differential (Thurstone) scales
- rating scales
- summated rating scales
- semantic differential scales
- interest inventories
- preference ranking
- projective techniques
- enrollment data
- other forms: clinical and anthropological observation

Differential scales, which Gardner terms 'Thurstone-type,' contain a number of opinion statements designed to provide various positions on an attitude continuum. The scale is composed of a large number of items, and respondents are asked to select those statements most closely resembling their own beliefs. Each statement has a scale value so that the respondent's score is the mean or median of the scale values of the statements selected (1975:4).

Rating scales do not appear to be widely used in research on attitudes to science, according to Gardner. In this method, a particular concept is presented and the rater places the ratee along a numerical scale. Sometimes self-reporting is used (1975:5).

Summated rating scales are more commonly used. In this technique a set of responses is available and each response has a weighting associated with it. The most commonly used form is the Likert-type scale. Each opinion statement reflects either a favorable or an unfavorable reaction and the respondent is asked to check a response usually ranging from strongly agree to strongly disagree (1975:5).

Semantic differential scales consist of a word or phrase representing an attitude object which is followed by a list of bipolar adjectives. These adjectives lie at opposite ends of a seven-point scale, and the respondent marks a position on each scale for each adjective pair.

Interest inventories, which may be either general or specific, contain items listing careers, topics, or activities and the respondent identifies those in which he/she is interested (1975:7).

The preference ranking technique involves having a respondent make comparisons between enjoyment of science and enjoyment of other subjects. One defect of this technique is that a student could have a positive attitude to all school subjects and rank science last while still having a more favorable attitude toward science than another respondent who disliked most school subjects and ranked science first (1975:9).

Projective techniques are used in an attempt to reveal attitudes the respondent may have hidden. They may involve sentence completion, word association, or interpretations of drawings (1975:9).

Enrollment data may be used as indicators of attitudes for courses of the elective variety, assuming that there is a relationship between interest and enrollment. However, factors other than interest may influence enrollment (1975:10).

Clinical observations of students as they work or play may also be used to determine attitudes. Anthropological methods with the researcher as a participant observer may also be used (1975:11).

Methodological Issues

Gardner, in his 1975 review, discussed five steps involved in constructing a valid and reliable attitude instrument: definition of the attitude(s) to be measured, scale construction, trial, appropriate use, and appropriate choice of research design and statistical analysis (1975:11). When one or more of these steps is ignored or inadequately carried out, problems result and the research which results is questionable.

The person developing an attitude instrument needs to clearly specify the theoretical construct which underlies this instrument. If more than one variable is to be measured, each should be specified in advance and the instrument should yield separate scores for each separate variable. According to Gardner, these requirements are frequently ignored. Not only are theoretical constructs lacking, items may be vague or ambiguous. Or items be in the form of a complex sentence which contains one part with which the respondent may agree and a second part with which he/she may disagree. Items may be included that do not reflect the construct the instrument purports to measure (1975: 12-14).

The attitude instrument needs to be tried with a sample similar to the target population to be involved in the research study. The data collected need to be analyzed to determine if the instrument is sufficiently sensitive to discriminate among individuals, if it is internally consistent, and if it is stable. Factor analysis may be done to see if items have been correctly allocated to scales and whether different scales load on different factors (1975:14-16).

When use is considered, Gardner urged that there needs to be some basis for arguing that there is a connection between the treatment and the outcome, but says this is frequently ignored in educational research. Subjects are frequently involved in a treatment and then asked to complete a test that is unrelated to the treatment (1975:16). Problems such as this may be avoided if the research design of the study is carefully examined and if appropriate statistical procedures are chosen, but these do not always prevent weaknesses in studies. That such weaknesses exist has been amply documented by Munby.

Munby's Investigation of Attitude Measurements

Munby undertook to conduct a thorough examination of instruments designed to measure attitudes to science. In 1981 he presented a paper at the annual meeting of the National Association for Research in Science Teaching (NARST) in which he reported on 30 studies in which one attitude instrument was used. This report eventually appeared in print in 1983 in the *Journal of Research in Science Teaching* (1983b). The instrument was Moore and Sutman's Scientific Attitude Inventory (SAI). As a part of his larger investigation (1983a), Munby was interested in determining how frequently attitude instuments had been used in studies other than the one in which the instrument was first reported.

Munby's review (1983a) covered the years 1967-1977. He considered six questions when reviewing the literature: (1) what is an appropriate instrument for measuring attitudes, (2) what instruments are available, (3) what model or conception of an attitude to science do they embody, (4) how do the instruments perform, (5) do they measure attitudes to science or scientific attitudes or both, and (6) do they avoid testing knowledge of science-related affairs? Munby was motivated by a larger question: what confidence can we have in instruments purported to measure attitudes to science?

Munby's search of the literature on attitude measurement in science education resulted in the identification of over 200 instruments. While Munby agreed that any evaluation of science curricula should consider affective as well as cognitive outcomes, he suggested that a moratorium on instrument development was needed (1983a:7). He also hypothesized that because there were so many attitude instruments reported in the literature, the science education community must not be carefully scrutinizing these instruments to see if they were indeed reliable and valid. Munby speculated that the findings, reported in the literature, of a decline in student attitudes might be due to defective instruments (1983a:27). Such defective instruments need to be removed from use or their defects remedied, if possible. In order to accomplish either of these goals, it was necessary to study the instruments.

In his review of the literature, Munby attempted to collect all research in which an instrument for measuring attitudes to science was cited. If the instrument was not part of the literature, he wrote to the author. He was able to develop files on 204 instruments. Such files consisted of the instrument, a paper on its development and characteristics, and reports of research in which the instrument was used (1983a:46). He limited his investigation to instruments related to the construct "attitude to science" and did not deal with any "scientific attitude" instruments in his analysis.

Munby limited his analysis to instruments that used the Likert or Thurstone scales or multiple choice questionnaires. Instruments using the semantic differential or projective techniques were not analyzed.

Instruments which Munby identified and located but did not analyze were included in the appendices of his report (1983a) so these are not lost but are available for study.

Munby's report contains 12 appendices, as follows:

A. Semantical Differential Instruments (30)
B. Projective Instruments (5)
C. Instruments Measuring Scientific Attitudes (14)
D. Instruments Measuring Science Career Preferences (6)
E. Instruments Measuring Attitudes about Science Teaching (6)
F. Instruments Measuring Attitudes to Specific Science Subjects and Subject Preferences (27)
G. Instruments Measuring Science Interests and Activities (20)
H. Instruments Measuring Attitudes to Science Courses and Science in School (24)
I. Instruments Measuring Attitudes to Specific Science Issues (1)
J. Unavailable Instruments (15)
K. Those Selected for Detailed Study (56)
L. Detailed Description and Analysis of 56 Attitude Instruments.

Munby chose to analyze attitudes to science (56 instruments) and devised what he termed a "clue structure" to use in his analysis. A detailed explanation of this clue structure and how it was derived is found in chapter two of Munby's report (1983a).

Munby reported that 56 of the instruments purported to measure attitudes to science used the Likert format for gathering data. Twenty-one of the 56 were used in more than one research study. Munby considered this unnecessary duplication (in developing instruments) and called for better communication within the research community.

Twenty-one of the 56 instruments had no reported reliabilities (1983a:106). There was a new calculation of reliability reported for only seven instruments used in more than one study, although 21 instruments were used more than once. Munby considered that Thurstone and Likert type instruments should have a reliability coefficient of .8. Munby wrote that if the reliability coefficient was less than .7, "another reliability tryout is needed." (1983a:111). Thirty-one of the 56 instruments had reliability coefficients of .7 or above.

Munby also examined the instruments' validity: did they measure what they purport to measure? For 18 of the 56 instruments, there was no evidence to indicate that validity had been established. Munby is skeptical of the determination of validity by the use of a panel of judges, citing some remarks by Lucas to the effect that the panel method rests on a myth of the majority being right (1983a:115). So, if those instruments whose validity was determined by this method were removed from the analysis, nine more instruments could be set aside. Only seven instruments had validity determined by two or more psychometric methods (1983a:115-116).

Munby also considered whether the attitude instruments included items that measured cognitive knowledge. Only 4 instruments contained no cognitive items. Cognitive items made up 50 percent or more of 17 instruments and 18 instruments had 25 percent or more items that were cognitive. Munby suggested that the inclusion of cognitive items helps explain why so many findings of no significant differences appear in attitude research in science education when attitudes are measured before and after treatment. If cognitive items are not related to the treatment (some experimental course or teaching methodology), scores are likely to be unaffected by the treatment (1983a:129). It is Munby's opinion that having a large number of cognitive items in an attitude instrument makes the validity of this instrument very questionable (1983a:132).

When Munby considered the problems of reliability, validity, and what items seemed to be testing, his pool of 56 instruments diminished. If those instruments Munby considered incomplete or not strictly measuring attitudes to science were removed, 50 instruments remained. When this group of 50 was culled to remove those whose reliability was not known, 33 were left for analysis. From this group were removed those instruments with reliability coefficients of less than .7; 29 instruments remained. From these 29 were removed those instruments whose validity was not tested or was established by the panel of judges method. There were seven survivors and even these were considered, by Munby, to be suspect on one basis or another (1983a:132-140).

In the final chapter of Munby's report he attempted to describe what he considered to be the situation in attitude research in science education. It is a large field of study but one which has not been well reviewed. Most of the reviews are selective and uncritical. Most reviews report what exists rather than evaluating it. It is Munby's contention that instrument developers are not doing all they could to assure that their instruments may be used with confidence. Other users seem to take validity and reliability for granted. Of those 21 attitude instruments used in more than one study, only 6 had a "fresh determination of reliability" (1983a:144) [on page

110 in this same document Munby reported this number as 7, not 6]. In only two studies was there an investigation of the validity of the instrument used (1983a:144).

Munby was also concerned over the fact that instrument developers mix scientific attitude items with items of attitudes toward science and that they include a high percentage of cognitive items in instruments aimed at measuring attitudes. Munby said, ". . . Evidently there are conceptual problems in the construction of instruments measuring attitudes to science . . ." (1983a:144). Perhaps if these conceptual problems were resolved, many of the conflicting research findings could be explained.

Munby speculated that the term **science** may be ambiguous and that what is needed are subscales or scales for target concepts such as "science in school" or "science careers" etc. He also pointed out that, because science is so much a part of daily life, it ". . . may be difficult to get at a person's attitudes to science if he or she is not totally aware of the extent to which science is a part of his or her intellectual and physical life . . ." (1983a:146).

Just as the members of the Educational Policies Commission wrote that the values of science are not taught by indoctrination, Munby was concerned about science educators' motives for cultivating positive attitudes in their students. He raised the question of whether getting students to like science or to feel positive about it should be considered an acceptable educational objective or some form of indoctrination. It is Munby's conclusion that science education experiences should foster knowledge and understanding, and from these should grow personal preferences and attitudes (1983a:148).

As Gauld called for a reconceptualization of "scientific attitude," so, too, Munby called for a reconceptualization of "attitude to science."

Recommendations for Research

Numerous writers have recommendations for improving attitude research. Munby included seven recommendations which he categorized as varying from mundane to significant. (1) Better written abstracts are needed in *Dissertation Abstracts International*, as well as more complete coverage of dissertations. If necessary, guidelines for writing abstracts should be provided to doctoral candidates and their major advisors. (2) Attitude instruments should be put into the ERIC system. This would result in the assigning of an ED number to the instrument and any related papers. Then, when an instrument was reported in a journal article, the ERIC reference could be included so that readers could find and retrieve the instrument that space limitations precluded from publication as part of the article. (3) Attitude instruments used in research should first be thoroughly examined for reliability and validity. (Page et al, 1983:7, contend there are no truly adequate methods for assessing the validity of attitude scales.) (4) Proper instrument development is such an exacting task that the development of a valid and reliable instrument should be considered worthy of dissertation requirements. The usual situation is that an instrument is developed in order to use it in the dissertation study. As a result, instrument development is a secondary goal of the study, not the primary one, and, as a result, the development process is not as thorough and sound as it should be. (5) Researchers interested in attitude measurement in science education need to review the other instruments from the pool of 200 Munby identified before producing any new instruments. The 30 instruments in the semantic differential format deserve further review. (6) Research needs to be done to determine influence of cognitive items, in attitude instruments, on attitude scores. (7) Research needs to be done on the effect of instrument length on attitude scores and on contradictory findings (1983a:149-154).

Haladyna and Shaughnessy (1982) provided support for Munby's first and second recommendations. Their frustration with what they termed "nonsynthesizable" reports for their meta-analysis project led them to say that, at a minimum, a research report should include (a) a description of the sample, including numbers of males and females and grade levels involved; (b) a description of instrumentation including reliability estimates and evidence of validity as well as information about obtaining the instrument (they also suggested that instruments be put into the ERIC system); (c) appropriate analysis procedures, and data presented in a format that communicates the essence of the findings as well as the *magnitudes* (italics the authors') of the effects (1982:558-559).

Gauld and Hukins (1980) grouped their recommendations as dealing with needs for improvement in communication, for an increase in conceptual clarity, for sustained research, and for the use of innovative techniques. They suggested that communication could be improved if there were more uniformity in the terms used and recommended that researchers become more familiar with Klopfer's taxonomy of objectives in the affective domain. (This taxonomy is described in detail in chapter 19, "Evaluation of Learning in Science," in the *Handbook on Formative and Summative Evaluation of Student Learning* by Bloom, Hastings and Madaus, 1971: 559-641.)

Gauld and Hukins wrote, "The survey approach adopted by many people for identifying components of the scientific attitude has turned attention away from the need to think seriously about what the scientific attitude is and how its components are related to one another at a theoretical level. . . ." (1980:153). They recommended that researchers needed to make explicit references to the model of science upon which their particular piece of research was based. They also stated that researchers need to be more aware of the complexity of those processes leading to the behaviors used to indicate the possession of particular scientific attitudes.

Gauld and Hukins argued for the need for coherence in research in science education and hypothesized that progress in research could be achieved through groups adopting a particular framework then spending a great deal of effort carrying out investigations within that framework, as compared to many people doing a lot of different things. They also pointed out that, if research on scientific attitudes is to be of value to the classroom teacher, more attention needs to be given to studying the effects of particular teaching strategies, teacher characteristics, and the interaction between these and pupil characteristics on the development of attitudes. They considered that innovative techniques are needed in attitude research so that respondents answer honestly rather than attempting to please the teacher or researcher (1980:154).

Schibeci (1983), in an article focused on the topic of selecting appropriate attitudinal objectives for school science, expressed some reservations about attitude research. His comments agreed with those of other writers when he said, "The poor psychometric qualities of many instruments used to assess attitudes is a major problem." (1983:599). Schibeci was also concerned that most attitude researchers did not consider the competing influence of school and nonschool variables on attitudes. Schibeci considered such studies to be important but acknowledged that they are more expensive and difficult to undertake—reasons for their not being done. Also not adequately studied, according to Schibeci, is the stability of attitudes. Researchers do not try to determine how long an exhibited change in attitude lasts. Perhaps if science education researchers were to act on Gauld and Hukin's suggestion for setting up sustained research efforts, some longitudinal studies could be done.

What Does All This Mean?

Writers have called for reconceptualization of the two major categories of attitude measured by science education researchers: scientific attitudes and attitudes toward science. Gauld wrote that when we as science teachers attempt to develop in our students the behaviors we characterize as those exhibited by scientists, we are creating a false image. Munby advocates that we work on knowledge and understanding of science and let our students develop their own preferences and attitudes. Various writers have criticized the shortcomings of the methodology involved in attitude studies in science education. Munby has called for a moratorium on attitude instrument development. Should we leave the field of attitude research and concentrate our efforts in another direction?

Such an action does not seem to be the intent of any of the authors reviewed. All want the situation to be improved so that we can put more faith in what we read when attitude research is reported. As Schibeci wrote, "A general, basic assumption of curriculum writers and researchers is that we can change attitudes in the desired direction . . ." (1983:600). What we need to keep in mind is that we probably cannot change all students without resorting to techniques that could be described as indoctrination or brainwashing. We also need to thoroughly question our assumption that because we have had success in helping students achieve objectives in the cognitive domain, we can expect similar results with affective objectives.

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Bulletin Editor

Schibeci argued that it is dangerous for curriculum writers (and others) to assume that attitudinal objectives may be treated in the same way as cognitive objectives (1983:601). Schibeci said:

> There appears to have arisen a vague assumption that attitudinal objectives are a "natural" part of a specification for a science curriculum. This assumption needs to be examined more critically by curriculum writers than has been done to date. A much clearer, explicit justification for inclusion of attitudinal objectives needs to be provided, both for curriculum and research purposes. (1983:601)

Each year the ERIC Clearinghouse for Science, Mathematics, and Environmental Education cooperates with the National Association for Research in Science Teaching to produce a review of the science education research published in the previous calendar year. Beginning in 1973 these reviews have been published as a part of the material in the journal *Science Education*. These annual reviews for the years 1973 through 1982 were examined to see what the authors had to say about any attitude research they reviewed. The most specific comments were found in the review for 1977 (Peterson and Carlson). These reviewers said that attitude research is chaotic because we in science education have allowed it to become so. They suggested that, to make order out of this chaos, a series of conferences on attitude research and/or a specialized journal might be useful.

It seems obvious that there is much work to be done and that there are many people interested in attitudes. Improved communication among this group, combined with more attention to methodological issues, would appear to be some issues that should receive priority from science educators interested in attitude measurement. These individuals would do well to keep in mind Zeidler's comments in reaction to Munby's article (1983b). Zeidler said that Munby's critique of the Moore and Sutman Scientific Attitude Inventory and its use brought to light a more fundamental validity problem of much of the attitudinal research in science education. Science education researchers borrow from other disciplines without giving adequate attention to the theoretical guidelines already established by those disciplines. In social psychological studies attitude is associated with one's beliefs, intentions and behaviors with respect to a given object or experience. Zeidler agreed that conceptual analysis is needed but not until science educators have considered whether or not their instruments are developed in a manner consistent with the formal criteria and theoretical guidelines of social psychology in the validation process (1984:341).

by Patricia E. Blosser, Associate Director, User Services

REFERENCES CITED

Educatio[illegible] Policies Commission. *Educatio[illegible] Spirit of Science.* Was[illegible] D.C.: National Education As[illegible]ation, 1966. ED 011 507.

Gardnor, P. L. "Attitudes to Science: A Review." *Studies in Science Education* 2:1-41, 1975.

Gauld, Colin. "The Scientific Attitude and Science Education: A Critical Reappraisal." *Science Education* 66(1): 109-121, 1982.

Gauld, C. F. and A. A. Hukins. "Scientific Attitudes: a Review." *Studies in Science Education* 7:129-161, 1980.

Haladyna, Tom and Joan Shaughnessy. "Attitudes toward Science: A Qualitative Synthesis." *Science Education* 66(4):547-563, 1982.

Klopfer, Leopold E. "Evaluation of Learning in Science," Ch. 19 in Bloom, B.S., J.T. Hastings, and G.F. Madaus, *Handbook of Formative and Summative Evaluation of Student Learning.* New York, NY: McGraw Hill Book Co., 1971.

Munby, Hugh. *An Investigation into the Measurement of Attitudes in Science Education.* Columbus, OH: SMEAC Information Reference Center, The Ohio State University, December 1983a. ED 237 347.

Munby, Hugh. "Thirty Studies Involving the 'Scientific Attitude Inventory': What Confidence Can We Have in This Instrument?" *Journal of Research in Science Teaching* 20(2):141-162. 1983b.

National Science Teachers Association. "Science-Technology-Society: Science Education for the 1980s," a position statement. Washington, D C.: National Science Teachers Association, 1982.

Nay, M. A. and R. K. Crocker. "Science Teaching and the Affective Attributes of Scientists." *Science Education* 54(1):59-67, Jan.-Mar. 1970.

Page, R. R. "Attitude Assessment in Science and Technology." An Occasional Paper. Bath, England: University of Bath, Science and Technology Education Centre, 1979. ED 179 385.

Peterson, Rita W. and Gaylen R. Carlson. "A Summary of Research in Science Education -1977." *Science Education* 63(4):429-533, Sept., 1979.

Schibeci, R. A "Selecting Appropriate Attitudinal Objectives for School Science." *Science Education* 67(5):595-603, 1983.

Zeidler, D. L. Comments and Criticisms on "Thirty Studies Involving the 'Scientific Attitude Inventory': What Confidence Can We Have in This Instrument"? *Journal of Research in Science Teaching* 21(3):341-342, 1984.

RELATED REFERENCES

Doran, R. L. "Assessing Affective Outcomes in Science," Ch. 2 in *Basic Measurement and Evaluation of Science Instruction.* Washington, D.C.: National Science Teachers Association. 1980. ED 196 733.

Eiss, A. F. and M. B. Harbeck. *Behavioral Objectives in the Affective Domain,* National Science Supervisors Association. Washington, D.C.: National Science Teachers Association, 1969. ED 028 101.

Haladyna, Tom, Robert Olsen, and Joan Shaughnessy. "Correlates of Class Attitude Toward Science." *Journal of Research in Science Teaching* 20(4):311-324, 1983.

Kahle, Jane B. "Can Positive Minority Attitudes Lead to Achievement Gains in Science? Analysis of the 1977 National Assessment of Educational Progress, Attitudes Toward Science." *Science Education* 66(4):539-546, 1982.

Omerod, M. B. and D. Duckworth. *Pupils' Attitudes to Science: A Review of Research.* Atlantic Highlands, NJ: Humanities Press, Inc., Nov., 1975. ED 118 372.

Shrigley, R. L. "The Attitude Concept and Science Teaching." *Science Education* 67(4):425-442, 1983.

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