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ABSTRACT

This study examined instruments measuring attitudes to science for the period from 1967 to 1977 as well as relevant research studies. Following an introduction (chapter 1), background information is provided in chapter 2, considering the importance of attitude measures in science education, reviews of research in science education, reviews of attitude research/instrumentation, and other areas. Chapter 3 discusses methodology used to identify potential source materials (in particular, machine searches of ERIC tapes) and instruments used in research, and how relevant instruments were distinguished from irrelevant ones. Chapter 4 discusses techniques used to subject these instruments to analysis which revealed information about their validity, reliability, and other characteristics. Results are presented and discussed in chapter 5, focusing on: general features, reliability, and validity of the instruments; analyses of instruments for statement type and view of science; and evaluation of instruments by selected criteria. In general, it was found that the field of attitude measurement in science education is not one in which confidence may be placed because the instrumentation is weak on many counts. Descriptions/characteristics of the 56 instruments examined, analyses of their items, abstracts of research in which they were used, and instrument items are included in an extensive appendix. (JN)

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SCIENCE EDUCATION INFORMATION REPORT

AN INVESTIGATION INTO THE MEASUREMENT OF ATTITUDES IN SCIENCE EDUCATION

THE ERIC SCIENCE, MATHEMATICS AND ENVIRONMENTAL EDUCATION CLEARINGHOUSE
in cooperation with
Center for Science and Mathematics Education
The Ohio State University

by

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Faculty of Education

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AN INVESTIGATION INTO THE MEASUREMENT OF ATTITUDES IN SCIENCE EDUCATION

SMEAC Information Reference Center
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Columbus, Ohio 43212

December, 1983

FOREWORD

The SMEAC Information Reference Center is pleased to publish this major study of attitude measures in science education. Dr. Munby has conducted an extensive analysis of attitude instruments spanning the ten-year era, 1967-1977, resulting in this significant state of the art report.

As an aid to interested practioners and researchers, we at the SMEAC Information Reference Center have appended a bibliography of studies reported since 1977. We believe this report to be an important contribution to science education and we invite your comments and suggestions for future publications.

Stanley L. Helgeson
Patricia E. Blosser

SMEAC Information
Reference Center

ABSTRACT

This research examined all the instruments measuring attitudes to science and the relevant research studies covering the ten years 1967-1977 which could be identified by machine searches. This report describes the generation of devices for subjecting these instruments to analysis which reveals information about their validity, reliability, and other characteristics. In general it is found that the field of attitude measurement in science education is not one in which one may have confidence because the instrumentation is weak on many counts. These findings are fully documented in this study, and in an extensive appendix which includes for each of the 56 attitude instruments examined intently, a description of the instrument and its characteristics, an analysis of its items, abstracts of research in which the instrument was used, and the items of the instrument itself.

ACKNOWLEDGEMENTS

The research reported here could not have been initiated without a grant from the Research and Development Committee of the Faculty of Education, Queen's University. The project itself would never have been conducted without the generous funding provided by the Canada Council (now the Social Sciences and Humanities Research Council of Canada). I am most grateful for this support.

Ron Bettney, Nora Boyd, and Nangar Sukumar have worked effectively and cheerfully on various parts of this research, and have given very valuable aid. Madalyn Wilson, Research Librarian to the Education Library at Queen's University, has gone to great lengths to resolve the most awkward search problems. For this help and for the secretarial work of Denise Curry and Patricia Whitaker I am very thankful.

Of course, the contents of this report, its information and errors, are my responsibility alone.

Hugh Munby

December 1983

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CHAPTER 1

INTRODUCTION

Purpose of the Study

This study concerns itself with attitudes to science in the area of science education. It is not, however, an attempt to measure these attitudes to science, for we are not here dealing with questions about the attitudes that learners might express. The overall purpose of this study is quite different, for instead of asking "What attitudes to science do various learners have?" this study opens a rather novel area of investigation by assuming that there are several studies which ask such questions (an assumption warranted by the studies identified by machine searches described later) and asking, "How do we come to possess this knowledge?"

At first glance, this question seems trivial and invites the retort that we simply measure attitudes to science by applying an appropriate instrument; but therein the complexity of the question is initially revealed: "What is an appropriate instrument?" And this is just the beginning of a string of questions that seem in need of answers: What instruments are available? What model or conception of an attitude to science do they embody? What do we know of how these instruments perform? Do these instruments measure attitudes to science, or scientific attitudes, or both? Can these instruments successfully avoid testing knowledge of science-related affairs and ask questions which yield an attitude score?

Perhaps these and related questions are best subsumed beneath the larger question: "What confidence can we have in instruments which are purported to measure attitudes to science?" The present investigation is directed at answering this question and in attempting to do so the work provides as full an account as possible of measurement of attitudes to science in the period 1967 to 1978 which, as we see later, includes a considerable amount of material completed previously The effort here is one of trying to be thorough so that those interested in questioning the confidence we might have in this area of educational research can find here one investigator's journey and his reasons for judging the explored territory in the way that he does.

Overview of the Study

Anyone who is even remotely familiar with the science education research literature might be justified in thinking that a study like this is unnecessary. After all, attitudes to science must surely be a significant topic for researchers and evaluators, so equally there must be good and thorough reviews of good and thoroughly developed instruments. Oddly, as Chapter 2 argues at length, not only are there very few useful reviews, but also none of these comes close to being comprehensive, and very few are critical. Furthermore, as the rationale for the study presses, there are some immediate grounds for thinking that existing instrumentation is less than adequate, and this is not just from a psychometric stance. True, there are some problems in the area of validity and reliability, but there are other problems and these focus on just what an attitude to science is. So, in this way, Chapter 2 argues that a critical and thorough inspection of instruments which measure attitudes to science is important to undertake at this time.

Chapter 3 explains in detail how sources for this investigation were identified and then procured. This is not just an uninterrupted account of machine searches, for we see quickly one recurring theme in the field: there are a large number of interpretations of what an attitude to science is. So the second part of Chapter 3 becomes one of developing some straightforward criteria which can then be used to sift out attitude to science measures from over 200 instruments which were identified. Some instruments measure scientific attitudes, others attitudes to science courses or to science activities experienced in school. Then there are subject preference scales and occupational interest inventories. All these, in some way or another, have been used as measures of attitude to science and they have to be distinguished. Chapter 3 describes how this is done and closes with a brief account of the list of 56 instruments which survive the sorting and which therefore become the main object of the present inquiry.

The present investigation is built on the assumption that it is impossible to examine and then judge phenomena or materials without consciously or unconsciously employing some theoretical perspective or other. In this study, a number of perspectives are employed: some are psychometric and others are more of a philosophical or analytical nature. For the results of applying a theoretical perspective to be of any value, the theoretical perspective itself must be made public. Chapter 4 is devoted to developing the necessary theoretical perspectives for scrutinizing the 56 instruments selected for detailed study. There is no attempt to suggest that these perspectives are the only ones that could be developed and used, neither is there any thought that these perspectives are superior, or even uniquely suitable. The claim is simply that the perspectives are theoretically sound and, furthermore, that they are useful. While Chapter 4 argues for their soundness, the usefulness of these perspectives is left to be seen in Chapter 5, where they are applied. The implicit argument, then is that useful perspectives enable one to make distinctions and judgments, and to see what previously might not have been noticed.

It is for the reader of this document to determine if the perspectives are indeed useful. Certainly, the evaluations which are presented in Chapter 5 present considerable amounts of information and little of it reflects well on the area of attitude measurement in science education. The tables show troubles in the psychometric aspects such as reliability and validity, and also raise questions about what indeed items of these instruments are measuring. The field is summarized at the end of the chapter by evaluating the 56 instruments on less than strict criteria and by finding that only seven satisfy these minimal standards. When the seven are looked at somewhat more carefully, we find there are grounds for doubting that they measure only attitudes to science, leaving us with concern for the basic conceptual validity of these devices. This takes us into the conclusions of the study, appearing in Chapter 6.

Products of the Study

There are three rather distinct products of the present investigation. First, there are conclusions to be made about the field of measures of attitudes to science, of the instruments and their characteristics, and of the research in which these instruments are wielded. Generally, to give a foretaste, the study finds instrumentation in this area of science education to be quite immature and inadequate, the corollary being that research studies built out of administering these instruments inherit weaknesses too. Second, there are the ubiquitous recommendations for further work. Here the attempt is to be very specific, from such mundane matters as abstracting dissertations to the more important matters surrounding the generation and testing of attitude instruments themselves. Additionally we can make suggestions about research and, in particular, about the delicate subject of dissertations in science education.

The third product and the most bulky is found in the appendices. With the exception of Appendix L, the appendices consist of lists of instruments according to types of attitude instruments and the sort of attitude measured. Appendix L is substantially more, and for many it may well be the most useful product of this investigation. This final appendix contains a section for each of the 56 instruments which have been the object of scrutiny in the study. Each section provides details of the instrument's characteristics, an analysis of the instrument's items, abstracts of research studies in which the instrument is used, and the instrument itself. (References are provided in each section so that it is self-contained.) Since there is no other collection of this sort which includes abstracts of relevant research studies, Appendix L alone can be viewed as an unusual source of information for researchers and evaluators. The remainder of the study, of course, stands as a source of information for those interested in the sorts of questions that should be raised from time to time about the customary ways in which we have been doing things for a number of years.

CHAPTER 2

BACKGROUND TO THE STUDY

As the previous chapter has shown, the effort in the present study is to probe the instruments used in science education to measure students' attitudes to science. So, while it is undoubtedly true that knowledge about what attitudes students hold is important, the claim in this chapter is that it is equally as important if not more important to know something of how we come to hold this knowledge. In short, the case is made here for collecting instruments used to measure attitudes to science and the studies in which the instruments are used, and for devoting considerable time to examine all of these in a coherent and systematic way.

It is possible that the argument could be simply made: I could report that over two hundred instruments were identified, as we shall see in Chapter 3, and then urge that the quantity alone suggests the need for an enquiry -- if not a moratorium. But the matter is not so shallow as this. (There are, for example quite different views to be found about what an attitude to science is.) Also, I suppose, I could report a list of instruments and their reliabilities and validities. But that too would be an oversimplified rationale. (It would fail to uncover both the conceptual confusion which is to be found in validity assessments and also what might be called the psychometric infelicities in this work.) So the argument which supports this study must go further and deeper, and thus provide the reader with a full account of what appear to be severe problems in the area of measuring attitudes to science. This is accomplished in five sections the first of which briefly sketches the importance of measuring attitudes to science in the first place. The second section looks carefully at what have become lately annual reviews of science education research, and reveals the way in which reviewers have perceived attitude instruments. Recently, there have been more specialized reviews of disparate thoroughness and quality, of the area of attitude and attitude measurement in science. An account of these works, in the third section, while showing something of the character of problems in attitude measurement becomes evidence for the present argument that a critical appraisal of instruments is far from complete. A broader view of attitudes to science is taken in the fourth section, so that we can see and compare some sociological research with research in science education, and thus begin to identify some confusions in the concept of attitude to science. The fifth section pursues these confusions and, by focussing on a single instrument and on some studies using it, demonstrates that conceptual confusions appear to lead to validity problems. A concluding section for this chapter begins to establish the procedures for sorting out the various puzzles to be presented below.

The Importance of Attitude Measures in Science Education

It has already been signalled that this first section is to be brief and it is, for two reasons. First, it hardly seems necessary to arm the reader with extensive documentation in order to make the point that any evaluation of science curricula ought to attend to affective as well as cognitive outcomes. Second, the argument of this chapter is not designed to advance this point anyway; instead, it argues for a scrutiny of how such a practice is presently conducted. Nevertheless, it is worth noting that attitudes to science still figure prominently in talk about curriculum development and evaluation, in education itself as well as in science education.

Bruner (1960) has commented that the then new curriculum programs in science usefully provide the sorts of experiences necessary to develop wholesome and favourable attitudes to science. Later, Schwab and Brandwein (1962) argued the need to develop favorable attitudes toward all aspects of science, so as to maintain and support scientific inquiry. Without doubt, secondary school science curricula developed in the sixties and the elementary and junior curricula developed thereafter appear to place increasing emphasis upon attitudinal objectives. Such objectives are readily found in Hurd's (1970) account of the new curricula for all education levels, which have been commercially produced. The same may be said of smaller and experimental curriculum projects which are listed in such compendia as

Lockard's (1972). Neither, of course have attitudinal objectives been omitted from the policy statements of educational jurisdictions. The recent guidelines for intermediate science in Ontario (Ministry of Education, 1978) lists the development of attitudes among its stated aims for this four-year program of science, in grades 8-10.

Given these programs and the general burgeoning of research in science education, it is hardly surprising to find as we do in the next section, that increasing attention is being paid to assessing students' attitudes toward science.

Reviews of Research in Science Education

Reviews of research in science education are becoming increasingly important sources of information, for two reasons. First, the very large amount of research undertaken in doctoral studies seems not to find its way into the principle research journals, Science Education and the Journal of Research on Science Teaching and the same may be said of materials which are submitted to the Educational Resources Information Center (ERIC). For example, the search strategies conducted for this study identified approximately two hundred doctoral dissertations which had not been published in any serials. Second, reviews of research at least provide the occasion for a reviewer to present the reader with a critical analysis not only of research directions and findings, but also of the appropriateness of research methodology and instrumentation. As we shall see, it is only quite recently that reviewers appear to have assumed the responsibility for critically appraising what they review; but when they do so they show clearly that there are good grounds for entertaining misgivings about the usefulness of the instruments that have been employed. The purpose of reviewing these reviews is twofold: we shall witness the concerns expressed by reviewers and we will note that these concerns are advanced without specific support or reference to particular studies with the result that anyone committed to improving the state of affairs will find it difficult to identify the examples which give rise to a reviewer's judgment.

The earliest reviews identified as possibly useful to the present study proffered very little critical information. These reviews, published in the Review of Educational Research (Boeck and Washton, 1961; Matala and McCollum, 1957; Miles and Van Deventer, 1961), reflect an uncritical style of reviewing which simply organizes and summarizes research and its findings. It is only when reviews are produced, in the late sixties with the cooperation of the ERIC Information Analysis Center for Science, Mathematics, and Environmental Education at Ohio State University that we can begin to detect the emergence of a critical stance, but still not in every case.

Taylor (1966), for example, summarizes his judgment of the quality of the research he reviewed with the single critical comment, "Serious questions might be raised about the depth of many of the studies and about the validity of instruments used" (p. 3). This sentence appears typical of the emerging critical review, for it and its similar successors fail to identify the studies we should be concerned about and the sorts of questions we ought to voice about issues of validity. So, while the review by Westmeyer, Snyder, and LaShier (1969) offers no critical commentary, that by Haney, Neuman, and Clark (1969) does at some length. They have this to say of instrumentation:

> Finally, the value of data derived from investigator-produced measuring instruments are often of questionable value (sic). In many cases these instruments are hastily constructed and evaluated because they are to be used to measure some variable which is under investigation. Actually, the identification of an important variable and the development of an instrument to measure it are of such value that this alone can constitute a doctoral study. Too many people are trying to do too many things in one investigation with the result that none of them are done well. (p. 16)

These reviews seem to represent the pattern for a number of years. Cunningham and Butts (1970) provide no critiques of the studies they examine, while Montean and Butzow (1970) provide some small critical commentary and say nothing about research methodology and instrumentation.

Yet Gallagher (1971) offers a limited critique of some of the studies appearing in his review and concludes by citing the criticisms advanced by Haney, Neuman, and Clark (1969) and by noting that the faults persist. Here, instrumentation is not mentioned as a factor, although many other methodological weaknesses are. Gallagher (1972) expands on these weaknesses in a later review and urges that the research methodologies and experimental treatments are inadequate. Instrumentation comes under scrutiny in Welch's (1972b) review for he expresses some dismay at the mismatch between tests and treatments. "If any explanation can be attributed to the nature of the tests (used), it appears to be in the lack of connection between the instructional procedure and the test chosen to measure the effect" (p. 110).

From 1972 onwards, reviews of research in science education are conducted annually and appear first as publications of ERIC and then as published supplements to Science Education. Moreover, perhaps as a consequence of the increasing attention given in studies to the measurement of attitudes, the reviews tend to isolate attitude research specifically, if they do not devote separate sections to this work. Thus, in his review of approximately four hundred studies, Trowbridge (1972) finds "Studies of measurement and instrument development were severely limited at the elementary level. Limited information was given on validity and reliability. Usability beyond the specific tasks for which instruments were designed is extremely improbable" (p. 27).

The situation is equally deplorable to Trowbridge at the secondary school level. "At this point, there are still few studies which involve the development of (attitude) measuring devices" (p. 38). And, of those attitude measures developed for studies of science teacher education, he declares "A serious weakness of attitude studies is the lack of adequate instruments for measurement and vagueness about the meaning of attitude" (p. 64). His overall judgment of the research he examines is:

> An honest assessment of the quality of the research efforts can only yield disappointing conclusions. The majority of the research is short-term, localized, and of questionable value in the overall advancement of effective science education. Over seventy per cent of the studies received were first efforts (doctoral dissertations). While this statement is not meant to demean the quality of dissertation research generally, it is nevertheless true that such studies are frequently based on small samples, attack small scale problems of a specific nature, and in many cases rely upon investigator-developed instruments the reliability and validity of which may be suspect. (p. 82)

This extensive review by Trowbridge is the first that offers any criticism about attitude studies to the general research consumer.

Three reviews appeared in 1973. Anderson (1973), reviewing work completed in 1971 gives some introductory criticisms on methodology, and usefully provides some critical commentary on studies reviewed. Yet, there appears to be no critical look here at instrumentation. The same year saw the publication of the Second Handbook of Research on Teaching (Travers, 1973); and in this volume, Shulman and Tamir undertake the task of reviewing research in science teaching which, by any measure (including the number of reviews cited so far) becomes an Herculean labor. The emphasis in this review is upon curriculum development and learning theory, so it is not surprising that little is said of work in attitudes to science. We can discern, though, some misgivings for this area in the following aside. "The Understanding of the Nature of Science Test (Kimball, 1967-1968) and the Inventory of Scientific Attitudes (Moore and Sutman, 1970) add to the list of instruments that purport to measure this crucial but undefined cognitive attitudinal attribute" (Shulman and Tamir, 1973, p. 1130). The third review of thi year (Novak, 1973) contains an examination of thirteen studies on attitudes to science and science values, and concludes:

> We lack a theoretical framework for the definition and elucidation of attitudes and attitude growth. Important as affective dimensions of school learning may be, we are not likely to make substantial progress in

> understanding attitude measurement and designing instructional practices for positive affective growth on the basis of research unless and until some better theoretical framework or paradigm is elucidated to guide our work. Krathwohl's, et al. (1964) taxonomy notwithstanding, we have a long way to go to su pass what insights warm, sensitive people have to offer at this time. (p. 35)

To this indictment of attitude research is to be added Novak's general conclusion about the state of evaluation studies::

> Evaluation in science education continues to suffer from inadequacies in available tests. This is particularly true with respect to measurement of affective variables. Some of the widely used tests are of doubtful validity, probably explaining in part some of the conflicting results reported in the literature. (p. 65)

Quite clearly, Novak's review reflects a litany of sorrows in the area of attitude measurement within science education research, and this is cause for looking at the field intently. But Novak's review cannot aid this sort of scrutiny for it, along with those which precede and follow it, fails to point the accusative finger at particular studies, particular instruments, and particular faults. Mallinson's

(1977) review is rather similar, with the possible exception of his singling out a review of attitude instruments (Gardner, 1975b) which is discussed in the following section. So it is not surprising that Mallinson seems to echo Novak's concerns, almost as if the research community was inattentive to the reviews of its work. The conclusion to a review of some twenty-seven studies appearing in 1975 is:

> A retrospective examination of the reviews of the studies on attitudes leads to frustration. Obviously, the affective domain of objectives is currently receiving considerable emphasis, whereas formerly the cognitive domain received practically all the attention. The frustration comes from the inconclusive, and in many cases contradictory, findings of the studies. It is reasonably obvious, as indicated in one of the reviews of research at the beginning of this section that no one has yet "gotten a handle" on the issue. The enhancement of positive attitudes does not seem to be a function of the material that is used, or the way it is used. It seems more likely to be a parochial function of the investigator or the other person who interfaces with the subject who is the target of the effort for attitudinal change. (p. 167)

Neither does the territory appear to be better mapped by the time that Renner, Abraham, and Stafford (1978) conducted their review of research appearing in 1976. They close their six pages of report on affective studies with a brief mention of some instruments, and with the following comment:

> The continued proliferation of instruments is a necessary evil until a battery of well developed, reliable and valid instruments can be developed. A system for categorizing and sharing these instruments for retrieval by researchers in the field is needed. Some sort of critical evaluation of existing instruments needs to be made and continually updated. (p. 69)

We might well wish to dissociate ourselves from the view expressed here that the proliferation of instruments is a <u>necessary</u> evil, especially if, as we have seen, reviewers are not at all impressed with the quality of these tools. Nonetheless, this review and the others discussed here present us with a generally alarming picture of the state of the art.

In fact, this discussion of reviews provides not only a picture of the state of the art, but also of the artist, for we have seen something here of the character of research reviews in science education; that is, where early reviews were uncritical and later reviews assume increasingly a critical role, these later reviews do not steer the reader directly to the evidence which gave rise to the critical judgment in the first place. Of course, it would be presumptuous to suggest that reviewers ought to have attempted this, but that is not the point. Rather, the point is that if the field is found inadequate and researchers are urged to do better, then it is enormously helpful to the researcher to have someone point specifically at the inadequacies. The present investigation of reviews shows clearly that general problems in attitude instruments exist, and thus justifies a more intensive look. The intensive look is further supported by the failure of these general research reviews to provide just that.

Specialized Reviews of Attitude Research and Instrumentation

Of course, the foregoing section dealt with general research reviews, and it is unlikely that a researcher would use these sources as a primary access to research on attitudes to science. More likely, a researcher would seek out specialized reviews for a sharper picture of problems in the field, for only a few problems have been identified in the above reviews and these with rather broad brushstrokes. The purpose of the present section is to press for this sharper picture and to begin to identify the specific difficulties to which the previous reviewers have alluded.

Probably the first move a researcher might make is to look at a volume of a publication such as Tests in Print. In fact, little in the way of attitudes to science measures appears to have found a place in commercial publishing houses, so it was not surprising to learn that the sole instrument in this area referenced in Buros (1974) is the "Science Attitude Questionnaire" by Skurnik and Jeffs (1971), which is examined in the present study. The instruments in this area then are to be considered unpublished, technically, and are to be found in journals, dissertations and similar materials. Mayer (1974) provides a useful listing of evaluation instruments used in science education, and some fifteen of these are directed specifically at attitudes to or interest in science. (Other attitude instruments in this collection deal with attitudes to or interests in more specific fields within science, such as chemistry, physics, biology, astronomy and so forth.) There are perhaps three reasons for being somewhat cautious in using Mayer's collection, though. First, it is quite clearly out of date, since it was published in 1974. Second, it is not comprehensive, nor was it intended to be. (The twenty-six affective instruments mentioned represent a fraction of the approximately two hundred devices uncovered by the searches undertaken for the present study.) Third, the information provided on each instrument is meagre. (While standard psychometric characteristics are given, there are no references to conceptual issues of validity or to studies in which the instruments have been used which could further demonstrate how they perform.)

A collection of a rather different type is Pupils' Attitudes to Science: A Review of Research (Ormerod & Duckworth, 1975). This ambitious survey and synthesis of research into affective outcomes is mildly dissatisfying for although the reviewing is careful there is no attempt at explaining contradictory findings when they are evident and, more significantly, there is no question raised of the reliability and validity of the instruments used to generate the large quantity of information which gave rise to the need for the book in the first place.

As we discover below, there are more satisfying reviews of attitude instruments to be found in journal articles. These appear to develop a critical stance in much the same way that the general research reviews described above did. Early articles are uncritical, later ones are critical. It is, of course, within the latter group that we finally get more than a glimmer of the major problems besetting this area of investigation.

An early runner in this group, by Aiken and Aiken (1969), reviews approximately fifty studies but, with one exception, omits any consideration of the quality of the instruments used in the research. The exception is an important one, and later in this study becomes a device for distinguishing between two sorts of interpretations of the construct "attitude to science". The distinction is between scientific attitudes, and attitudes to science. At first glance, there appears little to be said about the difference here, so it is worth a brief look at this point. Typically, scientific attitudes are taken to represent some sort of habits of mind that in other areas of the curriculum may well be considered elements of critical thinking. Such attributes as honesty, objectivity, open-mindedness, suspended judgment, willingness to pursue fresh evidence and explanations, and so forth, belong in this category of scientific attitudes. Attitudes toward science are quite distinct from these, for they are to capture such notions as feelings toward science, interest in pursuing a science-related career, beliefs about the relationship between science and technology and so on. Put another way, scientific attitudes appear to capture the notion of certain propensities to act on evidence, statements and ideas in a disciplined fashion, such as one might think scientists do; whereas attitudes to science refers to beliefs one holds about that discipline, whether these beliefs are about its processes, theoretical products, or technological products. This distinction receives more attention in Chapter 3.

A brief and selective review by Aikenhead (1973) focusses on six instruments which deal with the processes of science, nature of science, social aspects of science, and attitudes to science. Aikenhead judges that of the six instruments he reviews, two essentially tap matters concerning attitudes to science. This is certainly the case for the "Test on Social Aspects of Science" (Korth, 1968), a test which is reviewed later in the present study. Yet the other, the "Facts About Science Test" (Stice, 1958) consists of two subscales (understanding of science as an institution in society, and knowledge of scientists as an occupational group) which are by no means self-evidently testing affective outcomes, rather than cognitive outcomes. Aikenhead provides data to support his view that Stice's test is not very reliable, but there is no detailed examination of the validity of this or of Korth's instrument.

For the sake of completeness, two further reviews ought to be mentioned. Pearl (1974) briefly describes the growth of interest in attitude measurement in science education and offers a number of references to instruments without any details of their characteristics or any critical commentary. In "Evaluation Instruments for Integrated Science Teaching" Mayer and Richmond (1977) mention five attitude instruments among the thirty instruments cited. Again no psychometric or critical information is offered.

The remaining reviews to be considered here are rather more substantial and helpful. The first of these reviews is by Gardner (1975b). Gardner's extensive review begins with the distinction between attitudes to science and scientific attitudes, and then announces that his focus is on the former, with a particular emphasis on scales which purport to tap emotional reactions of students by focussing on variables described by terms such as "interest, satisfaction, and enjoyment" (p. 2). Gardner establishes the significance of attitude measurement to the field, and thus presents a useful survey of the basic instrument types used, and their characteristics, citing original sources for such techniques as the Thurstone, Likert, and semantic differential. Gardner's section on methodological issues is perhaps the most valuable portion of the review. Here he isolates a number of problems he has found in a sample of scales. He argues, for instance, that there is evidence of a lack of a coherent theoretical construct in some scales so that as many as three quite separate issues are found as three items in a single attitude scale. Other instruments, he shows, suffer from a confusion of several theoretical constructs with the result that genuinely different scales are combined (or reduced) to a single attitude score. He points out, for example, that Selmes' (1971) instrument "mixes together several constructs, e.g. attitudes toward science, attitude toward scientists, and understanding of scientific method, into a single score" (Gardner, 1975b, p. 13). Other scales, he finds, are relatively free of the more obvious faults in item-writing with the exception of ambiguous or double-barrelled items. The next section of the review investigates the relationship of attitude and other variables, such as personality, sex, and teacher variables. His work closes with a review of attitude and curriculum and instructional variables, treated according to the research design used in the studies.

Gardner's (1975b) review is somewhat puzzling in one respect. The early parts of the review present problems associated with some selected attitude instruments, while the latter part reviews the attitude research studies, but seems not to qualify their findings with any mention of the possible difficulties that exist in the measuring instruments themselves. For instance, Gardner notes the recommendation that scales be constructed with an equal number of favorable and unfavorable statements. Noting that this assumption is not supported in one study, he recommends "Clearly, the assumption should be checked for a wide variety of scales" (p. 31). Yet he concludes his review:

> Although it is undoubtedly true that much remains to be learned about the factors which influence students' attitudes towards science, it is also true that much is known already and left to wither in the educational research journals. Our knowledge may be incomplete, but a substantial body of knowledge does exist. (p. 33)

This is an odd statement to find at the end of a review whose major contribution has been to raise serious questions about the validity of instruments which have been used to produce this knowledge. Somewhat in his defence, we should note Gardner's justified disclaimer that the field is so large that "it is no longer possible to produce a comprehensive and detailed review within the confines of a journal article" (p. 2).

Gardner's (1975a) second review covers some of the same territory as did his earlier review (1975b), though its focus is more on British research. Approximately sixteen studies are cited, and while these are not critiqued thoroughly, the strength of this review, as with the previous one, lies in its treatment of the problems he finds in attitude instruments themselves and in their use. Two of these problems are mentioned in the first review. Gardner cites sample items from two instruments to show that the items themselves do not converge on any single meaning of the construct attitude. Indeed, the meanings are so diffuse for Gardner that "statistical procedures such as summing of item scores, split-half reliability and so on are irrelevant" (1975a, p. 102). Gardner's second criticism, as before, is that the attitude variable or target is frequently confused. Wilmut's (1973) scale appears to assume that attitude toward science and attitude toward scientists are to be regarded as a single unidimensional trait. Gardner argues that scales like these contain multiple attitudinal variables and that "multidimensional entities should not be reduced to unidimensional variables, unless the reduction can be stoutly defended" (p. 105). The third, and novel criticism is directed more at the general research style which somehow manages, as we have seen noted by Welch (1972a, p. 110), to use an outcome measure that is not clearly related to the instructional treatment. Gardner wonders, for example, if such items as Wilmut's (1973) "Scientists have proved that God does not exist" constitute a fair measure of attitude to science following work in Nuffield A-level physical science.

The principle subject of Gardner's (1975c) third review is "the relationship between attitude variables and curriculum treatments" (p. 25) which received more extensive treatment than it did in the first review (1975b). The criticisms of the forty-five studies reviewed are generally aimed at the design itself rather than at the instruments employed, although something of the criticisms made in the earlier reviews appears. Gardner finds that the studies generally show a decline in student attitudes, and he hypothesizes that the science curriculum reforms may be responsible for this and that "teacher behavior variables may be more influential than curriculum variables" (1975c, p. 35) Oddly, and despite his previous reviews, Gardner does not suggest that an explanation might be found in defective instrumentation.

The remaining two reviews worthy of note are by Fraser. Since the first of these (Fraser, 1977) relies initially upon a study by Klopfer (1973), this latter work must be presented briefly. Klopfer suggests that despite the availability of the Taxonomy of Educational Objectives, Handbook II: The Affective Domain (Krathwohl, Bloom, and Macia, 1964) for a number of years, little use has been made of it as a base for assessing the affective outcomes of science education. His paper presents what amounts to a table of specifications for testing, in the form of a grid. One axis of the grid identifies behaviors associated with the five major levels of affective internalization developed in the Handbook: receiving or attending, responding, valuing, organization, and characterization by a value or value complex. The second axis lists "the full range of phenomena toward which some affective behavior by the student is sought or hoped for in science education" (Klopfer, 1973, p. 301). The phenomena are: events in the natural world, activities, science, inquiry. In the remainder of this paper, Klopfer provides extensive lists of examples of each cell of the matrix.

Fraser's (1977) review is intended to "describe criteria to guide the selection, modification, and validation of scales for curriculum evaluation, and to illustrate the application of these criteria to a battery of five attitude scales" (p. 317). Klopfer's (1973) matrix serves to classify the objectives of the scales examined by Fraser. He argues that scales ought to be selected on the basis of educational importance, multidimensionality, and economy. The remainder of the paper describes how a single scale was developed from the five that survived initial screening, and what post-administration statistical tests are conducted. The second of his reviews (Fraser, 1978b) describes four attitude scales which have in his judgment overcome the following deficiencies: the generally unsatisfactory psychometric characteristics, the presence of mixed and confused variables, and the lack of economy (found in scales with large numbers of items which produce a single score). While both of these reviews are limited in scope, they serve to point up problems in the area of attitude measurement, and they also point specifically to a direction for improving instrumentation.

Indeed, Fraser (1978a) constructs his own scale from appropriate portions of those which pass his screening. There is another point to be noted about those reviews, though, and one which again suggests the need for a more extensive examination of attitude instruments: there are grounds for disagreeing with some of Fraser's findings. He reports, for example, that while the scale of Tamir, Arzi, and Zloto (1974) has a satisfactorily high reliability of .81, "this scale must also be considered grossly uneconomical since it consists of 76 items in all and yields only a single attitude score" (Fraser, 1978a, p. 379). This is a disputable judgment given the fact that reliability is a function of a scale's length. Earlier, Fraser (1977, p. 319) refers to the 60-item Moore and Sutman (1970) scale as unidimensional when, in fact, it is designed as six subscales of ten items each.

Given these reviews of attitude measurement in science education, it is quite clear that a number of problems persist which, as the general theme of this argument goes, appear to demonstrate the need for a more thorough examination of what is transpiring. It is peculiar to note, for example, that when attention is fastened on instrumentation, these reviews generally do not examine experimental studies using a particular instrument except the one in which the instrument is first used. It is also curious to observe that still, despite the points made about confusion in what is being selected as the attitude target, the vast quantity of attitude scales have not been organized into any coherent framework, such as that proposed by Klopfer (1976).

Further Confusion From a Broader View of Attitudes Toward Science

We have already noted Novak's (1973, p. 65) finding that the results of research he reviewed are ambiguous. We have seen too Gardner's (1975c, p. 35) conclusion that student attitudes often decline over instructional treatments. This, of course, is not the only area in science education that is faced with declines, and perhaps the decline that is of most concern to the field is the oft-mentioned decline in enrolments. The present section takes a look at declining enrolments in sciences at the universities as a way of entering the broader idea of general societal attitudes toward science. A discussion of the latter allows us to see something more of the conceptual difficulties which surround the question of what attitudes are, quite apart from how they are to be measured.

A useful account of the university enrolment picture in the United Kingdom is given by Ormerod and Duckworth (1975). Taking data from reports of the University Central Council for Admissions from 1968-69 to 1973-74 (dates which sit nicely in the years for which reviews of research are available, as we have seen), the authors show that there has been a decline in applications in all sciences including mathematics and combinations of science with non-scientific disciplines as a percentage of total applications from

20.95 per cent in 1969 to 18.01 per cent in 1974 (p. 107). The authors suggest that the main cause of the flight from the physical sciences (for physics and chemistry in the same period, 5.89 per cent to 3.96 per cent) is the perceived difficulty of the area, while a second reason might be a reflection of the decreasing industrial need for physical scientists. To these explanations, they cautiously add that "a significant number of young people in the 1970's are disenchanted with the physical sciences because of their anxieties about its (sic) possible harmful social effects" (p. 111). As we see below, there are grounds for considering this view to be reasonable, while there are other grounds for considering it to be doubtful.

In Canada, the Canadian Association of Physicists established a study group to investigate enrolment trends. An initial report (McNarry & O'Farrell, 1971) shows a pronounced drop. For twenty Canadian universities, first-year enrolments in physics as a percentage of total first-year enrolments dropped from 15.0 in 1960-61 to 11.3 in 1968-69. The report also establishes second-vear enrolments in nine Canadian universities as dropping from 15.0 per cent of total second-year enrolments in 1960-61 to 10.6 per cent in 1969-70.

Science Indicators 1976, (National Science Foundation, 1977) provides data which convey a similar pattern for enrolments in the United States. Referring to a contemporary national sample, the report finds that total junior-year undergraduate enrolment increased by two per cent between 1973 and 1974, while "the number of students majoring in science and engineering fields increased only 1.1 per cent, which was not significantly different" (p. 159). Furthermore, between 1960 and 1975, the number of engineering degrees awarded, as a percentage of all degrees declined from 10.0 to 4.0, with a decline in physical sciences from 4.0 to 2.0. (This decline is not found in doctoral degrees, for which an increase is noted.)

Given those data, it is not surprising to find attention turned to the public's attitude toward science and technology. Science Indicators 1976 reports the results of the Opinion Research Corporation's (1976) survey which show some interesting changes:

> About 70 percent of the public believed in 1972 and 1976 that science and technology have changed life for the better, and over half believed that they had done more good than harm. More favorable attitudes on these issues were expressed in 1974 than in either 1972 or 1976 (National Science Foundation, 1977, p. 168);

and:

> In 1976, 6 percent of the public thought that science and technology have caused most of our problems, 45 percent some of our problems, 2 percent few of our problems, and 14 percent none of our problems. In 1972, only 9 percent felt

> that none of our problems were caused by science and technology. (p. 168)

The difference between 1972 and 1976, which is reported as "a strong and significant increase" (p. 176), is suggested to reflect a favorable trend in the public's attitude toward science and technology. This view seems to undermine Ormerod and Duckworth's (1975, p. 111) explanation, couched in terms of science's perceived social harm. Accordingly, it is wise to take a wider look at the results of such public opinion polls.

Etzioni and Nunn (1974) critique what they perceive to be "a widely held belief among scientists and nonscientists that appreciation of science in the contemporary United States has declined" (p. 191) by closely examining polls from 1957 on. Among their findings are that the major shift from 1966 to 1973 "was not from great enthusiasm to great hostility, but from 'great confidence' to 'only some confidence' -- a middling shift by all accounts" (p. 193), and that college graduates are almost twice as favorably inclined to science than high school graduates (p. 196). We can note here that this finding weighs somewhat against Gardner's (1975c p. 35) conclusion about student attitudes declining over instructional treatments. Etzioni and Nunn find little support for the belief that college and college-bound students are distrustful of science, among the several surveys they review. In their conclusions they state:

> Of all American institutions, science seems to be the least understood by the wider public. And, spreading science information and educating various publics to its values seem to be relatively effective in improving attitudes toward science. (p. 203)

It needs to be acknowledged, of course, that some of the alleged anti-science sentiment comes from social criticisms of the sixties and seventies. It is within Roszak's (1968) work, an example of this form of criticism, that we can detect something of the difficulty of detecting attitudes to science when science is an integral part of our lives and thinking. Science is so deeply imbedded in our culture that, as Roszak puts it, it has given rise to a significant cultural myth (in the non-derogatory sense of that word), the Myth of Objective Consciousness, which guides our way of thinking about knowledge, science, and technology Roszak argues:

> If we probe the technocracy in search of the peculiar power it holds over us, we arrive at the myth of objective consciousness. There is but one way of gaining access to reality -- so the myth holds -- and this is to cultivate a state of consciousness cleansed of all subjective distortion, all personal involvement. What flows from this state of consciousness qualifies as knowledge, and nothing else does.

> This is the bedrock on which the natural sciences have built; and under their spell all fields of knowledge strive to become scientific. The study of man in his social, political, economic, psychological, historical aspects -- all this, too, must become objective: rigorously, painstakingly objective. At every level of human experience, would-be scientists come forward to endorse the myth of objective consciousness, thus certifying themselves as experts. And because they know and we do not, we yield to their guidance. (pp. 208-209)

This portrayal of science and our culture raises a difficulty in measuring anyone's attitude to science which is not too hard to see. For instance, anyone bent on developing a scientific, technological or any other sort of expertise whether he chooses to do so by formal education or by a system of apprenticeship is by Roszak's point, already caught up by the myth. So when asked of his opinion of science or technology, the answer derives from his thinking as it is influenced by the myth. A similar point can be made when we ask opinions about science of anyone who has come into contact with contemporary western culture. Now, it looks very much as if the Roszak's painting of the myth makes it itself impossible to detect: any thought about the myth is colored by the myth itself. Whether or not this is true is outside the present argument, for the relevance of Roszak's point is to considering the confusions around determining what an attitude to science is and how it is to be measured.

An analogy may well be helpful. There are probably a small and finite number of instances in which we are aware of the air we inhale and exhale so frequently -- processes of which we are generally unaware. When the air strikes us as unusual, we take note with such qualifiers as humid, hot, cold, foggy, damp, smokey and even fresh if we are urban folk. Imagine then what we might expect to have to ask of children or adults if we wanted to determine their attitudes to the air. In the very first place, we have to alert them to something they may not be alert to, and then we have to put the questions. Given the pervasiveness of science in our society, we ought not to be surprised to find some problems in defining what sorts of questions are appropriate to a science attitude scale. Questions about the prestige of being a scientist, about how scientists behave (perhaps bald, white-coated, with little time for such human groups as families), about science courses (lessons, laboratory exercises, and even teachers), about science processes (critical thinking and its progeny), about scientific laws (are they true, or the inventions of man), about science and society (oilslicks, atomic bombs, but rarely buildings, foodstuffs, and clothing): all these questions will tap the "atmosphere" in different ways and so present the researcher with considerable confusion about what represents an attitude to science, and what does not.

Conceptual and Empirical Validity: More Problems

We have identified a considerable amount of difficulty in the area of measuring attitudes to science: reviewers are not satisfied with instruments, the results are ambiguous if not unsettling, the overall picture of society's support of the enterprise is somewhat difficult to pierce, and there is some question about what sort of thing measures an attitude to science. This issue has to be ridden further because it hits directly at the problem of instrument validity. This section, then, argues again that a thorough scrutiny of existing measures of attitude to science is necessary, and this part of the general argument for the chapter is based on a brief look at a single instrument, "The Scientific Attitude Inventory" developed by Moore and Sutman (1970).

Despite the earlier distinction of this chapter between scientific attitudes and attitudes to science, the subscales of this instrument cover considerably more than a test of traits one might expect the honest and objective scientist to possess. The subscales are

1. Laws and theories of science are approximations of truth.
2. Observation of natural phenomena is the basis of scientific explanation.
3. To operate in a scientific manner one must display such traits as intellectual honesty, willingness to alter one's

position.

4. Science is an idea-generating activity. It is devoted to providing explanations of natural phenomena.
5. Progress in science requires public support.
6. Being a scientist or working in a job requiring scientific knowledge and thinking would be a very interesting and rewarding life's work.

This instrument is examined in detail later in the present study, but a few brief comments can be made here. First, there are instances in which items of the same subscale appear to ask rather different things. The following two items belong to subscale 2: "Anything we need to know can be found out through science." "Scientific explanations can be made only by scientists." Again, the following two items belong in subscale 5: "A scientist must be imaginative in developing ideas which explain natural events." and "The value of science lies in its theoretical products."

Additional difficulties arise when we look at items from the perspective of "Are they seeking attitudes or testing knowledge?" For instance, "I would like to work in a scientific field" is asking clearly for an expression of personal liking or disliking. But the item "Rapid progress in science requires public support" seems to be asking the respondent if he knows this to be a correct or an incorrect summation of what is the case.

Given these sorts of difficulties, one would expect a good deal of activity to have occurred in the area of validating such an instrument; it is, after all, a very popular one, which has been used in thirty studies identified in the present research. The authors attempt to establish the construct validity of the scale, but not its convergent or discriminant validity. This is unfortunate, for in other studies (Campbell & Martinez, 1976; Wilson, 1976) the scale converges at a statistically significant level with scales which do not profess to measure attitudes. In only one study is the validity of this scale questioned experimentally. Nagy (1978) investigated the scientific attitudes, achievement, IQ, and subject choices of 97 grade 9 students. Only small, though significant, correlations were found between attitudes and student subject preferences, when the effects of IQ and grade point averages were removed. A cluster analysis of the attitude scores yielded, importantly, clusters of items which did _not_ correspond to the instrument's subscales. Yet the subtests Nagy developed from the cluster analysis gave significant correlations with subject preference and achievement.

From this we see that the validity of an instrument cannot be taken for granted in later research, and the same can be said of its reliability. In only six of the studies using this scale was its reliability determined afresh, and then always its value was lower than that reported by the instrument's authors.

The difficulties in the "Scientific Attitude Inventory" are not unique, as reviews by Gardner (1975a, 1975b) have indicated, and as the full examination of instruments presented below shows clearly. It is evident that the field of measures of attitude to science needs serious attention

Summary

The purpose of this chapter has been to draw the reader's attention to the range of problems within the area of measuring attitudes to science, with a view to supporting the case that an extensive and thorough examination of this area is necessary and propitious. By way of summarizing the argument, and not by listing all the problems encountered thus far, we can note that previous reviews have not been sufficiently pointed in all cases so that particular weaknesses of instruments are revealed for all to see. Neither have previous reviews presented a thorough accounting of the field, in two specific ways. First, although we probably ought not to expect any review to cover the field entirely (a task which is likely impossible) we have to expect that the majority of instruments are mentioned, and this does not appear to be the case. Second, and somewhat unnerving, few if any reviews mention later research with an instrument which might convey important information about the instrument's performance, as we have seen in the case of the "Scientific Attitude Inventory." This sort of work is attempted in the present study, and the next chapter describes the collection of material and the division of that material into categories representing very different approaches to attitude measurement. This dividing provides a means for moving in on the problems of attitude measures in science, as we shall see.

CHAPTER 3

COLLECTION AND SELECTION OF SOURCES

This chapter describes how the file of instruments and research relevant to the present investigation was established. The chapter opens with a brief description of the sources used to identify potentially useful sources. This is followed by an account of the procedures used to identify instruments used in research and to obtain copies of these. The third section describes how the relevant instruments were distinguished from irrelevant ones. (It is at this point that we find a host of interpretations of the concept of attitude to science.) The result of this sorting was a collection of fifty-six instruments whose place is central in the present study, as described in the final section.

The Searches

Two machine searches of the ERIC tapes were conducted for this study. The first was undertaken in 1975, the time at which the investigator began to develop an interest in the problems associated with measuring attitudes to science. This search of the ERIC tapes was directed by the National Library, in Ottawa, as a retrospective search from the beginning of 1967 to the end of 1974. The second search, conducted through the Ontario Institute for Studies in Education, was also retrospective from October 1974 to December 1977. (The project itself began in January 1978.)

These searches identified published materials, doctoral dissertations, and materials in the ERIC collection which related to attitudes to science.

The two machine searches were supplemented with references from Mayer (1974) and Ormerod and Duckworth (1975). Additionally, the reviews cited in the previous chapter were used to check the accuracy and completeness of the machine searches. They were also used to broaden the scope of the investigation. It was originally planned to assess the literature on this topic over a ten year period. These two reviews allowed the investigator to examine earlier materials, though with the full knowledge that the studies in this earlier period are not identified exhaustively. It happened that the decision to allow the project to incorporate earlier material was a good one, for research studies appearing between 1967 and 1977 used earlier instruments. Whenever such an instrument was cited, an attempt was made to locate all research in which that instrument had been employed.

Approximately two thousand references were accumulated by these searches. A careful reading of the titles and abstracts led to the ready rejection of a large number of these since either they proved totally irrelevant or they had nothing substantial to add in the way of attitude measurement or research. The latter category seemed largely to consist of exhortations about the importance of inculcating favorable attitudes to science and the significance to the field of measuring these. It was decided that masters theses, few in number, could be excluded also on the grounds that first they are generally not very accessible to the reader and second they are probably less thorough (and thus less useful) than doctoral dissertations. This judgment appears to be supported implicitly by the reviews cited in the previous chapter. None of the major reviews of research in the United States cite masters theses. The only reviews which do are by Gardner (1975a, 1975b), Ormerod and Duckworth (1975), and Pearl (1974). Of course, those masters theses which were later published as journal articles were identified by machine searches, as one would expect.

Since it was recognized that many of the references which survived this initial screening would probably be found to be irrelevant when the materials themselves were read, no attempt was made to count the survivors precisely. It is conservative to say, however, that between seven hundred and fifty and eight hundred references were available for the more systematic processing described below.

Identification of Instruments

The point of obtaining those references to research and instruments was simply to ensure that as many instruments as possible would be identified through the research studies in which they are used. Accordingly, the references themselves had to be obtained so that the instruments could be identified and then procured. For a number of reasons, this proved to be at times rather exasperating. First, it is very unusual for journal articles to contain the instruments which are used in research, and thus if the author constructed a new instrument (a frequent occurrence) it became necessary to obtain his address and write for the instrument. As is to be expected, this technique proved to be slow and often fruitless. Yet, although a rather large number of requests are outstanding, it was in most cases possible to identify the type of instrument involved from the text of the article. (Over thirty letters to authors remain unanswered.) Second, it was found that researchers abstracting their doctoral dissertations do not customarily follow a pattern of providing the reader of Dissertation Abstracts International with details of the instrument employed in the research. Accordingly, in the great majority of cases, microfilmed dissertations had to be purchased, often leading to the discovery that the instruments were readily available in other sources. (There is clearly a need here for establishing some criteria for dissertation abstracts which will make the abstracting more useful while maintaining conciseness.) Of course, there are other problems with dissertations. Dissertation Abstracts International depends for its success upon the cooperation of universities and their doctoral students, and without this cooperation, the collection becomes incomplete. Oddly, dissertations were missing not only from Australian and British universities, but also from some universities in the United States.

Despite those difficulties, files on two hundred and four instruments were compiled, the intention being that each file contain the instrument, papers describing its development and characteristics, and reports of research in which the instrument was used. In this way, it was believed that complete knowledge of each instrument would have been collected. The next task for the study was to determine ways of sorting out this profusion of instruments.

Identification of Relevant Instruments

The discussions of reviews in the previous chapter has already demonstrated quite clearly that the general rubric "attitudes to science" covers a rather wide range of meaning. Put another way, when we begin to look at instruments and indeed items of instruments, we can detect a large number of interpretations and attitudinal objects. Since the intention of this study was to investigate the construct "attitude to science" and not, say, scientific attitude, attitude to science teaching, or even scientific interests, it became necessary to find a way to distinguish instruments which measured attitude to science from those which were irrelevant, even though they might be of interest to anyone engaged in evaluating science education practices. This section describes the basis for differentiating relevant material from irrelevant material, starting first with the format of instruments, then moving to the factors or variables that instruments purport to measure.

Instrument Formats

Since the present inquiry is directed at the concept "attitude to science", and since this sort of inquiry involves an analysis of the language used in items of instruments, of the meaning that these words convey, and of the range of interpretations that can be placed upon responses to these items, the instruments selected for the study must be amenable to this type of analysis. Most attitude instruments are constructed with formats such as Likert and Thurstone scales and multiple choice questionnaires, and these are suited to the present analysis. Two formats, however, are not suited -- the semantic differential technique, and the varieties of projective techniques. The semantic differential technique developed by Osgood and adequately summanized by Osgood, Suci, and Tannenbaum's (1957) collection of revised papers, presents the respondent with a target word and a list of between ten and twenty bipolar adjectival pairs which are marked along the continuum to indicate how he or she feels about the target words. This technique has met some critical appraisal, of course. Mordkoff (1963) has suggested that the adjectives are not antonyms, and Messick (1957) finds that the scale intervals are not equal. More recently Geis (1968) has criticized the use of factor analysis for interpreting semantic differential data. These and other difficulties notwithstanding, the semantic differential technique is used widely in measuring various sorts of attitudes in science education.

Thirty semantic differential instruments were identified in the present study, and these are listed in Appendix A for two reasons. First, it seemed important that the availability of these instruments be made known to the research community. Second, and more germane to the present chapter, the list offers the reader a ready view of the extraordinary range of concepts used in those semantic differential instruments. Here we see, then, the large number of targets that are apparently thought in some way or other to reflect "attitude to science." The list in Appendix A includes, as concepts, topics in science courses (e.g. hormonal regulation), specific subject areas of science (e.g. astronomy, geology, biology), names of famous scientists (e.g. Pasteur), professional careers (e.g. scientist, businessman, physicist), different instructional activities (e.g. working on science problems, earth science experiments, dissection of the frog), some science and society topics (e.g. health, the use of atomic energy has greatly changed our society), some "scientific processes" (e.g. the willingness to accept new ideas, making inferences from observations), and some concepts related to science in the school (e.g. learning about science, science class, science teacher, textbook). As we see below, this rather large range of attitudinal targets is to be found in the other instruments identified, and it accentuates the difficulty of determining which instruments are relevant to the business of detecting attitudes to science, and which are not.

The second format of instruments which is not suited to the present research is the projective technique. In fact, this technique appears rarely used in science education evaluation. Weingarten's (1958) "Picture Interest Inventory" is out of print and, as an interest inventory, fails to qualify here for detailed analysis. Mitias' (1970) scale, consisting of the two items "I conceive science as . . ." and "I conceive a scientist as . . ." cannot be analyzed; and Perrodin's (1966) twenty-item sentence completion instrument is an interest inventory also. Lowery's (1966) scale employs several projective techniques and is included in the list of instruments finally selected for investigation. These instruments are listed in Appendix B. All remaining instrument formats were considered suitable to the task of analyzing approaches to the measurement of attitudes to science.

Factors, Variables, or Targets

The major task facing this investigation, once references had been identified, was determining which instruments ought to be included for careful study, on the basis of the relevance of what are variously called the factors, variables or targets they measured to the general notion of attitude to science. The instruments collected in the study were categorized as suggested by Figure 1, and they are described below according to these categories.

ATTITUDES TO SCIENCE

SCIENTIFIC ATTITUDES

Scientific Attitude
Scientific Processes
Scientific Curiosity

ATTITUDES TO SCIENCE CAREERS

Career Preferences
Occupational Interests

ATTITUDES TO SCIENCE INSTRUCTION

Teaching Science
Science Subjects and Subject Preferences
Science Interests and Activities
Attitudes to Science in School

ATTITUDES TO SPECIFIC SCIENCE ISSUES

Energy Research
Reclaimed Water

ATTITUDES TO SCIENCE ITSELF

Figure 1. Factors, Variables or Attitudinal Targets of Instruments Identified

Scientific Attitudes

The first distinction shown in Figure 1 is between attitudes to science and scientific attitudes, a distinction which was explored in the previous chapter. As suggested then, scientific attitudes are thought to represent those habits of mind generally associated with critical thinking and typically supposed to characterize the mental processes of a scientist at work. The scientist is thought to keep conclusions tentative, to weigh evidence carefully, to be uninfluenced by the biases of his colleagues and himself, and so forth. Items in instruments which measure scientific attitudes are clearly not seeking responses to questions of beliefs, feelings and likes, as science attitude items do. For instance, Kozlow and Nay (1976) list among the variables they measure: "objectivity, willingness to change opinions, open-mindedness, questioning attitude, etc." (p. 153). And Vitrogan's (1969) scale has items tapping the following dispositions: "A predisposition to discern the degree in which one person or thing differs from another; an ability to differentiate between controlled and reliable observation as opposed to casual observation" (p. 151). A less obvious category of the construct "scientific attitude" is found in the instruments that are designed to measure scientific curiosity. Campbell's (1968) instrument for example contains the following items:

Have you ever wondered:

What causes clouds to form?

Why the earth is round and not some other shape?

Why earthquakes occur?

7. I would like to do some experiments about one of those topics.

8. In any discussion about such topics I would have several pertinent questions to ask.

9. I have developed a keen interest in such topics.

In some respects, it could be argued, instruments measuring scientific curiosity are similar to inventories of science interests, which also are irrelevant to this study as shown below. Yet, since scientific curiosity seems at least somewhat connected to the scientific attitudes found measured in other instruments, the decision was taken to include them at this point. An interesting and novel approach to measurement in this area is Maddock's (1975) scale for assessing preferred ways of explaining natural phenomena.

References to instruments measuring scientific attitudes appear in Appendix C.

<u>Attitudes to Science Careers</u>

The next category of instruments are those which are designed to assess career preferences and occupational choices. Naturally enough, the standard "Strong-Campbell Vocational Interest Inventory" (1961) and the "California Occupational Interest Inventory" (Lee & Thorp, 1956) were identified among the five instruments used in research on attitudes, and discovered by this study's searches. Of these instruments, Boger's (1973)is somewhat ambiguous, for it also attempts to discover factors influencing career choices.

These instruments were excluded from detailed study for, while they are obviously tapping something about a respondent's attitude to science, the focus is on a very specific part of the general idea of science, namely a career in science. Given this focus, these instruments are not considered here as measuring attitudes to science in any general sense. References to instruments of this category are given in Appendix D.

Attitudes to Science Instruction

Seventy-seven of the instruments which do not employ projective techniques are designed to measure attitudes to science instruction, defined in a number of ways as shown below. Whether these instruments measure attitudes to teaching science, to specific subjects, to science activities (and interests) or to science courses, it is clear that their focus is on a very particular and focussed aspect of science in which the respondent is generally directed to think of science exclusively as a subject to be learned (in school or college) or to be taught. Undoubtedly, as we move toward understanding what sorts of instruments measure an attitude to science, in a broad sense of "science", it is helpful to see completely why instruments aimed at science instruction are considered irrelevant to this study. For this reason, each type of instrument considered to belong in this category is exemplified by examples of instruments and items in what follows. These examples are chosen quite arbitrarily, but they clearly illustrate the instrument's intent. They serve another function, too: they show how, even at this level of specificity, the target concept, such as a science course, is measured by summing the responses to items containing very different concepts -- a problem noted by Gardner (1975b) and mentioned in the previous chapter.

Attitudes to Teaching Science

Appendix E lists references to instruments which measure attitudes to teaching science. (It seems that these devices are frequently used to evaluate pre- service and inservice courses.) The following items are from Good's (1971) instrument. (Page numbers refer to the first page of each instrument.)

3. Science is something you do and a textbook has little place in the elementary school.

10. Children should be taught to behave like scientists if they are to learn science.

22. The elementary school science teacher should not suggest to a child that he has given a wrong answer as a result of working with equipment during a science experiment. (p. 261)

Lindstrom's (1974) scale asks respondents to answer the following sorts of questions on a five-point scale:

5. To what extent should students be taught the anatomy of various body parts?

24. To what extent should students be taught the roles of biotic and abiotic factors in the balance of nature? (p. 128)

Other scales contain similar items, for instance

1. As a teacher I am afraid that science demonstrations will not work.

12. I enjoy constructing simple experiments.

14. I would be interested in working in an experimental curriculum project. (Shrigley & Johnson, 1974, p. 439)

Attitudes to Science Subjects, and Subject Preferences

Given the interest in enrolment fluctuations which has been mentioned earlier, it is not surprising to find a large number of instruments measuring attitudes to specific science subjects (such as chemistry and physics) and devices for determining school subject preferences. Gardner's (1977) scale is an example of the former, and includes the following items:

4. Chemistry is just a dull grind for me.

10. I find learning about reaction rates most enjoyable. (p. 8)

Holden's (1973) "Attitudes Towards Physics" is a further example:

2. I am always under a terrible strain in physics classes.

8. I am interested in learning more about surface tension.

41. The reading material in this unit was a relief from other reading material used before in class. (p. 75)

Subject preference instruments usually require respondents to make choices among competing subjects. Prouse's (1964) scale is set out as follows:

Make a choice for a subject in each pair even though you may think you like each subject well.

1.	(A) English	(B) Physical Education
2.	(A) Science	(B) Social Studies
3.	(A) Mathematics	(B) Social Studies
4.	(A) Music	(B) Social Studies
5.	(A) English	(B) Science etc.

A different format is used by Stonecipher (1966). Here, respondents are asked to mark the scales for such subjects as English, Biology, 4th Year Math, Economics, Physics:

1. This subject should be taken by (all, most, some, few, very few) students.

2. This subject is (extremely difficult, difficult, moderately difficult, easy, extremely easy). (p. 73)

References to instruments of this type may be found in Appendix F.

Science Interests and Activities

The twenty instruments in this category, and listed in Appendix G, deal with the area of science interests and attitudes to science activities. As before, this way of construing attitudes to science is quite restrictive for, as the examples show, respondents are requested in the majority of cases to consider a science activity which is readily associated with science classes in schools. There are exceptions to this, Shrigley's (1968) "Science Attitude Inventory" being a possible example; yet even here, most items seem to steer the respondent to thinking of science as science classes in school. Evidence from the samples below again justifies the exclusion of this type of instrument from detailed analysis.

Foster's (1967) "Science Activity Inventory" asks respondents to indicate how often they have done the following things they wanted to do:

1. Volunteered to answer questions in class because I was interested in the topic.
6. Tried to find out about the problems of space travel.
17. Tried to find out about the structure of atoms and their size. (p. 67)

Meyer's (n.d.) "A Test of Interests" is more extensive. Topics in this instrument include:

Listening to the radio . . .

1. To stories and plays by famous authors.

2. To talks on science.

3. To talks on art.

Preferred ways of finding out about things, e.g. the name of a fossil . . .

33. Jim said he would try to find pictures of it in books.

34. Grace said she would rather ask her science teacher.

35. Don said he would go to the museum and compare the fossil with the ones on show there.

36. Jane said she would ask someone at the museum.

Learning things . . .

26. What science was like 100 years ago.

53. How the pattern of stars in the sky changes each month.

Talking together . . .

2. I do not like to be told the answer to a problem, I like to work it out for myself.

16. I enjoy experimenting with new things.

And, talking about science in school . . .

3. I usually enjoy the science lessons.

10. I usually lose interest in the science lessons.

(p. 1)

On the other hand, Norris' (1975) instrument is clearly directed at science in school:

6. I like to work by myself in science class (Yes/No)

11. I like to read science books.

15. I like to help the aide in science class. (p. 15)

while Shrigley's (1968) inventory measures both in-school and out-of-school interests and activities on a five point scale:

1. I like to watch the weather report on television.

9. The science equipment helped me to learn more easily.

14. The study of the sun, moon and earth was interesting.

27. I like to take science tests.

32. I love to handle science equipment. (p. 110)

Attitudes to Science in School

The final set of instruments placed in the general category of "Attitudes to Science Instruction" are the twenty-four instruments (in Appendix H) which measure attitudes to science courses and to science in school. That these are quite different from those attending to science interests and activities is readily apparent from the following sample items.

Ault's (1970) "Science Instruction Attitude Inventory" includes:

7. Science would be (unenjoyable 1 2 3 4 5 enjoyable) if the required mathematics was less difficult.

13. I frequently (get very bored 1 2 3 4 5 enjoy) studying science by conventional methods.

18. I find reading and studying materials dealing with natural phenomena (unenjoyable 1 2 3 4 5 enjoyable). (p. 117)

DeGroote (1972) asks:

3. Does your teacher give you work that is too hard?

22. Is science one of your favorite classes?

30. Do you like to come to school everyday? (p. 42)

Hedley's (1966) scale contains:

5. Much of the information given in my science textbook is out-of-date.

25. I spent too much time on learning trivial laboratory techniques which were not important to getting my experiments done.

61. I usually know what I am supposed to do in the laboratory. (p. 162)

Klopfer's (1974) "How I Feel" scale is designed for young children:

5. I would like to study more about science.

7. I cannot wait for science class to be over.

11. I really like my science teacher. (p. 245)

while the well-known instrument by Remmers (1960) is aimed at the secondary school level, and is designed for use in any subject.

2. I believe this subject is the basic one for all high school courses.

8. This subject has its drawbacks but I like it.

14. This subject seems to be a necessary evil. (p. 1)

The "Class Activities Questionnaire" (Steele, House, and Kerins, 1971) is also designed for any type of class. Students react to such items as the following, on a four-point scale:

4. Most class time is spent doing other things than listening.

10. Great emphasis is placed on memorizing.

24. Students do not enjoy the ideas studied in this class. (Obtained from the authors.)

Although it is not our business here to undertake a detailed study and evaluation of these types of instruments, we can make some general observations about those which measure attitudes to science instruction, however that concept is construed. Even a cursory look at the titles and descriptions of instruments listed in Appendices E, F, G, and H cannot help but reveal a considerable amount of duplication. (And, of course, we need to remember that these lists exclude the semantic differential and projective instruments listed in Appendices A and B.) Another notable feature of these instruments is the wide range of topics mentioned in the items of each instrument, which is evident from the samples provided above. As noted earlier, this range raises questions about the linearity of scales (are we correct in assuming that scores on various items can be summed?), and about the fidelity of an overall score.

Attitudes to Specific Science Issues

Probably as a consequence of the search strategies employed for this study, very few instruments measuring attitudes to specific science issues were identified. One of these (Hartman, 1972) is a semantic differential measuring attitudes to energy research, and is included in Appendix A. The other instrument, listed for the sake of completeness in Appendix I, deals with attitudes toward reuse of reclaimed water. This instrument (Bruvold, 1974) contains a substantial section on attitudes to science and is also included in the list of instruments selected for detailed study.

Attitudes to Science

The final category of instruments are those measuring attitudes to science itself, and are characterized by their conception of "attitudes to science" as being broader and more pervasive than the conceptions we have noted in the instruments discussed above. It is this category of instruments which is the target for the present investigation.

The Pool of Fifty-Six Relevant Instruments

Note has already been made of the difficulties encountered when attempts were made to obtain copies of the instruments identified for this study. In many cases, it was possible to categorize unavailable instruments from the information provided in reports of research in which the instruments were used. Sometimes, this was not possible. Also, in some instances, it was impossible to obtain instruments which were plainly relevant to this inquiry. References to these instruments are listed in Appendix J.

Fifty-six instruments survived the selection procedures described in this chapter, and became the pool of instruments destined for the detailed study which is the purpose of this research. These instruments are listed in Appendix K. It will be noted that some of these instruments do not appear immediately relevant, given the criteria we have established, and it is useful to justify their inclusion at this point.

Kimball's (1968) "Nature of Science Scale" is included because it contains a number of items which speak to issues relating to philosophical positions about the nature of theories and concepts in science. This particular portion of "beliefs about science" is of interest to the present study, for the investigator wished to see if in answering "attitude items" a respondent might also be committing himself to a philosophical position. Thus Kimball's instrument presents a very useful comparison when taken with other instruments.

Two scales ostensibly measuring attitudes to physics are included for detailed analysis, even though it seems that this should have been placed in the category of "Attitudes Toward Science Instruction" (Appendix F, to be precise). Gardner's (1972) "Physics Attitude Index" is included for two reasons. First, Gardner, we have seen is responsible for specific and useful reviews of the area of attitude measurement in science education (1975a, 1975b, 1975c). Second, portions of this scale have been incorporated by Fraser (1978) into his attitude instrument, the characteristics of which are better known from the information available in Gardner's instrument. The second attitude to physics instrument included is by Tamir, Arzi, and Zloto (1974). This device uses the words physics and physicist in a way that suggests they might be interchanged by science and scientist. Indeed, Hofstein et al. (1977) use the same scale with the words chemistry and chemist. The possible generalizability of this scale led to its inclusion for detailed study.

The fifty-six instruments in Appendix K need to be examined to determine how much confidence we can place in their use. The next chapter describes the generation of the system of clues used to analyze the instruments and their related research studies.

CHAPTER 4

DERIVATION OF ANALYTIC TECHNIQUES

Introduction

The previous chapter showed how fifty-six instruments were identified as measuring general attitudes to science. The remaining instruments, from the two hundred or so located in the literature, were seen to be measuring such things as scientific attitudes, attitudes to science teaching and activities, and occupational interests. The relatively straightforward distinctions employed in Chapter 3 provide one way of differentiating among the many available attitude instruments. But clearly the matter must go further. Other ways of making distinctions are needed for this research if it is to present a detailed study of instruments so that their usefulness to the field may be critically appraised and judged. Finding these distinctions is the task of the present chapter.

Making distinctions turns out to be a matter not lightly undertaken. Distinctions are viewed here as conceptual tools which must be grounded in recognizable and sound considerations, and which must be useful to making systematic choices. (In fact, it is unlikely that a poorly conceptualized distinction can ever give rise to systematic choices.) The distinctions which have to be developed for the present study must enable the reader to see plainly how instruments differ, how questions about validity can be raised, and how the nature of items themselves relate or do not relate to the instrument's intention of measuring attitudes to science.

It is not unreasonable to suppose that a useful starting point for developing distinctions might lie in the body of work which has come to be known as attitude theory. The first section of this chapter reviews some of the distinctions in this area and shows why there is little that can be used here. Definitions of attitude turn out to be very varied, to the extent that it is impossible to find a set of distinctions which could be used productively to distinguish one type of attitude item on an instrument from another. Since a major part of the present inquiry is directed at asking what items can in fact be measuring (their construct validity), it becomes necessary to turn to other sources for appropriate distinctions. The first section, then, simply presents an account of the variety of conceptions of attitude which may be found, and points to the beginning of some useful distinctions.

The second section shows that more powerful distinctions can be made from those which exist already in the area of analytical philosophy. Here, then, a set of distinctions or clues are developed which permit one to detect considerable differences among the variety of items to which youngsters respond. This clue structure is developed in two parts, the first dealing with statement types, and the second dealing with positions about the nature of science. The section contains examples of how this derived clue structure can be applied, and provides evidence of the degree to which different users agree when the clue structure is applied. This "interobserver agreement" provides an estimation of the reliability of this first and major portion of the clue structure.

The second portion of the clue structure comes from relatively non-technical aspects of psychometrics. Presumably, users of attitude measures are interested in the standard psychometric characteristics of these devices, and in the details of flaws in test construction. This portion of the clue structure is developed in the third section of the chapter.

The final section of the chapter describes the format in which the analysis of each instrument is presented and becomes, in effect, a guide to the detailed analyses which appear for each instrument in Appendix L.

Definitions from Attitude Theory

The literature on attitude theory and measurement is considerably complicated by the diversity of ideas about what an attitude is. Many definitions of attitude attempt to distinguish the concept from others which at first glance appear to be related in some way or other. Concepts like value, belief, affect, and emotion are themselves unclear yet have to be conceptually differentiated from the concept attitude if the latter is to be a usable concept in social science. Because of the complications involved in making the concept attitude distinctive, it is difficult to see how one might use attitude theory as a source of clues for distinguishing among and thus judging a variety of attitude measures. Nevertheless, we can see how the beginning of a clue structure emerges from what appears to be a continuum of definitions of attitude extending from the position that attitudes are purely cognitive to the view that attitudes are multidimensional and have cognitive, affective, and behavioral components.

A useful starting point to explicating the concept of attitude is to consider that an attitude represents some evaluation of a subject or object, and that this evaluation can run the range from positive or negative (Bern, 1970). There can be no neutral position for this would imply that the subject or object has no meaning. The sort of evaluation which leads to the construction of an attitude is generally distinguished from such ideas as opinions and beliefs by the argument that attitudes are more enduring than opinions or beliefs (Audi, 1972; Krech, Crutchfield, and Ballachey, 1962; Rokeach, 1970). Opinions and beliefs are said to demand less emotional commitment than attitudes and are therefore more open to re-evaluation.

Attitudes are thought of as either learned or implicit, (Chein, 1948; Doob, 1940; Shaw and Wright, 1967; Fishbein, 1967) which supports the idea that, while somewhat enduring, attitudes can be changed. This feature provides for some further differentiation between opinions and attitudes.

"Opinions are conscious and verbalizable while attitudes may be mediated by nonverbal processes or are unconscious" (Shaw and Wright, 1967, p. 5). The last common characteristic among the many definitions of attitudes is that attitudes are interrelated or organized. They are value complexes.

Other characteristics of an attitude appear less generally accepted, and at this point we may begin to construct a continuum of definitions, containing three definable positions: a unidimensional and a multidimensional view, and a third position which distinguishes between using the multidimensional view to measure attitudes directly and using it to measure them indirectly.

The unidimensional view supported by Fishbein (1967) in his early writing and Bern (1970) among others is that attitudes are essentially cognitive, there being no useful distinction to make between affect and cognition. So, possessing a positive attitude toward art would simply involve having sufficient knowledge of art so that it is appreciated. Here, it appears that attitudes converge with understanding.

The multimensional view of attitude consists of three dimensions: cognitive, emotional, and behavioral (conative). The cognitive dimension is derived from the idea that attitudes are evaluative; that is, to make an evaluation one must hold some knowledge of the subject or object, however minimal that knowledge might be. The emotional dimension incorporates both the instant liking or disliking of an attitude object and the judgment one forms of the object, where judgments are seen as decisions made out of imperfect knowledge about the object. The behavioral or conative dimension is to represent a person's predisposition to respond to an object in a certain way. The three dimensions comprising the multidimensional view of attitude appear to be supported by a substantial number of attitude theorists (Audi, 1972; Katz and Stotland, 1959; Krech et al., 1962; Osgood, Suci, and Tannenbaum, 1967; Rokeach, 1970).

There seem to be two distinct methods of measuring the multidimensional view of attitude, the direct and indirect or implied. The direct measurement of attitudes involves tapping the knowledge of persons about the object, their emotional feelings about it, and observing their behavior when presented with the object or what responses they give to a written instrument asking direct questions about the object. Attitude theorists subscribing to this way of measuring attitudes are Katz and Stotland (1959), Newcomb, Turner, and Converse (1964), Osgood, Suci, and Tannenbaum (1967), Rokeach (1970), and Rosenberg (1960).

The indirect or implicit method of measuring attitudes involves conceptualizing the prerequisities to having that attitude and measuring them. Rather than measuring the attitude of a person to dogs, for example, the prerequisites to liking dogs would be measured. These might be a liking for animals in general, a lack of fear of dogs, some past and positive experiences with dogs. From this kind of information the person's attitude to dogs could be inferred.

Audi (1972), Chein (1948), Doob (1940), Krech et al. (1962), Newcomb, Turner, and Converse (1964), and Shaw and Wright (1967) are among theorists subscribing to this view.

This brief review of the range of definitions of attitudes is helpful to devising a suitable clue structure in that it provides us with the basic continuum along which definitions are spread, between an entirely cognitive, unidimensional view, and a multidimensional view. This distinction is limited, though, for it does not provide us with the sort of tool that could usefully help us systematically distinguish among the very different sorts of items which appear in the attitude instruments under study. As the next section demonstrates, and as we have seen in the previous chapter, a variety of very different demands are occasioned by the types of attitude items which appear in instruments, and a surer footing is needed for identifying the differences and what they might mean.

Development of Clue Structure from Conceptual Analysis Distinctions of Statement Types

Something of the problem encountered by anyone interested in the conceptual validity of instruments measuring attitudes to science can be discerned by looking at some sample items. The following four items appear in the "Attitudes toward Science and Scientists" scale by Cummings (1970), which appears in full in Appendix L.

1. The majority of scientists are irreligious.
16. Scientific work is boring.

29. Government favoritism toward extraordinary scientific talent is undemocratic.

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

Responses (on a five-point scale) to items such as these are intended to provide one with a measure of attitude to science, and there is no doubt that the items themselves speak generally to science-like topics. Yet a closer examination reveals that the items are very different in the sort of response demanded. That is, the character of the items differs so that one might expect the respondent to have to employ rather different mental resources to answer them. For instance, while item 16 calls for an emotional sort of reaction, item 1 seems to ask for some judgment about the truth of a claim about states of affairs. Similarly, item 37 calls for a judgment about preferred activities, while item 29 presents a statement which is true by definition and which leaves one wondering if it is testing an understanding of the term "undemocratic". Since these interpretations of the intent and meaning of the above items bear directly on the matter of construct validity, it seems useful to try to find a systematic clue structure for noting these differences. Such a clue structure is available in some basic distinctions among statement types in analytical philosophy and it is to this source that we turn for the first portion of the needed clue structure.

It is important to note first that there are precedents for the use of clue structures drawn from analytical philosophy in this kind of work. Roberts and Russell (1975) describe five studies in which clue structures are developed from philosophical considerations and then applied to educational phenomena in order to bring a new perspective to them. Further work in this genre of research is available in Munby, Orpwood, and Russell (in preparation). Here the general approach to developing philosophical tools for the systematic analysis of educational phenomena is developed fully in ten separate studies. Of course, a theoretical perspective for examining any sort of phenomena is just that: a theoretical perspective. There is no thought that the perspective represents the exclusive way to examine the phenomena in question. As a tool, though, the theoretical perspective or clue structure must be systematically derived, comprehensible to others, and useful in its application: it must enable us to see what we had not noticed beforehand.

The primary source for the present clue structure is Wilson's (1967) categorization of statement types. Here, Wilson categorizes statements as follows

a. Imperative and Attitude statements: For Wilson these statements give commands and express personal wishes, hopes, desires and fears. "I hate science" would qualify as an attitude statement in this light.

b. Empirical statements: Empirical statements give information about the world, and are true or false depending on their correspondence with the world. "The majority of scientists are irreligious" qualifies as an empirical statement.

c. Analytical statements: These are similar to definitions and show how the meanings of words are related; they do not depend for their truth upon observations of the way the world is.

d. Value statements: Value statements invoke a principle of judgment and evaluate or prescribe "Science should be studied by all" is a value statement on this scheme.

e. Metaphysical statements. This final category of statements is for those whose truth cannot be determined because we are unsure of how we should go about determining their truth. "God is love" is a metaphysical statement.

This categorization can be adapted to suit our purposes by making one deletion, and by amalgamating two of the categories. It can be expected that very few if any items in an attitude instrument will be metaphysical statements and so this category is deleted. (This decision is upheld by the analysis of instruments in Appendix L, which revealed no metaphysical statements among the fifty-six instruments examined.) Next, we can discern a similarity between Wilson's categories and the continuum of attitude definitions which allows us to combine the empirical and analytic statements into a single category. Both statement types can be thought of as cognitive. In this way, the preliminary clue structure for distinguishing items of attitude instruments contains three initial categories, as shown in Figure 2.

At this stage, then, the clue structure allows us to make useful comments about what any given attitude item is asking. If the item is an analytic or empirical statement, such as "scientific explanations can only be made by scientists," then it is categorized as cognitive, with the recognition that the statement is possibly tapping the respondents' knowledge of matters related to science. Alternatively, if the statement is commending, "Scientists should not criticize each other's work," then it is categorized as a value statement calling for some judgment about what should be the case. Lastly, an item might be calling for an expression of personal likes or dislikes, such as "Science is fun" and "I would like to work in a scientific field"; then the statement is categorized as an attitude statement.

A preliminary examination of a small number of attitude instruments showed that some items could not be placed in any of these categories simply because the items belonged quite clearly in the category of scientific attitudes, rather than attitudes to science -- a distinction which has been discussed beforehand. Given the possibility that other instruments in the collection might contain such items, it was decided to enlarge the clue structure to accommodate these items thus allowing the reader to see better the construct validity of any particular instrument. Items

Attitudes to Science

A. Cognitive (Analytic and empirical)

B. Value (Judgment, commending, should, better)

C. Attitude (Emotional response, personal likes)

Figure 2. Preliminary Version of the Analytic Clue Structure

measuring scientific attitudes do so in three quite distinct ways, giving rise to three more categories in the clue structure. The first two ways seem to test the possession of scientific attitudes, while the third way calls for a self-report.

The first category of items measuring scientific attitudes directly tests for those intellectual skills associated with science by posing questions of logic. An example is:

> "The class discovered that magnets will attract objects made of iron or steel. A magnet will pick up Betty's hair clip.
> Conclusion: The clip must be made of iron or steel."

The second category consists of items which determine the respondents disposition to reason "scientifically" or objectively. The following are examples:

> "I would view with suspicion any findings reported by a scientist of another country."
>
> "If a famous scientist and an unknown scientist disagree, we should accept the view of the famous scientist."

The third category in this portion of the clue structure classifies items which appear to ask the respondent to make a self-report on his or her scientific attitudes. Examples are:

> "Logical thinking plays a large part in my life."

"I don't have the intelligence for a successful scientific career."

When these categories are added to the clue structure, it is expanded to six categories, as shown in Figure 3.

In this form, the clue structure offers some immediate usefulness to the reader. For instance, we can judge whether an attitude scale constructed as a five-point Likert scale possesses the characteristics which Likert wished this type of instrument to exhibit. Likert argues that it is essential that all statements be expressions of desired behavior and not of fact (Likert, 1967). Using the language of the clue structure, we would expect items of a Likert scale to be value items, and not cognitive items. To take an example, twenty-nine of the sixty items comprising Brown's (1975) "Attitude to Science Scale" are cognitive items, and only ten items are value items. Probings of this sort are possible with the clue structure developed here.

(It is worth noting that while the clue structure itself contains the word attitude as one of its categories, this is not to imply that items classified as cognitive or value are not useful for measuring attitudes. The word attitude in the clue structure simply conforms to Wilson's terminology.)

Attitudes to Science

A. Cognitive (Analytic and empirical)

B. Value (Judgment, commending, should, better)

C. Attitude (Emotional response, personal likes)

Scientific Attitudes

D. Test of Possession -- Intellectual Skills

E. Test of Possession -- Dispositions

F. Self-Report Dispositions

Figure 3. Second Version of the Analytic Clue Structure

Distinctions from Philosophy of Science

Earlier work by this writer has suggested some interesting possibilities for exploring further the conceptual validity of attitude instruments. Munby (1973) derived a clue structure from considerations in the philosophy of science which, when applied to science teaching, showed quite plainly that quite different views of the nature of science are conveyed in teaching discourse. Later work (Munby, 1976) suggests that similar messages about science are implicit in textbooks. An examination of the "Scientific Attitude Inventory" (Moore and Sutman, 1970) revealed that these distinctive views of science can be found, implicitly or explicitly, in some of the items. The significant outgrowth of this finding, so far as construct validity goes, is the suggestion that some items in science attitude measures might not be measuring attitudes to science, but rather are assessing the respondents' philosophical views of the nature of science which, by definition, is not attitudinal but largely cognitive, since it is based upon knowledge and understanding of science. Additionally, of course, if an attitude item contains an implicit view of science, there is always the possibility that in responding to the attitude item one is bound to commit himself to this view of science. For these reasons it was decided that the present clue structure be enlarged by adding the writer's previous clue structure for detecting views of science.

Two views of science are detected using this clue structure, which appears in Figure 4. These views of science which were originally derived from the work of Nagel (1961) and others are Realism and Instrumentalism. For Realism, scientific theories and explanations are taken to be true descriptions of the world, and scientific constructs are thought to have an ontological status similar to that of common-sense objects of perception. For Instrumentalism, though, scientific theories and explanations are instruments for ordering perceptions, and scientific constructs are postulated entities. The clue structure for detecting these views is derived from these two positions to give the statements appearing in Figure 4, which is adapted from Munby (1974).

The present clue structure for analyzing attitude instruments incorporates the view of science clues by the inclusion of categories for the two views of science and for whether these views are implicit or explicit. The result of this union appears in Figure 5. Some examples of items containing explicit or implicit views of science show again some of the complexities involved in establishing the construct validity of scales to measure attitudes to science. Consider item 22 of the "Scientific Attitude Inventory":

> "Scientists discover laws which tell us exactly what is going on in nature."

REALIST:

a. Theories are stated as if they have the same logical status as observation statements.

b. "Scientific objects" (postulated entities) are talked about as if they have the same ontological status as common-sense objects of perception. They have a physical reality.

c. Science presented as the only acceptable way of describing or explaining the world or phenomena.

d. Science spoken of as superior to alternative explanatory modes.

e. Past theories are presented as false.

f. Lapsed "scientific objects" given as inaccurate accounts of reality.

g. The potential of science for explaining or describing is given as unlimited.

h. That a model, law, theory, or convention is being used is not signalled to pupils.

i. A model, law, theory, or convention is invoked as description of phenomena.

INSTRUMENTALIST:

a. Theoretical and explanatory statements are stated as if they have a logical status different from that of observation statements.

b. "Scientific objects" presented as having a different ontological status from common-sense objects of perception. They are postulated entities.

c. Science presented as one way of explaining the world or phenomena.

d. Science spoken of as in competition with alternative explanatory modes.

e. Past theories presented as inadequate.

f. Lapsed "scientific objects" given as inadequate explanatory devices.

g. The potential of science for explaining and describing is given as limited.

h. That a model, law, theory, or convention is being used is signalled to pupils.

i. A model, law, theory, or convention is invoked as an explanation of phenomena.

Figure 4. Munby System for Detecting Views of Science

Attitudes to Science

A. Cognitive (Analytic and empirical)

B. Value (Judgment, commending, should, better)

C. Attitude (Emotional response, personal likes)

Scientific Attitudes

D. Test of Possession -- Intellectual Skills

E. Test of Possession -- Dispositions

F. Self-Report -- Dispositions

View of Science

G. Explicit -- Instrumentalist

H. Explicit -- Realist

I. Implicit -- Instrumentalist

J. Implicit -- Realist

Figure 5. Clue Structure for Analyzing Item Meanings

On the face of it, this item is a cognitive item asking whether or not the respondent thinks that scientists discover laws of a certain type. The item, though, can be seen quite readily to be saying something important about the type of law which a scientist may discover. The statement clearly conveys the Realist view, implicitly then, that the laws are true statements about the world, and not conceptual conveniences subject to change and limitations. The item "Statements are not accepted as scientific knowledge unless they are absolutely true" is also a Realist item, but in this case the view of science is being put forward explicitly, and the item is directly tapping it.

Similarly, the view of science in the following item is put forward explicitly, though in this case it is Instrumentalist. "The scientist knows that ideas will change if new facts are found." The message here is that ideas are not more than ways of conceptualizing facts. The item "Construct a theory before you try to solve a problem" conveys a major thought about how to proceed in science; yet implicit in this item is the view that theories are constructed, so the view of science implicit here is Instrumentalism.

Estimating the Reliability of the Clue Structure

As we have already noted, a clue structure must not only be thoroughly grounded but it must also be usable in a way that yields similar results when applied by different people. In a sense, this criterion is not unlike the psychometric notion of reliability and it will be referred to in this way. Strictly, though, this criterion speaks more to the objectivity of the device or the inter-user agreement when it is used. The reliability of part of the clue structure is already known with some confidence. Munby and Wilson (1978) used the Munby System in a convergent and discriminant validity study and obtained a correlation of .97 when forty-seven science lessons were analyzed by two independent coders.

Estimating the reliability of the remainder of the clue structure proved to present something of a problem, for a number of reasons. As a consequence, reliability information while available is sparse, and undeniably restricts the confidence one might otherwise have in the use of the clues. During the construction of the clue structure, and the trials at making the clues (and their instructions for use) suitable to the task, a small number of informal attempts at obtaining an interobserver agreement were undertaken. At one point, an agreement of 93 percent was obtained between two coders for the sixty items of the Moore and Sutman "Scientific Attitude Inventory" (1970). Following this, it was only possible to conduct reliability estimates on two instruments, Myer's (1967) and Redford's (1974). These estimates were from coding by the present writer and a graduate student who had not been trained in the use of the clue structure to any extent, so the results (73 per cent and 76 per cent respectively) probably represent a conservative estimate of the clue structure's reliability.

The classifications of the items in the Meyers and Redford instruments are presented in Tables 1 and 2 with the judgments "a", "b", "c" representing the categories Cognitive, Value, and Attitude respectively, with one item of the Myers' instrument classified as "d".

An effort was made to estimate the statistical significance of these percentage agreements using chi square as a test of independence of the two judges. It happens that none of the items of the Redford instrument were classified as measuring scientific attitudes, and only one of the Myers' items fell in this category. So it seemed unreasonable and unwise to construct contingency tables to accommodate more than the three categories, Cognitive, Value, and Attitude. The addition of cells for the scientific attitude categories would have led to an excessive number of cells with expected frequencies less than 5 which violates the conditions of the chi square test. (The scientific attitude item is coded "a" to maximize disagreement.) Of course, the decision to restrict the number of cells in the contingency tables to half the number that could have been used gives a very conservative estimation of the statistical significance. Contingency tables for the data in Tables 1 and 2 appear in Table 3. Both of these tables contain a large number of cells in which the expected frequency (fe) is less than 5. Ferguson (1971) suggests that the expected frequencies can be as low as 2 (when degrees of freedom exceed 2) to permit an "estimation of roughly approximate

Table 1. Coding of the Myers Instrument by Two Judges[2]

	Coding			Coding	
	Judge 1	Judge 2		Judge 1	Judge 2
Item			Item		
1	a[1]	a	23	a	b
2	a	a	24	a	a
3	a	a	25	a	a
4	b	a	26	a	a
5	b	c	27	b	a
6	b	a	28	a	a
7	a	a	29	a	a
8	b	a	30	a	a
9	a	a	31	a	a
10	b	a	32	a	a
11	b	a	33	a	a
12	a	a	34	c	f
13	a	a	35	a	a
14	b	a	36	a	a
15	a	a	37	a	a
16	b	a	38	b	a
17	c	c	39	a	a
18	b	b	40	a	a
19	a	a	41	a	a
20	a	a	42	b	b
21	a	a	43	a	a
22	b	b	44	a	a

[1]"a" Cognitive item
"b" Value item
"c" Attitude item
"f" Self-Report -- Dispositions

[2]Percentage agreement - 73%

Table 2. Coding of the Redford Instrument by Two Judges[2]

Item	Coding Judge 1	Judge 2	Item	Coding Judge 1	Judge 2
1	b[1]	b	22	b	b
2	b	b	23	c	c
3	c	c	24	c	c
4	b	b	25	c	b
5	a	a	26	a	a
6	a	b	27	b	a
7	a	a	28	a	a
8	a	b	29	b	b
9	a	a	30	a	a
10	b	a	31	a	a
11	a	a	32	c	c
12	a	b	33	a	a
13	a	b	34	a	a
14	a	a	35	c	c
15	a	a	36	b	b
16	a	a	37	c	c
17	b	b	38	b	a
18	b	b	39	a	a
19	a	a	40	c	b
20	b	b	41	a	a
21	b	b	42	a	b

[1]"a" Cognitive item
"b" Value item
"c" Attitude item

[2]Percentage agreement - 76%

Table 3. Contingency Tables for Myers and Redford Coding

Myers

		Judge 2 a	Judge 2 b	Judge 2 c	
Judge 1	a	(25)[1] 28	(2.6) 1	(1.3) 0	29
	b	(11.2) 9	(1.2) 3	(.6) 1	13
	c	(1.7) 1	(.2) 0	(.1) 1	2
		38	4	2	44

Redford

		Judge 2 a	Judge 2 b	Judge 2 c	
Judge 1	a	(9.5) 16	(8.5) 5	(3) 0	21
	b	(5.9) 3	(5.3) 10	(1.9) 0	13
	c	(3.6) 0	(3.2) 2	(1.1) 6	8
		19	17	6	42

[1]Expected frequencies appear in parentheses

probabilities" (189). Popham and Sirotnik (1973) caution that no more than twenty per cent of cells have expected frequencies less than 5.0 (p. 287). Both the tables in Table 3 exceed these guidelines considerably. Guilford (1975, p. 241) advises that rows or columns of a table may be combined, though this produces a meaningless contingency table if cells represent agreements and disagreements. In this case, both contingency tables may be combined, giving the configuration in Table 4. Here only one cell has an expected frequency less than 2, although more than twenty per cent have expected frequencies less than 5. Given these difficulties, chi square is estimated only.

In Table 4, chi square is 65.78, where for df=4, a value of 18.46 is significant at the .001 level. Given the low values of expected frequencies, especially for cell cc, we can safely estimate chi square by substracting the contribution that rows or columns containing cc make to chi square. The results of these subtractions (65.78-44.82= 20.96, and 65.78-45.52= 20.26) both exceed the value of chi square significant at the .001 level. Accordingly, we have a very compelling estimate that the chi square is highly significant. That is, the agreements between the judges are estimated to be statistically significant beyond the .001 level.

As we have noted above, this single determination of the clue structure's reliability represents a limitation of the present study. Nevertheless, the reliability determined here is a conservative one. The reader may judge for himself

Table 4 ... Table and Chi Square for Combined Co...

Conti...

Judge 2

	a	b	c	
a	(33.1) 44	(12.2) 6	(4.7) 0	50
b	(17.2) 12	(6.3) 13	(2.4) 1	26
c	(6.6) 1	(2.4) 2	(.93) 7	10
	57	21	8	86

$\frac{(fo-fe)^2}{fe}$

Judge 2

	a	b	c	
a	3.59	3.15	4.7	11.44
b	1.57	7.13	.82	9.52
c	4.75	.07	40.0	44.82
	9.91	10.35	45.52	

Chi Square= 65.78

the reliability of the use of the clue structure by examining the analysis of items presented in full for each instrument in Appendix L.

The Psychometric Portion of the Clue Structure

This last portion of the clue structure is designed to enable one to assess something of the psychometric characteristics of the attitude instruments collected for study. Here, though, the clue structure differs from the previous sort in which it was used to categorize items, for the object is to be able to report psychometric characteristics which can be done without making inferences. Accordingly, the clue structure is less formal here. It is developed in three parts: Validity and Scale Construction, Reliability, Item Characteristics.

Validity and Scale Construction

Much of the previous portion of the clue structure was aimed at the conceptual validity or construct validity of the items comprising a given attitude scale. This is seen as distinct from ways in which validity might be determined experimentally. Accordingly, the point of this part is to allow the reader to note if there was an experimental determination of validity, how this was performed and with what results. Here, then, we might expect to find details of a factor analytic or convergent and discriminant validity determination. Frequently, validity determination is a component of scale construction, such as when likely items are found to be useful by a pool of expert judges. This is particularly true for Likert and Thurstone scales, and when these are used, it is important that we can be assured that the scales are constructed in a manner which conforms to generally accepted techniques. These are outlined below.

Likert (1967) lists the following characteristics of a Likert scale:

1. It is essential that all statements be expressions of desired behavior and not of fact.
2. Each statement must be clear, concise, straightforward and in simplest vocabulary. No double negatives nor double-barreled statements are used.
3. Statements should be worded so that the modal reaction to some is more toward one end of the attitude continuum, to others more in the middle or other end.
4. Half the statements should have the continuum left to right, the remainder being reversed.
5. Initial statements should be tried on a group similar to the one whose attitudes are to be measured.
6. A sufficient number of statements should be used in each form of the scale to obtain the desired reliability. (pp. 90-95)

It is not clear what this optimal number might be. Edwards and Kenney (1967) suggest between 20 to 25 items, noting that the Likert scale introduces more variability than does the Thurstone scale, and is thus potentially more reliable.

Thurstone (1967) offers the following guidance for the construction of the Thurstone scale:

1. Several groups write opinions on the issue in question yielding between 100 and 150 statements, representing all possible gradations. Statements should be as brief as possible and phrased so that they can be rejected or endorsed. Between 80 and 100 statements should survive initial editing.
2. Statements are placed on cards and submitted to two or three hundred subjects who arrange them in eleven evenly spaced piles. Ogives are prepared.
3. Statements with high ambiguity (defined as the standard deviation of the best fitting curve through the observed proportions) are removed. (pp. 77-89).

While Thurstone offers no guidance for the optimum number of items, Edwards and Kenney (1967) suggest the same number as for Likert scales.

Of course, there are several other types of scales. Sax (1974) gives the following guidelines for constructing multiple-choice items.

1. The stem should delimit the task and make clear the purpose of the item.
2. Options should have similar length.
3. Items should have suitable vocabulary.
4. Stems and options should be stated positively.
5. Options should be plausible.
6. There should be a defensible correct or best option.
7. Items measuring opinions (presumably in cognitive tests), should be avoided.

8. The placement of correct option should be varied.
9. Overlapping alternatives should be avoided.
10. Use "none of the above" only if there is an absolutely right answer.
11. Avoid "all of the above".
12. Stem must be grammatically correct and contain elements common to each option.

And the following are provided for tests containing matching items (Sax, 1974):

1. Use homogeneous options and items.
2. Have more options than items.
3. Arrange options and items alphabetically or numerically.
4. Limit the number of items within each set.
5. Place the shorter responses in column B.
6. Provide complete directions.
7. Place options on the same page.
8. Avoid specific determiners.

A similar set of guidelines may be found in Thorndike (1971).

Reliability

The information we might seek on the reliability of an instrument extends further than the value of the reliability to include how the reliability was determined (split-half, parallel form, test/retest). But, there is little information about optimum values of reliability. Edwards and Kenney (1967) suggest that the reliability of a Likert scale might lie between .8 and .9, and none of what might be considered as standard sources on measurement (Cronbach, 1960; Edwards, 1957; Oppenheim, 1966) suggest an optimum range, so this portion of the clue structure simply requires that the value of the reliability is reported.

Additional Item Characteristics

There are some general characteristics of items that are thought best avoided in psychological testing, and this part of the clue structure is designed to give a place for mentioning these:

1. Trick questions.
2. Confusing formats, often using double negatives.
3. Excessively difficult items.
4. Grammatically incorrect items.
5. Items containing spelling errors.
6. Ambiguous or double-barreled items.

These sorts of flaws in design allow further judgment to be made about the usefulness of an attitude instrument.

Format of Analysis

So far, this chapter has described the clue structure used to describe and analyze the instruments listed in Appendix K. The intention of this section is to provide the reader with a description of the format used in reporting the analysis of each instrument as it appears in Appendix L. It will be seen that while there is a very close relationship between the clue structure and the reported analysis, the order of the latter is altered for convenience. Figure 6 identifies the sections and subsections of the analysis, and

AUTHOR'S NAME

TITLE OF INSTRUMENT

Principle reference to instrument

Instrument Characteristics

Format:

Population:

View of Attitude:

Subscales:

Validity:

Reliability:

Analysis

Cognitive item:

Value items:

Attitude items:

Test of possession -- Intellectual Skills:

Test of possession -- Dispositions:

Self-Report -- Dispositions:

View of Science:

Additional Characteristics:

Research Studies

Commentary

Items of the Instrument

Figure 6. Format of Instrument Analysis

is described in order below.

The analysis of each instrument opens with the author's name, the title of the instrument, and the principle reference to it. Wherever possible, all references to dissertations have the Dissertation Abstracts International (DAI) volume and page number included. Numbers are provided for documents appearing in the ERIC collection. Efforts were made to cite the more accessible references for the reader's convenience.

The section on "Instrument Characteristics" reports in order, the format of the instrument (Likert, Thurstone, multiple choice, etc.), the intended population, the view of attitude (if it is stated, cited or if it can be inferred), the subscales if they are given by the author, the validity (including details of scale construction when given), and the reliability and its determination.

The section called "Analysis" refers to the inferences made on the basis of the first portion of the clue structure, mostly. The actual item numbers of items identified by the categories are listed, with the totals provided in parentheses. In some cases, item numbers appear with a ".1" or ".2" after them. This is to draw attention to ambiguous (double-barreled) items in which part of the stem is classified one way, and part the other. For example, the item "Public understanding of science is necessary because scientific research requires financial support through the government," is ambiguous. The first part

"Public understanding of science is necessary" is a value statement because of its prescriptive nature, and could be identified as 12.1 (if the item was number 12) in value items. The second part "Scientific research requires financial support through the government" is an empirical statement, so 12.2 would appear in Cognitive items.

View of science also appears under "Analysis" and reflects the clue structure precisely. The subsection "Additional Characteristics" provides a place to record those items having some of the characteristics generally recognized as undesirable.

The section "Research Studies" gives the full references of each research study identified in which the attitude instrument in question was used. An abstract is also provided which focuses on those parts of the study germane to the attitude instrument; other parts of the study are not abstracted.

The present writer's overall judgment of the usefulness of the instrument appears in "Commentary", which is followed by the text of the complete instrument. (Where the format of the response is clear from the type of instrument, response formats have been omitted.)

The reader can see that Appendix L provides very detailed and public information on each of the instruments identified for intensive study, and this appendix will be of use to readers wishing detailed information about selected instruments. Summary information concerning all the instruments may be of value also, and this is presented in the following chapter.

CHAPTER 5

RESULTS OF INSTRUMENT ANALYSIS

The clue structure developed in the previous chapter can be used in two very different ways. First, it can be used as a perspective for surveying the complete collection of instruments which are intended to measure attitudes to science. Second, the clue structure can be used to provide a detailed account of each instrument separately. As has been noted, Appendix L consists of this detailed account of each instrument, and the reader has already been directed to this source. But the arrangement of Appendix L makes comparisons among instruments awkward and a summary of the state of the art impossible. The point of this chapter, then, is to provide a synthesis of what can be detected when the clue structure is brought to bear on the 56 attitude instruments selected as relevant to the measurement of attitudes to science. The organization of this chapter reflects that of the clue structure itself: we start with some general characteristics, move on to consider reliability and validity, and then look at the types of statements found in each instrument's items. The chapter continues with some specific considerations stemming from the use of the clue structure, and closes with an overview of instruments which appear to meet some minimal criteria of acceptability.

General Features of the Attitude Instruments

Table 5 provides information for each of the 56 instruments which might be useful for selecting an instrument on the basis of format, population, and length. In addition, the number of studies identified in which each instrument is used is given so that we have some measure of the degree to which we can expect to know something about the way it performs in different experimental settings. Some explanation of the table is necessary.

The format used is reported in full except in the cases of True/False (T/F), which includes Agree/Disagree, and multiple-choice (M/C). The "National Assessment of Educational Progress" (#40) uses a variety of different formats. The age-range of the population is noted as Elementary (E), Secondary (S), College (C), and Adult (A), the final category including teachers. Length of each instrument refers to the number of items which, in the case of the "National Assessment of Educational Progress" (#40) is not specified since only a portion of this large instrument is directed at attitude measurement. Lastly, the number of research studies is listed under frequency.

Two points from the array of information in Table 5 seem particularly striking. First, 38 of the instruments employ a Likert format. The popularity of this format may well be the consequence of the apparent ease with which such instruments are constructed. On the face of it, the format appears simply to require the generation of statements placed above,

Table 5. General Features of the Selected Attitude Instruments

		Scale Format	Population	Length	Frequency of Use
1.	Allen	Likert	S	95	8
2.	Allison	Likert	E	95	3
3.	American Institute of Physics	Likert	S	18	1
4.	Arntson	Likert	C	40	1
5.	Baldwin & Boedeker	T/F	C	5	1
6.	Bauman	Likert	S	40	1
7.	Belt	Likert & M/C	S	60	1
8.	Berkland	Likert	C	20	1
9.	Billeh & Zakhariades	Thurstone	S,C,A	36	1
10.	Bixler	Likert	A	14	1
11.	Brown S.A.	Likert	E	60	3
12.	Brown S.B.	Likert	E	20	3
13.	Bruvold	Open & Guttman	A	2	1
14.	Bulletin of Atomic Scientists	Open & Guttman	C	4	1
15.	Clark B.M.	Likert	E	5	1
16.	Clark W.A.	Likert	A	28	1
17.	Cummings	Likert	C	67	3
18.	Dutton & Stephens	Thurstone	C	20	5
19.	Eggleston	Likert	S	68	1
20.	Estes	Likert	E,S	15	1
21.	Fancher & Gutkin	T/F, M/C	C	56	1
22.	Feerst	Likert	E	23	1
23.	Fellers	Likert	C	55	1

		Scale Format	Popu-lation	Length	Frequenc of Use
24.	Fisher	Likert	S	20	1
25.	Fraser	Likert	E,S	70	2
26.	Gardner	Likert	S	40	6
27.	Hackett	Likert	E	42	1
28.	Hagerman	Likert	A	70	1
29.	Houston & Pilliner	Likert	S	38	1
30.	Ivany	T/F	S	18	1
31.	Jaus	Likert	E	10	1
32.	Kimball	Likert	A	29	6
33.	Korth	Likert	S	52	3
34.	Leavers	M/C	C	4	1
35.	Lowery	Projective	E	22	5
36.	Mann	Interview	E	19	1
37.	Moore & Sutman	Likert	S	60	30
38.	Motz	Likert	E,S	50	5
39.	Myers	Thurstone	C	44	1
40.	National Assessment of Educational Progress	Varied	A	-	3
41.	National Science Foundation	Interview	A	8	1
42.	Nordstrom & Friedenberg	Q-Sort	A	32	1
43.	Novak	T/F type	C	35	1
44.	Ormerod	Likert	S	49	3
45.	Parish	Likert	C	43	1
46.	Redford	Likert	C,A	42	0
47.	Remmers	Likert	S	-	6

		Scale Format	Population	Length	Frequency of Use
48.	Schwirian	Likert	S,C	40	12
49.	Selmes	Likert	S,C	56	2
50.	Shallis & Hills	Varied	A	17	1
51.	Skurnik & Jeffs	Likert	S	58	0
52.	Swan	Likert	E	50	1
53.	Tamir, Arzi, & Zloto	Likert	S	76	2
54.	Tilford	Likert	C	21	2
55.	Weinhold	T/F	C	70	1
56.	Withey	T/F	A	12	1

usually, a five-point scale. This procedure certainly seems less onerous than, say, the Thurstone technique which involves testing a large number of prepared items and then selecting them according to a defined scaling procedure (Thurstone, 1967). Of course, the Thurstone technique embodies a validity tryout, and so the difficult matter of determining the validity of a Likert scale is undertaken after the scale's items are selected. More on this matter appears later in this chapter.

The second striking point of Table 5 is the rather large number of instruments for which only one (or less) research study was identified. Only 21 of the 56 instruments appear to have been used in more than one reseach study. On the face of it, this suggests that there is some unnecessary duplication, given the large number of known instruments that have been used in more than one study. Yet there may be reasons for this apparent duplication, and perhaps the most obvious of these is the lack of communication about available instruments within the research community. Given that several instruments are located in doctoral dissertations and that a portion of these are insufficiently abstracted or simply not published, it would not be surprising to find that their existence is relatively unknown. The implications of this state of affairs are quite serious. Simply put, unless extensive work is done with a new instrument to establish its performance characteristics, the data which it provides are of rather questionable value. This thought leads directly to considerations of the reliability and, later, the validity of measures.

The Reliability of Attitude Instruments

Table 6 provides information about the reliabilities of the attitude instruments and how these were determined. The legend "NA" indicates that reliability information was not available to this investigation. Apart from this, the first column simply shows how the reliability was determined by each instrument's author, while the second column reports the range of the reliabilities. (The reliability for instrument #51, by Skurnik and Jeffs, is low since this range is of the subscales and not of the whole instrument.) The third column provides the values of reliability found in later uses of each instrument. The legend "-" indicates that there were no later studies, while "0" shows that even though later studies use the instrument, there is no attempt to calculate reliability coefficients from freshly acquired data.

Some points emerge from Table 6 which deserve comment. First, 21 of the 56 instruments have no reported reliabilities. (Perhaps the scales of Allen and Remmers may be excused since they are old and original sources could not be traced.) This state of affairs is surely grounds for concern about the confidence we can have in data that these instruments produce. Second, it is interesting to note that the preferred way of calculating reliability appears to involve the split-half technique -- 22 of the 35 determinations use this method and this method alone, while only four instruments have reliabilities determined by more than one method. Of course, the

Table 6. Reliabilities of the Selected Attitude Instruments

		Determination	Range	Later Values
1.	Allen	NA	NA	.82 - .98
2.	Allison	Split-half	.93 - .97	.73 - .91
3.	American Institute of Physics	NA	NA	-
4.	Arntson	Test-retest	.68	-
5.	Baldwin & Boedeker	NA	NA	-
6.	Bauman	Split-half	.94	-
7.	Belt	Split-half	.58 - .65	-
8.	Berkland	NA	NA	-
9.	Billeh & Zakhariades	Split-half	.55 - .74	-
10.	Bixler	NA	NA	-
11.	Brown S.A.	Test-retest	.86 - .92	0
12.	Brown S.B.	Split-half	.73	0
13.	Bruvold	Agreement	90%	-
14.	Bulletin of Atomic Scientists	NA	NA	-
15.	Clark B.M.	NA	NA	-
16.	Clark W.A.	NA	NA	-
17.	Cummings	Split-half	.92	0
18.	Dutton & Stephens	Test-retest	.93	0
19.	Eggleston	Split-half	.65 - .94	0
20.	Estes	NA	.85 - .88	-
21.	Fancher & Gutkin	NA	NA	-
22.	Feerst	Split-half	.70 - .91	-
23.	Fellers	Various	.63 - .84	-
24.	Fisher	Various	.79 - .83	-
25.	Fraser	Various	.78 - .84	-

		Determination	Range	Later Values
26.	Gardner	Split-half	.78	0
27.	Hackett	Split-half	.92	-
28.	Hagerman	NA	NA	-
29.	Houston & Pilliner	NA	NA	-
30.	Ivany	NA	NA	-
31.	Jaus	Test-retest	.85 - .92	-
32.	Kimball	Split-half	.72	.15 - .38
33.	Korth	Split-half	.71	0
34.	Leavers	NA	NA	-
35.	Lowery	Agreements	.81 - .92	0
36.	Mann	NA	NA	-
37.	Moore & Sutman	Test-retest	.934	.58 - .81
38.	Motz	Split-half	.78 - .79	.79 - .92
39.	Myers	Split-half	.44 - .70	-
40.	National Assessment of Educational Progress	NA	NA	NA
41.	National Science Foundation	NA	NA	NA
42.	Nordstrom & Friedenberg	NA	NA	-
43.	Novak	Split-half	.53	-
43.	Ormerod	Test-retest	.62 - .91	-
44.	Parish	Test-retest	.72	-
45.	Redford	Split-half	.84 - .88	-
47.	Remmers	NA	NA	.90 - .92
48.	Schwirian	Split-half	.87	.74 - .75
49.	Selmes	Various	.74 - .87	0
50.	Shallis & Hills	NA	NA	-
51.	Skurnik & Jeffs	Split-half	.16 - .42	-

		Determination	Range	Later Values
52.	Swan	Split-half	.90	-
53.	Tamir, Arzi, & Zloto	Split-half	.75 - .87	0
54.	Tilford	Split-half	.81	0
55.	Weinhold	Split-half	.65 - .73	-
56.	Withey	NA	NA	-

split-half method involves only a single administration of an instrument, making it attractive, but the more significant point to make is that it is generally misleading to speak of reliability without qualifying the talk with a mention of the type of reliability. So it becomes important to recognize that split-half reliabilities are more accurately construed as measures of internal consistency than as indicators or even predictors of consistency from one use to the next. And this recognition becomes crucial to our interpretation of the third point emerging from Table 6: while 21 of the instruments have been used in more than one study, new calculations of reliability are reported for only 7 of these instruments. Even then, as a glance at relevant pages of Appendix L will show, these new determinations do not appear in every use of a given instrument. For example, new determinations of the reliability of the Moore and Sutman instrument are reported in only 4 of the 30 studies identified. On the face of it, there appears to be no obvious cause for a researcher to determine afresh the reliabilities of the instruments he uses. Yet, if the reliabilities are in fact measures of internal consistency, then it becomes more important to ensure that the instrument can be relied upon to perform consistently from one research use to the next. Calculations of reliability coefficients in later research would give us this information.

Lastly, and a more complex matter, we note a wide range of reliabilities in an area where even rules of thumb about optimal values appear somewhat scarce. Edwards and Kenney

(1967) suggest that reliability coefficients of about .8 might be expected of Thurstone and Likert scales, so it is not unreasonable to suggest that coefficients of less than .7 might be taken as a signal that either another reliability trycut is needed or that further work might be done on the instrument's items. Thirty-two of the instruments qualify as reliable on the .7 criterion.

The Validity of the Attitude Instruments

We have seen earlier that a major factor affecting our views about the usefulness of attitude instruments is their validity: do the instruments measure what they purport to measure? This matter has been treated in the clue structure in several ways. The first of these concerns the procedures used by authors to establish validity, and these are discussed in this section. The remaining concerns about validity are about conceptual validity and gave rise to the detailed analysis of items (according to type), and are presented in the sections which follow.

Table 7 presents the steps taken by authors to establish the validity of their instruments. Where no information on validity is available, this is signalled by "NA". The notation "Panel of judges" refers to the technique of having judges agree to the suitability of items for a scale and in cases where percentage agreements or correlations are available, these are reported in the table. In one case, Fellers (#23), the author attempted to establish validity and acknowledged that he failed.

Table 7. Validities of the Selected Attitude Instruments

1.	Allen	Correlation between judges, .81 to .89
2.	Allison	Correlation among high school students, .81
3.	American Institute of Physics	NA
4.	Arntson	Panel of judges
5.	Baldwin & Boedeker	NA
6.	Bauman	Factor analysis
7.	Belt	NA
8.	Berkland	NA
9.	Billeh & Zakhariades	Thurstone technique, content and construct validitity
10.	Bixler	NA
11.	Brown S.A.	Panel of judges, factor analysis
12.	Brown S.B.	Panel of judges, correlation with information test
13.	Bruvold	NA
14.	Bulletin of Atomic Scientists	NA
15.	Clark B.M.	NA
16.	Clark W.A.	Panel of judges
17.	Cummings	Factor and item analysis
18.	Dutton & Stephens	Thurstone technique
19.	Eggleston	Factor analysis
20.	Estes	Cluster and factor analysis, convergent validity
21.	Fancher & Gutkin	Correlation with choice of major, .42
22.	Feerst	Panel of judges

23.	Fellers	Correlation with behavior (not established)
24.	Fisher	Panel of judges
25.	Fraser	Panel of judges, item analysis
26.	Gardner	Panel of judges, item and factor analysis
27.	Hackett	Panel of judges, correlations with behavior, .29 to .43
28.	Hagerman	NA
29.	Houston & Pilliner	Item analysis
30.	Ivany	NA
31.	Jaus	Panel of judges
32.	Kimball	Panel of judges, item analysis
33.	Korth	Panel of judges, item analysis, correlations
34.	Leavers	NA
35.	Lowery	Consistency of scores, 80 per cent
36.	Mann	Panel of judges
37.	Moore & Sutman	Panel of judges, field testing
38.	Motz	Item analysis
39.	Myers	Thurstone technique
40.	National Assessment of Educational Progress	NA
41.	National Science Foundation	NA
42.	Nordstrom & Friedenberg	NA
43.	Novak	Panel of judges
44.	Ormerod	Thurstone technique, factor analysis correlation with science grades, .40 to .55

45.	Parish	Panel of judges
46.	Redford	NA
47.	Remmers	NA
48.	Schwirian	Item analysis
49.	Selmes	Item analysis and teacher rating, .38 to .55
50.	Shallis & Hills	NA
51.	Skurnik & Jeffs	Item analysis, correlations with achievement
52.	Swan	Item analysis
53.	Tamir, Arzi, & Zloto	Panel of judges (items from students)
54.	Tilford	Panel of judges (items from professors)
55.	Weinhold	Panel of judges, item analysis, .29
56.	Withey	NA

Supposing we are interested in only those instruments whose validity is established. Immediately, 18 of the 56 instruments may be deleted from the list of likely instruments. Next, we ought to consider the confidence we can have in the use of a panel of judges. Lucas (1975) has criticized the procedure of using a panel to establish a model for tests of knowledge about science. His points are equally relevant to developing a model of attitudes to science. The panel of judges technique, he argues, does not guarantee an adequate model because:

> it rests upon the methodological assumption that consensus, in the literature and/or among a panel, will produce the correct model. This is the "nine-out-of-ten-film-stars-can't-be-wrong" myth much beloved by soap advertisers. The myth probably results from the unjustified extension of the political principle, "the majority rules" to an epistemological principle, "the majority is right." (p. 481)

So, we might remove from the list of potentially valid instruments those whose validity is agreed to by a panel of judges only. Thus the list is reduced again, from 38 to 29. In other words, for only slightly more than half of the instruments are attempts made to establish validity by anything more rigorous than panels of judges agreeing that the items of a given scale are suitable. Given this, it pays to look closely at other ways by which validity coefficients have been determined.

Factor analysis, used in five cases, provides a sound empirical check on the consistency of subscales within an instrument, as does cluster analysis (one case). Item analysis, which is surely a basic way to determine item discriminability and test power, is used in 11 cases to which we should add the 4 instances in which a Thurstone technique is employed to construct the instruments. Generally, the remaining techniques involve correlating attitude scores with ratings of behavior or scores on other instruments, often science information or achievement. While correlating attitude scores with behaviors goes some distance, at least conceptually, toward establishing validity, this is not clearly the case with correlations between attitude and achievement scores, and the ambiguity here is best revealed by considering what is meant by convergent and discriminant validity (Campbell & Fiske, 1959; Munby & Wilson, 1978).

If two instruments measure the same trait, then when they are applied we expect that the sets of scores correlate almost perfectly thus establishing the convergence of the scales. Accordingly, the convergent validity of a new IQ test may be established by correlating its scores with those of other IQ tests of known characteristics. It is equally important to know that the test in question does not correlate with all test scores; that is, we would want assurance that the test is not measuring some generalized trait such that it correlates with several conceptually unrelated variables.

For this reason, we might elect to correlate scores from the new IQ test with those of a personality test with the expectation that divergent validity is established by a correlation approaching zero. Clearly, it is desirable to have all instruments subjected to this sort of scrutiny, but for attitude instruments, it is not so clear how we might interpret the results. Let us consider an example.

Ormerod's instrument "The Brunel Socatt Scales" (#44) is validated in several ways including correlations with science grades, the latter giving values between .40 and .55. It is difficult to know what to make of this information for, while it could be argued that we have here evidence of convergence, only approximately 30% of the variance is accounted for by the science grades. To add to the difficulty of judging whether or not convergence is demonstrated here, it should be noted that there may be further ambiguity. One view of attitude and learning might well be that the first influences the second to the extent that we ought to expect statistically significant correlations between attitude and achievement scores. On the other hand, using part of the clue structure developed previously, we can see that 17 items in this 49-item scale are cognitive items and these can thus be taken to represent a test of science knowledge. If this view is taken, a correlation such as the above is expected quite aside from any considerations of the convergent validity of the scale in question.

Given these sorts of difficulties, perhaps the most that can be done is to note which instruments have been subjected to a variety of validity determinations. Excluding the use of "Panel of judges," only seven instruments have had validity determined by two or more psychometric methods: Billeh and Zakhariades (#9), Estes (#20), Gardner (#26), Korth (#33), Ormerod (#44), Selmes (#49), and Skurnik and Jeffs (#51).

There is an indirect way in which a reader may establish more of the validity of the selected instruments, and that requires an examination of studies using the instruments to see whether or not any possibly useful correlations are available or even if further validity determinations have been attempted. Table 8 lists the number of psychometric validity determinations undertaken by each instrument's author, and whether or not additional validity information is available. Details of this information may be found in the research abstracts presented in Appendix L. ("Panel of judges" is rated as zero in Table 8 since this procedure involves no correlations or percentage agreements.) Readers will note that in two cases (the instruments of Allen and of Moore and Sutman) new validity determinations take issue with the original ones, and that of the studies noted in Table 8, only these two were specifically designed to investigate validity.

We have already noted that Likert scaling is a strikingly popular mode for constructing attitude instruments, and that the Thurstone technique incorporates some validity testing

Table 8. Availability of Additional Validity Data for the Attitude Instruments

		Number of Original Determinations	Number of Later Determinations
1.	Allen	1	1
2.	Allison	1	
3.	American Institute of Physics	0	
4.	Arntson	0	
5.	Baldwin & Boedeker	0	
6.	Bauman	1	
7.	Belt	0	
8.	Berkland	0	
9.	Billeh & Zakhariades	2	1
10.	Bixler	0	
11.	Brown S.A.	1	1
12.	Brown S.B.	2	1
13.	Bruvold	0	
14.	Bulletin of Atomic Scientists	0	
15.	Clark B.M.	0	
16.	Clark W.A.	0	
17.	Cummings	2	
18.	Dutton & Stephens	1	
19.	Eggleston	1	
20.	Estes	3	1
21.	Fancher & Gutkin	1	
22.	Feerst	0	
23.	Fellers	1	

		Number of Original Determinations	Number of Later Determinations
24.	Fisher	0	
25.	Fraser	1	
26.	Gardner	2	1
27.	Hackett	1	
28.	Hagerman	0	1
29.	Houston & Pilliner	1	
30.	Ivany	0	
31.	Jaus	0	
32.	Kimball	1	1
33.	Korth	2	3
34.	Leavers	0	
35.	Lowery	1	5
36.	Mann	0	
37.	Moore & Sutman	1	14
38.	Motz	1	1
39.	Myers	1	
40.	National Assessment of Educational Progress	0	
41.	National Science Foundation	0	
42.	Nordstrom & Friedenberg	0	
43.	Noval	0	
44.	Ormerod	3	1
45.	Parish	0	
46.	Redford	0	
47.	Remmers	0	
48.	Schwirian	1	2

		Number of Original Determinations	Number of Later Determinations
49.	Selmes	1	1
51.	Shallis & Hills	0	
51.	Skurnik & Jeffs	2	1
52.	Swan	1	
53.	Tamir, Arzi, & Zloto	0	
54.	Tilford	0	
55.	Weinhold	1	
56.	Withey	0	

within it which is not the case for the Likert scale. Given this, it seems important to determine the degree to which psychometric validity testing has been conducted on the Likert scales collected here for study. Table 9 presents the frequency of validity determinations for these scales by the method used, "Other" referring to various correlations that have been attempted. There is psychometric validity data available on only 21 of the 37 instruments listed here. And of these, only six have validity information available from more than one method.

We shall return to the matter of validity below, but even at this point we can see that validity determination is not a strength in the construction of instruments to measure attitudes to science.

Analysis of Instruments for Statement Type

The first analytical portion of the clue structure sought to distinguish different types of items from each other according to the basic categories: cognitive, value, attitude, and items speaking to scientific attitudes. The results of applying this clue structure to the instruments appears in Table 10, which for ease of comparison also gives the total number of items in each instrument. (The use of parentheses in the scientific attitude column indicates that the instrument contains subscales specifically designed to measure scientific attitudes.) Some analyses are omitted from this table, as follows. The Eggleston device procured for study was an early and shorter version of the final instrument,

Table 9. Validity Determinations for Likert Scales

		Nil	Panel	Item	Factor	Cluster	Other
1.	Allen		1				1
2.	Allison		1				1
3.	American Institute of Physics	1					
4.	Arntson		1				
6.	Bauman				1		
7.	Belt	1					
8.	Berkland	1					
10.	Bixler	1					
11.	Brown S.A.		1		1		
12.	Brown S.B.		1				1
15.	Clark B.M.	1					
16.	Clark W.A.		1				
17.	Cummings			1	1		
20.	Estes				1	1	
22.	Feerst		1				
23.	Fellers						1
24.	Fisher		1				
25.	Fraser		1	1			
26.	Gardner		1	1	1		
27.	Hackett		1				1
28.	Hagerman	1					
29.	Houston & Pilliner			1			
31.	Jaus		1				

		Nil	Panel	Item	Factor	Cluster	Other
32.	Kimball		1	1			
33.	Korth		1	1			
37.	Moore & Sutman		1				1
38.	Motz			1			
44.	Ormerod				1		1
45.	Parish		1				
46.	Redford	1					
47.	Remmers	1					
48.	Schwirian			1			
49.	Selmes			1			1
51.	Skurnik & Jeffs			1			1
52.	Swan			1			
53.	Tamir, Arzi, & Zloto	1					
54.	Tilford	1					

Table 10. Instrument Analysis by Statement - Type

		Total	Cog.	Value	Att.	Sci.Att.
1.	Allen	95	59.5	28.5	6	1
2.	Allison	95	63	26	5	1
3.	American Institute of Physics	18	8	9	1	0
4.	Arntson	40	3	31	6	0
5.	Baldwin & Boedeker	5	1	4	0	0
6.	Bauman	40	0	0	40	0
7.	Belt	30	20	7	2	1
8.	Berkland	20	1	7	12	0
9.	Billeh & Zakhariades	36	13	4	1	(18)
10.	Bixler	14	3	11	0	0
11.	Brown S.A.	60	29	10	12	(9)
12.	Brown S.B.	20	11.5	8.5	0	0
13.	Bruvold	1	0	1	0	0
14.	Bulletin of Atomic Scientists	4	0	4	0	0
15.	Clark B.M.	5	0	0	5	0
16.	Clark W.A.	28	18	9	1	0
17.	Cummings	67	37	15	14	1
18.	Dutton & Stephens	20	6	4.5	7.5	2
19.	Eggleston	68	Analysis not performed			
20.	Estes	15	5	3	7	0
21.	Fancher & Gutkin	52	25	12	16	2
22.	Feerst	23	11	1	6	5
23.	Fellers	55	24	30	0	1
24.	Fisher	20	8	1	3	8

		Total	Cog.	Value	Att.	Sci.Att.
25.	Fraser	70	13	11	33	(13)
26.	Gardner	40	18	4	8	(10)
27.	Hackett	42	6	4	14	(18)
28.	Hagerman	70	34	24	3	9
29.	Houston & Pilliner	38	8	6	14	(10)
30.	Ivany	18	7	7	4	0
31.	Jaus	10	1	1	8	0
32.	Kimball	19	26.5	1.5	1	0
33.	Korth	52	36	13	3	0
34.	Leavers	4	2	0	2	0
35.	Lowery	Projective				
36.	Mann	19	3	5	8	3
37.	Moore & Sutman	60	30	15	6.5	(8.5)
38.	Motz	50	45	5	0	0
39.	Myers	44	37	4	2	1
40.	National Assessment of Educational Progress	Partial scale				
41.	National Science Foundation	18	9	3	6	0
42.	Nordstrom & Friedenberg	32	25	7	0	0
43.	Novak	35	11.5	3.5	1	19
44.	Ormerod	49	17	17.5	14.5	0
45.	Parish	43	26	10	5	2
46.	Redford	42	19	17	6	0
47.	Remmers	Partial scale				
48.	Schwirian	40	10	30	0	0
49.	Selmes	56	36	6	10.5	3.5

		Total	Cog.	Value	Att.	Sci.Att.
50.	Shallis & Hills	12	10	1	1	0
51.	Skurnik & Jeffs	58	8	14	28	8
52.	Swan	50	6	9	22	(13)
53.	Tamir, Arzi, & Zloto	76	56	17	3	0
54.	Tilford	21	4	1	10	6
55.	Weinhold	70	22	7	9	32
56.	Withey	12	6	5	1	0

which was not received. The Lowery test is a projective test; and the National Assessment of Educational Progress and Remmers scales contain attitude items only as part of the overall scales.

There is clearly a large variation in the sorts of items used in these instruments, but it is perhaps surprising to see so many cognitive items in the collection when the purpose of an attitude instrument is considered. Value items identify that a judgment is made ("More money should be spent on science") and attitude items are clearly personal expressions of likes and dislikes ("I hate science"), yet cognitive items present the subject with a statement which is either true or false. Accordingly, a subject could know the correct response, give it, and still not feel that his basic resentment of science is both violated and tested. Since it is possible to know such answers independently of one's feelings about what is at point, we can raise again questions about the validity of instruments which incorporate large numbers of this type of item. Table 10 shows that only 4 of the 52 instruments analyzed there contain no cognitive items, and that fully 17 instruments contain 50% or more cognitive items, with another 18 containing 25% or more such items. With this information at hand, it does not seem too hard to explain two puzzling findings which tend to recur as the abstracts in Appendix L are read. First, some experimental courses or teaching methodologies yield no significant differences in attitudes measured before and after the treatment. If the attitude instrument contains a number of cognitive items which are not related to the actual content of the treatement then no matter how positively or negatively a subject might feel about science his score on this portion of the attitude scale is likely to be unaffected by the treatment. The second recurring feature of research is the tendency for attitude scores to correlate with achievement scores. This may be unsurprising if one holds the thesis that attitude correlates with motivation and motivation correlates in turn with achievement. Yet, there is a puzzling alternative to consider. If upwards of a quarter of the items in the attitude instrument used to procure these correlations are cognitive items, then the correlation ought not to surprise us on logical grounds, quite aside from the psychological conjectures. This is certainly a question that might be pursued in further analysis of the material collected for the present research.

It can of course be reasonably objected that the mere presence of cognitive items does not of itself automatically invalidate an attitude scale. After all, as we have seen in the previous survey of the attitude theory literature, there is a view that attitudes are cognitive. But we can still make something of this analysis, for Likert (1967) has argued that the items of a Likert scale ought to be statements of observed behaviors, that is, they ought to be value or attitude statements in the words of the present clue structure. Table 11 presents the analysis by statement type of the 36

Table 11. Analysis of Likert Instruments by Statement - Type

		Total	Cog.	Value	Att.	Sci.Att.
1.	Allen	95	59.5	28.5	6	1
2.	Allison	95	6.3	26	5	1
3.	American Institute of Physics	18	8	9	1	0
4.	Arntson	40	3	31	6	0
6.	Bauman	40	0	0	40	0
7.	Belt	30	20	7	2	1
8.	Berkland	20	1	7	12	0
10.	Bixler	14	3	11	0	0
11.	Brown S.A.	60	29	10	12	(9)
12.	Brown S.B.	20	11.5	8.5	0	0
15.	Clark B.M.	5	0	0	5	0
16.	Clark W.A.	28	18	9	1	0
17.	Cummings	67	37	15	14	1
20.	Estes	15	5	3	7	0
22.	Feerst	23	11	1	6	5
23.	Fellers	55	24	30	0	1
24.	Fisher	20	8	1	3	8
25.	Fraser	70	13	11	33	(13)
26.	Gardner	40	18	4	8	(10)
27.	Hackett	42	6	4	14	(18)
28.	Hagerman	70	34	24	3	9
29.	Houston & Pilliner	38	8	6	14	(10)
31.	Jaus	10	1	1	8	0
32.	Kimball	29	26.5	1.5	1	0
33.	Korth	52	36	13	3	0

		Total	Cog.	Value	Att.	Sci.Att.
37.	Moore & Sutman	60	30	15	6.5	(8.5)
38.	Motz	50	45	5	0	0
44.	Ormerod	49	17	17.5	14.5	0
45.	Parish	43	26	10	5	2
46.	Redford	42	19	17	6	0
48.	Schwirian	40	10	30	0	0
49.	Selmes	56	36	6	10.5	3.5
51.	Skurnik & Jeffs	58	8	14	28	8
52.	Swan	50	6	9	22	(13)
53.	Tamir, Arzi, & Zloto	76	56	17	3	0
54.	Tilford	21	4	1	10	6

complete Likert instruments. Only in one case (Bauman, #6) is Likert's prescription followed. Fifty percent of items in 1 instruments and 25% of items in a further 10 instruments are cognitive items. Of course the impact of this situation is not easy to assess, though we can say that it reinforces the view that the validity of existing attitude instruments in science education is seriously questionable.

This part of the clue structure also picks out items which are directed at scientific attitudes rather than attitudes to science. Table 10 shows the number of such items in each instrument, with the number placed in parentheses in the case of eight instruments designed with explicit subscales for measuring scientific attitude. (The reader will be able to see from Appendix L the extent to which these items fall with the intended subscales.) Seven instruments have a fairly large proportion of scientific attitude items: Feerst (5 of 23), Fisher (8 of 20), Hagerman (9 of 70), Novak (19 of 35), Skurnik and Jeffs (8 of 58), Tilford (6 of 21), and Weinhold (32 of 70).

Analysis of Instruments for View of Science

The clue structure was designed so that items which appear to measure a philosophical view of science may be identified in instruments. Use of the clue structure allows one to see if a view of science is explicit or implicit and whether the view is Realist or Instrumentalist. Table 12 provides the results of this analysis and gives, for comparison, the length of the instruments by number of items.

Table 12. Analysis of Instruments by View of Science

		Length	Explicit		Implicit	
			R	I	R	I
1.	Allen	95	2	2	1	3
2.	Allison	95	3	3	1	2
3.	American Institute of Physics					
4.	Arntson	40		10	3	
5.	Baldwin & Boedeker					
6.	Bauman					
7.	Belt	30			2	1
8.	Berkland					
9.	Billeh & Zakhariades	36	3	1	1	9
10.	Bixler					
11.	Brown S.A.	60	2	2	3	
12.	Brown S.B.	20	2			
13.	Bruvold					
14.	Bulletin of Atomic Scientists					
15.	Clark B.M.					
16.	Clark W.A.					
17.	Cummings	67		1	2	
18.	Dutton & Stephens					
19.	Eggleston					
20.	Estes					
21.	Fancher & Gutkin	56	4	7		2
22.	Feerst					
23.	Fellers	55	6	1	1	
24.	Fisher					

		Length	Explicit		Implicit	
			R	I	R	I
25.	Fraser					
26.	Gardner	40	-		2	-
27.	Hackett	42	1	2		1
28.	Hagerman	70	4	5	2	2
29.	Houston & Pilliner	38	1	2	4	1
30.	Ivany					
31.	Jaus					
32.	Kimball	29	3	3		
33.	Korth	52	2			
34.	Leavers					
35.	Lowery					
36.	Mann	19	3	1		
37.	Moore & Sutman	60	11	10		3
38.	Motz	50	2	5	11	2
40.	National Assessment of Educational Progress					
41.	National Science Foundation					
42.	Nordstrom & Friedenberg	32		1		3
43.	Novak	35	2	1	3	3
44.	Ormerod	49				1
45.	Parish	43			1	1
46.	Redford	42			1	
47.	Remmers					
48.	Schwirian	40			1	2
49.	Selmes	56	2	6	3	3

		Length	Explicit		Implicit	
			R	I	R	I
50.	Shallis & Hills					
51.	Skurnik & Jeffs					
52.	Swan	50			1	1
53.	Tamir, Arzi, & Zloto					
54.	Tilford					
55.	Weinhold	70	1	3	4	5
56.	Withey	12			1	

It can be seen that on the whole the instruments avoid items embodying a philosophical view of science. Twenty-five instruments contain no such items, and a large number have only a sparse scattering of them. There are cases, though, in which the proportion of view of science items seems worthy of note. Instruments of Arntson (10 of 40), Billeh and Zakhariades (14 of 36), Fancher and Gutkin (13 of 52), Hagerman (13 of 70), Moore and Sutman (24 of 60), Motz (20 of 50), Selmes (14 of 56), and Weinhold (13 of 70), have a relatively large number of these items for their length. At the present, there is no way of determining how the presence of such items acts in attitude scales. Clearly, for the above instruments, we need to know something of the effects if we are to be assured that the instruments do indeed measure an attitude to science, and not something else. In the absence of this information it is not unreasonable to conclude that we might be skeptical of the validity of these devices.

Evaluating Instruments by Selected Criteria

The information in this chapter shows that, in many ways, we can raise questions about the instruments designed to measure attitudes to science. Our analysis has revealed problems in reliability, validity, and in what the items themselves seem to be testing, and the tables have shown something of the character of the field of attitude measurement in science education. It is useful, though, to move further than this and to address the question of which of the 56 instruments might meet some minimal criteria. This is accomplished below as a way of summarizing the present chapter.

For the sake of argument, we shall reduce the list of 56 instruments by removing those which are incomplete or which are not strictly measuring attitudes to science, although these have been included in the analysis thus far. The instruments of Gardner and of Tamir, Arzi, and Zloto are attitude to physics scales. That of Kimball is a test of understanding science. Eggleston's instrument is an early version whose successor was not available, and those of Remmers and of the National Assessment of Educational Progress are part scales. (Details of these instruments are available in Appendix L, of course.) Accordingly, we are left with 50 instruments for this examination.

If we remove from these 50 instruments those whose reliability is not known, 33 remain. Of these, 4 have reliability coefficients less than .7, leaving 29. (The .7 value is arbitrary, but less than the .8 of Edwards and Kenney (1967).) We can subtract from these, those whose validity is either untested or is established by a "panel of judges" giving us 22 instruments. This number may be reduced further by eliminating instruments whose validity is established by only one psychometric technique (or whose validity is questioned in later research). Fifteen instruments have either known internal validity (by factor <u>or</u> item analysis) or known construct validity (by correlations with other measures) but not both. These criteria are survived by a group of seven instruments whose characteristics are summarized in Table 13. (The initials refer to levels: Elementary, Secondary, College and University, and Adult.)

Our examination of the instruments cannot end at this point. We should note that the reliability of four of these instruments is determined by a split-half technique -- a measure of internal consistency, the Selmes and Ormerod instruments being those whose reliability is known to have been determined by a test-retest method. (The materials in the Estes instrument do not indicate how reliability is determined.) Furthermore, none of these instruments have had reliabilities computed in later studies, despite the fact that four instruments have been used in three other studies. Also, we should take note of the high proportion of cognitive items appearing in these instruments and realize that this raises again the question of what these devices are measuring. (All instruments are Likert scales, except for the Thurstone scale of Billeh and Zakhariades.) And lastly, we need to recall from Table 12 that the Billeh and Zakhariades instrument contains four items which measure view of science explicitly and four which measure this implicitly. Similarly, the Selmes instrument has eight items measuring view of science explicitly and six measuring it implicitly. (As noted previously, the Billeh and Zakhariades scale has explicit subscales for scientific attitudes.)

Given this information, I do not think we can say with

Table 13. Characteristics of Seven Potentially Useful Instruments

Author	Population	Use	Length	Cognitive Items	Scientific Attitude Items
Billeh and Zakhariades	S,C,A	1	36	13	18
Brown, S.B.	E	3	20	11	0
Cummings, J.R.	C	3	67	37	1
Estes, T.H.	E	0	15	5	0
Korth, W.W.	S	3	52	36	0
Ormerod, M.B.	S	3	49	17	0
Selmes, C.S.	S,C	2	56	36	3

E - Elementary

S - Secondary

C - College and University

A - Adult

confidence that any of the seven potentially useful instruments meet our expectations of how an attitude instrument should perform and of what its items should appear to be measuring. In all cases, there are grounds for suggesting that these instruments need further work if we are to be satisfied that they give a reliable and valid picture of a subject's attitude to science.

CHAPTER 6

CONCLUDING DISCUSSIONS

The discussions in this chapter are presented in three sections. The first of these draws substantially upon the previous chapter and gives the reader a general picture of the field of measuring attitudes to science in science education. (Since evidence for the claims in this section is presented earlier, detailed evidence is not given below.) The second section broaches the matter of what an adequate model of attitude to science might be, since a major difficulty in current instrumentation appears to reside in the multiple conceptions (and thus, measures) of the central concept. Additionally, this section suggests that elements of attitudes to science may not be the proper concern of science educators. The final section offers a list of recommendations which fall directly from the present study.

General Conclusions

Perhaps the most immediately striking feature of the field we have investigated is its size. This study collected over 200 instruments. In addition, approximately 120 pieces of research were identified which used one of the 56 instruments that have been classified as measuring attitudes to science. Given the size of the field, one might expect it to be well reviewed, and this brings us to our first general conclusion. Chapter 2 has shown that with very few exceptions reviews of work in attitudes to science are selective and uncritical. There seems to be a strong tendency to confine reviewing to mere reporting. So Ormerod and Duckworth's (1975) extensive review of studies omits critical appraisal of the instruments used. Gardner's (1975b) review is critical and, uniquely, cites additional studies in which selected instruments are used. But this review is selective.

Our next conclusion stems from the work in Chapter 3 which describes how the instruments identified in the study's searches were sorted according to the attitudinal target they appeared to be using. The variety of conceptions of attitude to science is well illustrated in Figure 1, and the range extends from scientific attitudes, through attitudes to science courses and activities, to career and interest preferences. (A glance at Appendices A to K gives an indication of the amount of duplication within the field.) Yet, the variety of conceptions does not end here for even among the 56 instruments chosen for detailed study one can readily detect a very wide-ranging interpretation of what sorts of targets are appropriate in the items of attitude measures. The reader has only to leaf through some sections of Appendix L to see that all of the following pass as legitimate attitudinal targets: scientists, scientific courses, the difficulty of science, financial support of science, (governmental) control of science, scientific knowledge (laws, theories), science teachers, teaching science, and so on. The ambiguity surrounding what constitutes a proper model of attitude to science as evidenced by this proliferation of target concepts may well account for some of the conflicting research reports which are also found in Appendix L.

It would be pleasant to report that these conceptual ambiguities are more than compensated by exactness in establishing the psychometric characteristics of the 56 instruments studied here. Unfortunately, such is not the case. As reported in Chapter 5, 21 of the 56 instruments have no reliability information reported. Here we also noted that 22 of the 35 instruments whose reliability is known have reliabilities determined by the split-half technique. While this method removes the need for administering an instrument more than once, it yields a measure of internal consistency during one performance, and not a measure of consistency from one performance to the next.

Validity too is a problem. A total of 27 instruments have no validity information reported or have validity determined by a panel of judges. For only 29 instruments has any attempt been made to validate the scales psychometrically. Very few instruments have been validated by more than one psychometric technique, and only in nine cases is an attempt made to establish convergent validity.

With very few exceptions it is clear that authors of instruments are not taking all the steps they might to assure that their instruments may be used with confidence. And what is equally distressing to find is that other users seem to take validity and reliability for granted. Twenty-one of the

56 attitude measures are used more than once, as we have seen. But fresh determinations of reliabilities are established in later research for only six of those instruments. Yet the matter does not end here. In only two studies was an effort made to investigate the validity of an existing instrument (Lawrence, 1971; Nagy, 1978).

The analyses performed on the instruments' items yielded some interesting features too. It was found that 17 instruments contained 50% or more cognitive items (which amount to tests of science-related information), and a further 18 contain 25% or more such items. We also found that 26 instruments contain items which clearly measure scientific attitudes and not attitudes to science, though only 8 of these had explicit subscales for scientific attitudes. Lastly, eight instruments contain a proportion of items which measure or imply philosophical views of the nature of science.

Perhaps the best illustration of the significance of all these findings is the consequenc[illegible] sifting the 56 instruments through some minimal criteria, as we saw at the end of the previous chapter, and finding that 7 survive, only to notice that they have high proportions of cognitive items. Evidently, there are conceptual problems in the construction of instruments measuring attitudes to science. Were these resolved we might be able to explain the many conflicting research findings, such as those of LaShier and Nieft (1975) and Lauridsen (1972) who use the Moore and Sutman instrument to evaluate the same program with different results. (Their studies are abstracted in Appendix K in the section on the Moore and Sutman instrument.)

The Concept "Attitude to Science"

A very large quantity of the findings that we have listed above point us in the direction of the concept "attitude to science," and suggest that we question it. (We have witnessed confusion in types of items, and a variety of target concepts to mention two.) So it seems appropriate to devote a section to this topic separate from the general conclusions and the recommendations.

One problem anent to measuring attitudes to science, especially those of learners, is that the very idea of science might be ambiguous. We can easily see how the concept "science" may be taken to refer to the science courses and lessons taken in school and college and the substance of those lessons. It is not that such lessons do not portray science, but that they probably give science experiences to youngsters which are quite different from those of an historian or philosopher of science. Of course, it is equally probable that some will view science in the professional sense, and so the concept conjures up meanings related to careers in science. These differences in how meaning is attached to concepts may be avoided if instruments are designed strictly with subscales or entire scales given clearly to the target concepts, such as science in school, a science career, and so forth. In fact, some framework similar to the one appearing in Figure 1 could constitute the bases of at the least distinguishing the varieties of subscales from one another. While all this seems to be a necessary part of reducing the ambiguity of the target concept "science" it may not readily extinguish it, for the ambiguity extends beyond these interpretations. Science, it could be argued is so much a part of western thinking that its meaning and its implications for society might get lost behind the rather more obvious and superficial (if not newsworthy) ways in which its presence is felt. We see the impact of science on society and nature very clearly when we consider nuclear weaponry and oil-slicks. Less prominent, though significantly ubiquitous, is the impact of science on our clothing, food-stuffs, and, as suggested in Chapter 2, on our thinking, so that we tend to picture our environment as it is painted by science. The extent of science's permeation is beyond the scope of the present discussion. Suffice it to say that it may be difficult to get at a person's attitudes to science if he or she is not wholly aware of the extent to which science is a part of his or her intellectual and physical life.

Any inquiry directed at unpacking the concept of "attitude to science" must contend with this sort of problem. It must also look at the educational appropriateness of making the possession of "positive attitudes to science" so important an objective that it has become an obviously acknowledged source for some of the measuring equipment wielded by researchers and evaluators in science education. The call here, then, is that we attend to whether getting someone to like science or "feel positive" about it is an educational objective or an objective that is more properly characterize as miseducational or indoctrinaire (if indeed the latter is not subsumed by the former). Accordingly, we have to ask what business it is of science education to promote a liking for science and science related matters, and why science education ought not to restrict itself to bringing about awareness, understanding, and knowledge. Again, it seems that any fresh conceptualization of "attitude to science" undertaken for science education must attend to the conceptual relationships that "attitude to science" has with education and not, say, to public administration, to the study of political movements, or to the examination of social expression, each of which has its own (disciplined) conceptual relationships.

A possibly useful starting point might be found in Klopfer's (1976) structure for the affective domain in science education. Yet this structure itself seems not to consider the philosophical and ethical problems just noted. For instance, an example of low-level affective responding is "The student is sensitive to the singing of birds" (p. 303). Others, though, are more controversial: "The student consistently prefers to study science over studying in other areas whenever he or she has a free choice" (p. 306). Is this to suggest that we should aim science instruction at having students take more science? Or again, "The student feels a sense of kinship with people who are scientists" (p. 303), and "The student changes his or her opinion on controversial issues when an examination of the evidence and the argument calls for revision of opinions previously held" (p. 311). It is not transparent that these are legitimate objectives of science education without some careful treatment of whatever relationships might exist between having a good understanding of science and liking scientists and between knowing how to behave within the discipline of science and making personal choices on controversial issues. Part of the problem here may be a direct descendant of the wedge that has been driven to separate the cognitive from the affective domain so far as speaking about the outcomes of learning goes. The wedge is manmade, however, and so we ought to ask if the affective domain itself is a useful basis upon which to construct a fresh analysis of the concept "attitude to science." It might be more useful to start with the view that whatever personal preferences and attitudes people might have, these ought to be formulated wisely and thus grow out of the knowledge and understanding of science which is the business of science education to foster.

Whatever the direction taken in an attempt to reconceptualize "attitude to science" in science education, it is one finding of the present study that such a reconceptualization is urgently needed.

Recommendations

A number of quite specific recommendations for research and evaluation in science education can be derived from the findings of the present study. We begin the list with some rather mundane suggestions, and then continue with the more significant ones.

Dissertation Abstracts International

The initial work of the investigation was hampered by some variation in authors' use of *Dissertation Abstracts International* (DAI). This publication is undoubtedly a major source of information about doctoral dissertations, but its contents are controlled almost entirely by the doctoral candidates themselves. The first point to make is that not all dissertations are listed in *DAI*, and it probably goes without saying that all doctoral candidates should ensure that their work is publicized in this way, thus enabling interested persons to read the abstract and, if necessary, procure a bound or microfilmed copy of the dissertation itself. Second, there is considerable variation in the quality of abstracts. Many, for example, failed to report whether the instruments used in a study were author-constructed or developed by other workers. Sometimes, the titles of instruments are given in the abstract, but this was insufficient information for locating the instrument used. Generally, the results of an investigation are given, though in a few cases this was not so. For the entries in *DAI* to be useful, it is quite clear that they must be complete. It would not be out of place for professional organizations such as the American Educational Research Association, the National Association for Research in Science Teaching, and the Canadian Society for the Study of Education to produce guidelines for dissertation abstracts.

Availability of Instruments

Instruments developed for dissertation research are in almost every case available in the dissertation itself, yet instruments used in research published only in journals are frequently difficult to obtain. Probably, restrictions of cost and space limit an editor's freedom to insert author-constructed instruments in journal articles, yet this should not make it necessary for interested readers to locate the author's current address and write to him in order to examine a copy of the instrument. A simple solution to this problem is at hand. Any author may place his work before the research community by submitting it to the Educational Resources Information Center (ERIC) which will then announce the document together with an identification number. Once this number is available, the author may use it in the reference list at the end of a research article so that the reader has immediate access to the instrument. We could go further than this and urge editors to insist that author-constructed instruments be referenced in this way before an article is considered for publication.

Dissertation Research

A considerable portion of the materials investigated in this study, either as sources of instruments or as uses of other instruments, is composed of doctoral dissertations. If it is wished, the reader may examine the abstracts presented in Appendix L and learn something of what research is undertaken at the doctoral level. The quality and significance of this work is not the immediate concern of the present discussion, though, except as it pertains to the use of instruments measuring attitudes to science. Several dissertations use instruments developed in previous studies, but tend to do so rather uncritically. That is, it is not at all evident that doctoral candidates attempt to locate all the information about an instrument's performance which is available in reports of other studies in which the instrument has been employed. Equally worrying is the finding of Chapter 5 that in so few cases do users attempt to re-establish the validity and reliability of the instruments they select for their research. Unless proper care is taken to determine the performance characteristics of an instrument used in research, then no matter how significant the problem and how tight the design, the results themselves cannot be considered trustworthy. For dissertations of this sort to make a significant contribution (which presumably is what they are supposed to do) dissertation advisers must insist that the reliability and validity of instruments be thoroughly examined and reported before a dissertation is presented for examination.

The Development of Instruments

Some dissertation researchers, as Appendix L shows, go further than using existing instruments, and instead develop their own for reasons which are not always clear. This route toward the production of high quality, significant, and useful research is fraught with difficulties and should be banned. Proper instrument development, as explained below, is sufficiently taxing and complex as to provide evidence of a candidate's admissibility to a doctoral degree. Typically, though, when doctoral candidates develop their own instruments, they appear to put their efforts into the research problem rather than into instrument development with the result that the conclusions enlist little confidence for they are derived from inadequately developed measures.

Instrument development itself begins with conceptual analysis, perhaps of the sort suggested in the previous section. Once items have been selected, the test must be subjected to a variety of psychometric trials to establish and improve its reliability (using test-retest techniques) and its validity (using item analysis, factor analysis, and some form of convergent and divergent analysis). As we have seen in this study, too many questions can be raised of instruments which have not been developed in this way for them to be considered trustworthy.

Reviews of Instruments and Research

Only 56 of the approximately 200 instruments identified in this study have been thoroughly investigated. There remains, then, large numbers of instruments measuring other aspects of attitudes in science education which have not been examined nor have the research studies in which they are used been identified and explored. Additionally, the semantic differential format has not been considered here. For the research community to judge the results yielded by these instruments, it is clear that they too need to be reviewed thoroughly. Certainly, given the numbers involved it seems wise to undertake thorough reviews of this nature, and it would be wiser still to do so prior to the production of any new instruments.

Problems for Research

The analyses presented in Chapter 5 raise a number of questions, mostly about how the presence of types of items affect overall scores on instruments. If indeed items identified as cognitive items in this study are measuring knowledge or understanding and not attitude then it is important to determine the extent of their influence on attitude scores. Similarly, it might be important to know the nature of the contributions that items measuring scientific attitudes and views of the nature of science have on attitude scores.

Other interesting possibilities arise out of the analyses in this study: Is it possible to explain contradictory findings (of studies abstracted in Appendix L) by the presence of cognitive items in so-called attitude measures? Are contradictory findings related to the way in which reliabilities and validities are determined? What is the effect of instrument length on contradictory findings, and on attitude scores? And so forth.

It is anticipated that the material in the body of this study and in the large Appendix L will be helpful to those sorts of inquiries in science education research. At the least, these materials might be expected to provoke some interest in questioning the usual ways in which we have investigated attitudes to science.

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APPENDICES

APPENDIX A

SEMANTIC DIFFERENTIAL INSTRUMENTS

The following semantic differential instruments were identified in the searches for this investigation, but are not analyzed. The scale by Bauman (1970) is something of an exception, for this scale is compared with a Likert scale of his construction which is analyzed in detail for the study. Where possible, the titles of instruments are provided together with the variable(s) measured, usually in the form of the target concept.

1. Andersen (1975). No title.
   Biology as a career, hormonal vs. neural regulation, the willingness to accept new ideas, etc.

2. Antonnen, "Science and Me."
   Cited in Buckley (1976). Science and Me.

3. Bauman (1970). No title.
   Being a scientist, working on science problems, reading science investigation reports, following a scientific procedure, working in a science laboratory.

4. Brown and Elliott (1973). No title.
   Perceptions of the study of physics.

5. Butts and Raun (1969) "My Perception of Teaching Science."
   Teaching science, students, science, the scientist, ISCS, etc.

6. Butzow (1974). "The Science Involvement Scale."
   Work in the area of electrical power production, underwater behavior of sound waves, identification of sugars and starches, etc.

7. Connor (1972). No title.
   Music, school, science class, scientist, science.

8. Dean (1968). No title.
   Science.

9. DeLuca (1970). "Semantic Differential Test for Attitude."
   Geology Lab Activities, Study of Rocks and Minerals, Study of Maps, etc.

10. Gallagher and Korth (1969). No title.
Science, Scientists, Science Teachers, Myself as a Scientist.

11. Hartman (1972). No title.
The use of atomic energy has greatly changed our society, atoms are as real as people, science has produced the present state of humanity etc.

12. Harvard Project Physics (1968). No title.
Artist, Biologist, Doctor, Physicist, Plumber, Secretary, Teacher, Businessman, Me.
This instrument is discussed fully in Geiss (1968)

13. Hecht (1970). "Word Association Scale."
Scientists, High School Science Teachers, Science Research Done by Scientists, etc.

14. Henson (1970). No title.
School, Science, Earth Science Experiments, Reading Earth Science, etc.

15. James (1971). "Science Related Semantic Differential."
Experiment, Lecture, Teaching, Textbook, Science, Self, etc.

16. Jingozian (1973). No title.
Science

17. Jones (1970). No title.
Science and mathematics.

18. Klopfer (1969). "Word Association Test."
Astronomy, Arithmetic, Most Scientists, Reading about Science, My Science Teacher, etc.

19. Lucas (1974). "Inventory of Attitudes."
Learning about Science, Fernbank Science Center, Meteorology.

20. McNarry and O'Farrell (1971). No title.
Engine, Health, Study, Scientist, Me, Sister, Technology, etc.

21. Milson (1972). No title.
Science Class, Science, Science Teacher, Heat and Temperature.

22. Osborne (1976). No title.
(Concepts refer to units of laboratory work.)

23. Quinn (1974). "Biology Interest and Attitude Inventory."
Knowing how the kidney functions, making observations in the biology lab., the dissection of the frog, etc.

24. Rothman (1968). No title.
    Thermometer, Pollution, Edison, Research, Computer, Biology, Pasteur, etc.

25. Russell and Hollander (1975). No title.
    Biology.

26. Schafer and Vargo (1976). "Self-Concept in Science."
    In Science class I am . . .

27. Spradlin (1974). No title.
    Physical Science, Doing Experiments, Making Inferences from Observations, Physical Science Instruction.

28. Turpin (1971). No title.
    Science, Pencil.

29. Wernegreen (1971). No title.
    Scientists, Science, Science Teachers, Mathematics, etc.

30. Yanagidate (1971). No title.
    Science.

APPENDIX B

PROJECTIVE ATTITUDE INSTRUMENTS

The following are references to instruments using projective techniques. Where titles are available, these are placed in quotation marks. In the absence of identifiable titles, brief descriptions are given:

1. Lowery (1966). "Projective Test of Attitudes."
2. Mead and Metraux (1957). Image of the scientist.
3. Mitias (1970). Science and scientists.
4. Perrodin (1966). Interest inventory.
5. Weingarten (1958). "Picture Interest Inventory."

APPENDIX C

INSTRUMENTS MEASURING SCIENTIFIC ATTITUDES

The following are references to instruments measuring scientific attitudes. Where titles are available, these are placed in quotation marks. In the absence of identifiable titles, brief descriptions are given.

1. Campbell (1972). "The Scientific Curiosity Inventory."
2. Cohen (1971). A test of scientific attitudes.
3. Coulter (1966). "Test of Scientific Attitude."
4. Downs (1972). "Affective Domain Measuring Scale."
5. Dunlop and Fazio (1977). "Abstract Preference Survey."
6. Edwards and Wilson (1958). "Prudent-Theoretic and Theoretic-Immediate Scale."
7. Howard and Robertson (1940). A test of scientific attitudes.
8. Hughes (1971). A test of scientific attitudes.
9. Jenkins (1969). A test of scientific curiosity.
10. Kozlow and Nay (1976). "Test on Scientific Attitudes."
11. Maddock (1975). "The Environmental Phenomena Attitude Scale."
12. Ralph (1972). "Science Attitude Scale."
13. Richardson (1971). "Scientific Curiosity and Interest Inventory."
14. Vitrogan (1965). "Generalized Attitude Toward Science Scale."

APPENDIX D

INSTRUMENTS MEASURING SCIENCE CAREER PREFERENCES

The following are references to instruments measuring science career preferences. Where titles are available, these are placed in quotation marks. In the absence of identifiable titles, brief descriptions are given.

1. Boger (1973). Career and interest scale for chemistry students.
2. Kuder (1956). "Kuder Preference Record."
3. Lee and Thorp (1956), "California Occupational Interest Inventory."
4. MacCurdy (1956). Career and interest scale.
5. Potter (1961). Scale of interest in science as a career
6. Strong and Campbell (1961). "Strong-Campbell Vocational Interest Inventory."

APPENDIX E

INSTRUMENTS MEASURING ATTITUDES ABOUT SCIENCE TEACHING

The following are references to instruments measuring attitudes about science teaching. Where titles are available these are placed in quotation marks. In the absence of identifiable titles, brief descriptions are given.

1. Good (1971). Attitudes about elementary-school science teaching.
2. Lindstrom (1974). Priorities for teaching topics in biology.
3. Moore (1973). Attitude to science teaching.
4. Pempek and Blick (1973). "Teacher Attitudinal Scale."
5. Shrigley (1974). "Science Attitude Scale."
6. Shrigley and Johnson (1974). Attitude of elementary teachers to science teaching.

APPENDIX F

INSTRUMENTS MEASURING ATTITUDES TO SPECIFIC SCIENCE SUBJECTS, AND SUBJECT PREFERENCES.

The following are references to instruments measuring attitudes to specific science subjects and to subject preferences measures. Where titles are available these are placed in quotation marks. In the absence of identifiable titles, brief descriptions are given.

1. Briggs (1976). Attitude to studying physics at university.
2. Duckworth and Entwistle (1974). Attitude to school subjects.
3. Elliott (1972). Attitudes to physics courses and lectures.
4. Gardner (1977). "Enjoyment of Chemistry Scale."
5. Glass (1970). "Biology Attitude Assessment Scale."
6. Granger and Yager (1970). Biology programs at high school and college.
7. Haladyna (1977). "Affective Reporting System" (for school subjects).
8. Halpern (1967). Academic interest measure.
9. Harvard (1968). "Academic Interest Measure."
10. Heikkinen (1973). "Student Opinion Survey in Chemistry."
11. Holden (1973). "Attitudes towards Physics."
12. Houslop and Weeks (1948). Ranking school subjects.
13. Huston (1971). Chemistry preference schedule.
14. Johnson (1976). Earth science self-evaluation questionnaire.
15. Johnstone (1974). Preference for topics in a chemistry syllabus.

16. Leader (1951). Topics and subjects in a science survey course.

17. Levine (1972). Subject preference.

18. Oines (1971). Attitude to astronomy course.

19. Ormerod (1975). "Brunel Subject Preference Grid."

20. Poole (1972). "Science Attitude Inventory" (attitudes to physics)

21. Prince (1974). School subject inventory.

22. Prouse (1964). "Prouse Subject Preference Scale."

23. Riggs (1972). Student and instructor attitude to biology and biology labs.

24. Sims (1956). "Fields-of-Study Motivation Record."

25. Snitgen (1971). Attitude to biological science.

26. Steiner (1970). Biology student behavior inventory.

27. Stonecipher (1966). School subject preference.

APPENDIX G

INSTRUMENTS MEASURING SCIENCE INTERESTS AND ACTIVITIES

The following are references to instruments measuring science interests and activities. Where titles are available, these are placed in quotation marks. In the absence of identifiable titles, brief descriptions are given.

1. Clark (1971). "Science Interest Checklist."
2. Downing (1966). "Science Interest Inventory."
3. Foster (1967). "Science Activity Inventory."
4. Hardin (1964). "Children's Activity Checklist."
5. Harvard (1968). "Activity Inventory."
6. Hasan (1975). Science interest scale.
7. Meyer (n.d.) "A Test of Interests."
8. Meyers (1975). "What I Like to Do."
9. Norris (1975). "How I Feel about School and Science."
10. Palmer (1973). "Science Interest Inventory."
11. Partin (1967). "Informal Interest Inventory."
12. Rallison (1939). Science interests.
13. Reed (Cooley & Reed, 1961). "Science Activity Inventory."
14. Safran (1969). "Safran's Student's Interest Inventory."
15. Shrigley (1968). "Science Attitude Inventory."
16. Skinner and Barcikowski (1973). Science activities checklist.
17. Stevens (1972). "Science Interest Inventory."
18. Sumner and Wilson (1972). "A Questionnaire for Students Studying Science."

19. Vanek and Montean (1972). "Science Attitude Scale."

20. Winder (1966). "An Interest Test."

APPENDIX H

INSTRUMENTS MEASURING ATTITUDES TO SCIENCE COURSES AND SCIENCE IN SCHOOL

The following are references to instruments measuring attitudes to science courses and science in school. Where titles are available, these are placed in parentheses. In the absence of identifiable titles, brief descriptions are given.

1. Anderson and Kubicek (1973). Evaluation of an earth science course.
2. Ault (1970). "Science Instruction Attitude Inventory."
3. Ayers and Price (1975). "Science Attitude Inventory."
4. Bateman (1943). Attitude toward any educational program.
5. DeGroote (1972). "School Sentiment Index."
6. Hedley (1966). "Student Attitude toward Science Scale."
7. Heffernan (1973). "Student Science Attitude Survey."
8. Hornsby-Smith (1973). Attitude to university science courses and teaching styles.
9. Keeves (1974). Attitude toward school and school learning.
10. Kelly (1961). Science in school and career.
11. Kipp (1971). Like or dislike of science in school.
12. Klopfer (1974). "How I Feel" (studying science).
13. Kruglak (1970). Reasons for not taking high school physics.
14. Lawlor (1974). What I like about science in school.
15. Pare (1973). Attitude to a course.
16. Randall (1974). Science as a school subject.

17. Remmers (1960). "A Scale to Measure Attitude Toward any School Subject".

18. Schafer and Vargo (1976). "Science Attitude Scale".

19. Shymansky et al. (1974). Self-perception in science.

20. Stanhope and Richardson (1974). Attitude to science lessons.

21. Steele, House and Kerins (1971). "Class Activities Questionnaire".

22. Thistlethwaite (1972). College press and attitude scale.

23. Weinstock and Watters (1970). Attitude to science course and teaching methods.

24. Zubulake (1970). Science as a subject.

APPENDIX I

INSTRUMENTS MEASURING ATTITUDES TO SPECIFIC SCIENCE ISSUES

The following is a reference to an instrument measuring attitudes to a specific science issue.

1. Bruvold (1974). Attitudes toward reuse of reclaimed water.

APPENDIX J

UNAVAILABLE INSTRUMENTS

The following are references to instruments which could not be obtained for this study. Accordingly, it is not known if they are relevant to measuring attitudes to science.

1. Angus (1950).
2. Caffrey and Lile (1976).
3. Champlin (1970).
4. Charen (1966).
5. Choppin (1974).
6. Daniels (1966).
7. Isserstedt and Schmidt (1971).
8. Kevin and Liberty (1974).
9. Laughton and Wilkinson (1973).
10. Newton (1975).
11. Sadler (1968).
12. Simmons and Esler (1972).
13. Simpson, Rentz and Shrum (1976).
14. Walters and Sieben (1974).
15. Waugh (1975).

APPENDIX K

INSTRUMENTS MEASURING ATTITUDES TO SCIENCE SELECTED FOR DETAILED STUDY

The following are the instruments measuring attitudes to science which were selected for detailed study. Titles are either those used by the authors or represent how the authors describe the instruments.

1. Allen (1959). "Attitudes toward Science and Scientific careers."
2. Allison (1966). "Allison Science Attitude Scale."
3. American Institute of Physics (1975). "Student Opinionnaire."
4. Arntson (1975). "Attitude Toward Science Test."
5. Baldwin & Boedeker (1975). "General Attitude Survey."
6. Bauman (1970). "Science Interest Measure."
7. Belt (1959). "Science and Scientists Knowledge Test and Opinion Survey."
8. Berkland (1973). "Science Attitude Questionnaire."
9. Billeh and Zakhariades (1975). "Scientific Attitude Scale."
10. Bixler (1958). "Public Opinion Questionnaire."
11. Brown S.A. (1975). "Attitude to Science Scale."
12. Brown S.B. (1954). "California Elementary School Science Attitude Test."
13. Bruvold (1974). "Attitude Scale."
14. Bulletin of Atomic Scientists (1971). "Attitudes on Science."
15. Clark B.M. (1968). "Post-Experimental Attitude Scale."
16. Clark W.A. (1970). "Attitude Scale."

17. Cummings (1970). "Attitudes toward Science and Scientists."

18. Dutton and Stephens (1963). "Attitudes toward Elementary School Science."

19. Eggleston (1968). "Science Pupil Opinion Poll."

20. Estes (1975). "Estes Attitude Scales."

21. Fancher and Gutkin (1971). "Science Questionnaire."

22. Feerst (1973). "Attitude Inventory."

23. Fellers (1972). "Science Students' Attitude Inventory."

24. Fisher (1973). "Science Opinionaire."

25. Fraser (1978). "Test of Science Related Attitudes."

26. Gardner (1972). "Physics Attitude Index."

27. Hackett (1972). "Affective Self-Report Instrument."

28. Hagerman (1974). "Attitude toward Science and Science Teaching."

29. Houston and Pilliner (1974). "Test of Attainment in the Affective Domain."

30. Ivany (1973). "Science Opinionaire."

31. Jaus (1977). "How I Feel about Science."

32. Kimball (1968). "Nature of Science Scale."

33. Korth (1968). "Test of Social Aspects of Science."

34. Leavers (1975). "Opinion Survey."

35. Lowery (1967). "Projective Test of Attitudes."

36. Mann (1972). "Interest in Science."

37. Moore and Sutman (1970). "Scientific Attitude Inventory."

38. Motz (1970). "Science and Scientists Attitude Inventory."

39. Myers (1967). "Attitudes toward Scientists and Science."

40. National Assessment of Educational Progress (1970, 1975, 1978). Attitude questions.

41. National Science Foundation (1977). "Attitudes of U.S. Public Toward Science and Technology."

42. Nordstrom and Friedenberg (1971). "Q-Sort Scale."

43. Novak (1958). "Scientific Attitude Test."

44. Ormerod (1976). "Brunel Socatt Scales."

45. Parish (1975). "Pre-Test and Post-Test of Science Attitudes."

46. Redford (1974). "Attitudes toward Science and Science Teaching."

47. Remmers (Heath, Maier, Remmers and Rodgers 1957, Erlick and LeBold, 1975). "Purdue Opinion Polls."

48. Schwirian (1968). "Science Support Scale."

49. Selmes (1973). "Attitudes towards Science."

50. Shallis and Hills (1975). "Image of the Scientist."

51. Skurnik and Jeffs (1971). "Science Attitude Questionnaire."

52. Swan (1965). "Inventory of Science Attitudes, Interests and Appreciations."

53. Tamir, Arzi and Zloto (1974). "Physics Attitude Scale."

54. Tilford (1973). "Attitude toward Science Scale."

55. Weinhold (1970). "Science Attitude Inventory."

56. Withey (1959). "Science and Scientists."

APPENDIX L

DETAILED DESCRIPTION AND ANALYSES OF 56 ATTITUDE INSTRUMENTS

This appendix presents one section on each of the 56 attitude instruments chosen for detailed study. Each section contains a description of the instrument's characteristics, an analysis of its items, abstracts of research studies in which the instrument is used, an evaluative commentary, and the items of the instrument itself. References are provided in each section, with ERIC numbers and Dissertation Abstracts International (DAI) volume and page numbers as appropriate.

The format of the analysis is fully described in Chapter 4 of this report.

The contents of Appendix L are listed on the following page.

ALLEN

ATTITUDES TOWARD SCIENCE AND SCIENTIFIC CAREERS: REACTION INVENTORY

Hugh Allen, Jr. Attitudes of certain high school seniors toward science and scientific careers. Bureau of Publications, Columbia University, New York, New York. 1959.

This publication is no longer available. Information about the scale comes mostly from the studies whose authors are noted. Three adaptations of this scale exist. Those of Lennek and Fiasca are treated here. The Allison adaptation is treated separately.

Instrument characteristics

Format:	95 item Likert Scalc.
Population:	Assume grade 10 - college.
View of attitude:	No explicit statement is available.
Subscales:	Impact of science in society, scientist and his work in a social setting, stereotypes of scientist, positive nature of science, motivations of the scientist.
Validity:	Six judges (scientists and professors) chosen for long experience in science and science teaching required to arrange the items. Correlations between judges ranged from .81 to .89.
Reliability:	Not available.

Analysis

Cognitive items: (58.5)	2, 3, 4, 5, 7, 9, 10, 12, 15, 16, 17, 18, 19, 21, 24, 27, 28, 31, 33.1, 34, 37, 40, 42, 43, 45, 46, 47, 48, 49, 50, 51, 53, 54, 56, 57, 58, 59, 66, 67, 68, 69, 70, 71, 72, 73, 75, 77, 79, 80, 82, 83, 85, 87, 88, 90, 91, 92, 93, 95.
Value items: (28.5)	1, 6, 8, 11, 13, 14, 22, 23, 25, 26, 32, 33.2, 35, 38, 39, 55, 60, 61, 62, 63, 64, 65, 74, 76, 78, 81, 86, 89, 94.

Attitude items: (6) 20, 30, 36, 41, 52, 84.

Self-Report of Disposition: 44.

View of Science: Explicit - Realist, items 46, 80
Instrumentalist, items 69, 85.

Implicit - Realist, item 59
Instrumentalist, items 4, 18, 57.

Additional characteristics: Double-barrelled, item 33.

Research Studies

Brown, Terrance Ralph. Attitudes toward science and critical thinking abilities of chemistry and non-chemistry students in the Tacoma Public Schools. Unpublished Ed.D. dissertation, Oregon State University, 1967. (DAI: vol. 28, p. 1611)

Reliability and validity of the Allen instrument is "assumed" in this one-year examination of attitude change. There is no difference in attitude change, and no further information about the Allen instrument appears.

Fiasca, Michael Aldo. Feasibility of integration of selected aspects of CBA chemistry, CHEMS chemistry and PSSC physics into a two year physical science sequence. Unpublished Ed.D. dissertation, Oregon State University, 1966. (DAI: vol. 27, p. 2439)

49 items selected from the Allen inventory, validity checked with a "panel of practicing scientists". Only 15 items used in the analysis (2, 16, 18, 22, 25, 26, 34, 41, 46, 64, 69, 84, 85, 90, 91), being those which yielded the largest differences between treatment and control groups. The courses do not differentially affect attitudes toward science, scientists, scientific careers and impact of science on society.

Giddings, Morsley Grenfell. Factors related to achievement in junior high school science in disadvantaged areas of New York City. Unpublished doctoral dissertation, Columbia University, 1965. (DAI: vol. 26, p. 7113)

This study used a 55 item version of the original Allen instrument, the items being carefully selected so that in a third trial with judges all agreed totally with each item. Two intellectually comparable groups (15 in each group) were studied. High science achievers demonstrated a more favorable attitude to science than did low science achievers. On the whole there were minimal differences in attitudes toward science, scientists and scientific careers. (The research explores many additional variables.)

Lawrence, Donald Allen. A study of categorizing and comparing the attitudes of secondary school students toward science utilizing multivariate statistical techniques. Unpublished Ph.D. dissertation, Southern Illinois University, 1971. (DAI: vol. 32, p. 5061)

The factor loadings did not correspond with Allen's subscales for the 561 sets of full data. 19 factors are found. A subjective analysis of groupings allowed elimination of items which did not correlate, giving a scale of 69 items for the post-test. No significant changes in attitudes were found.

Lennek, David. Open-ended experiments in junior high school science. A study of their effect on the acquisition of science information, laboratory skills and attitudes toward science. Unpublished Ed.D. dissertation, Columbia University, 1967. (DAI: vol. 28, p. 3074)

Allen scale revised for Grade 7 and reduced to 45 items. Validity determined by "judges". Reliability ($k\text{-}R_{20}$) for experimental group (n=30) .86, control group (n=31) .82. No significant change in attitude found over one semester. (This version of the Allen scale appears at the end of this section.)

Mahan, Luther Alvin. The effect of problem-solving and lecture-discussion methods of teaching general science in developing student growth in basic understandings, problem-solving skills, attitudes, interests, and personal adjustment. Unpublished Ed.D. dissertation, Pennsylvania State University, 1963. (DAI: vol. 24, p. 1097)

Validity of the Allen scale is given as "obvious", and a split-half reliability of .98 for the 1553 grade 7-9 pupils is reported. Neither method is found superior in developing "desirable" (positive) attitudes, over one academic year.

Tatara, Walter T. Effect of novels on ideas about the scientist. Journal of Educational Research, 1964, 58, 3-9.

Reports that the validity of the Allen instrument is supported by a jury of six scientists and science educators, and that the test-retest reliability of the same judges' responses is high. Over one term, IQ, reading achievement and science achievement are independent of what the 120 high school students think of the scientist. Only girls' ideas about the scientist changed significantly.

Wickline, Lee E. The use of motivational films to favorably change the attitudes of high school students toward science and scientists. ED 003 598. 1962.

No significant changes found for the students in grades 10-12 science courses. No additional information is given of the Allen instrument.

Commentary

Sixty-three per cent of the items are cognitive items; that is, they are factual questions, which might be better answered when students are given more information about science and society, and scientists. Yet little in the research suggests that student attitudes do change over instruction. Accordingly, the validity of the scale is to be suspected.

Items of the Allen Scale*

1. Science is not sufficiently appreciated by most people.

2. Science is a systematic way of thinking.

3. Scientists are seldom concerned with their working conditions.

4. The development of new ideas is the scientist's greatest source of satisfaction.

5. Friends often discourage girls from taking high school science courses.

6. Science and technology are essential to the development of present-day cultures.

7. Increased radiation resulting from bomb tests is a threat to civilization.

8. Scientists are too narrow in their views.

9. Industries use research as a means to improve their economic position.

10. The application of scientific knowledge to the development of new industries enriches society.

11. The President's cabinet should be enlarged to include a Secretary of Science.

12. The scientist will make his maximum contribution to society when he has freedom to work on problems which interest him.

13. A scientist might aptly be described as a nonconformist.

14. Scientists should be looked upon as "subjects for suspicion."

15. Scientific investigations are undertaken as a means of achieving economic gains.

16. To become a scientist requires superior ability.

17. Science requires creative activity.

18. Scientists are willing to change their ideas and beliefs when confronted by new evidence.

19. Scientists have unusually intelligent mothers.

20. Scientists are "longhairs."

21. The complexity of science hides its cultural values.

22. Modern science is too complicated for the average citizen to understand and appreciate.

23. Scientists possess too much power in our society.

24. Decisive economic, political, and social processes are greatly influenced by science.

25. It is undemocratic to favor exceptional scientific talent.

26. The monetary compensation of a Nobel Prize winner in physics should be at least equal to that given popular entertainers.

27. Hazards created by the increased use of radioactive materials make scientific work less attractive than previously.

28. Scientists are shy, lonely individuals.

29. Loyalty checks and security clearances have seriously interfered with the work of scientists.

30. For me, training for a career in science is not worth the time and effort required.

31. Science is primarily a method for inventing new devices.

32. Scientists are more emotional than other people.

33. Girls have very little mechanical aptitude, and therefore should not consider scientific careers.

34. Scientists are honored persons who stand very high in popular prestige.

35. To appreciate modern society fully, a person must understand the importance of science.

36. Scientists are an "odd" lot.

37. Science without mathematics is impossible.

38. Science is the greatest unifying force among nations.

39. Maintenance of scientific work is essential to national survival.

40. The use of scientific achievement is often hampered by selfish individuals.

41. Scientific work is boring.

42. Scientific activity is greatly influenced by culture.

43. The free flow of scientific information among scientists is essential to scientific progress.

44. I don't have the intelligence for a successful scientific career.

45. The winning of the esteem of his associates is one of the main incentives for the scientist.

46. Scientific findings always lead to final truths.

47. Scientists are as concerned as are other groups with the policies of the company for which they work.

48. Industrial developments are based more on practical experience than on laboratory research.

49. The scientist can expect to accumulate little wealth as compensation for his work.

50. Science is a man's world, there is little room in it for women.

51. Science is primarily responsible for the frequent changes which occur in our manner of living.

52. Scientists are "eggheads."

53. Scientific work requires long years of labor and self-discipline.

54. A great research scientist is little concerned with the practical applications of his work.

55. Scientists are communistic.

56. Science is an attitude towards life and environment.

57. Our foremost scientists are primarily concerned with their own thoughts and ideas.

58. Science has done little for the average citizen.

59. Scientific truths are usually found by persons seeking economic gain.

60. The neglect of basic scientific research would be the equivalent of "killing the goose that laid the golden eggs."

61. Science receives too little serious attention in the mass media.

62. Scientists today are subject to too many governmental restrictions.

63. The engineer serves a more practical purpose in society than does the research scientist.

64. There is much self-satisfaction to be received from work as a scientist.

65. A scientist's life is full of adventure.

66. The average American home discourages girls from scientific careers.

67. Universities do little scientific research that is of immediate practical value.

68. Scientists do not need the physical stamina necessary for most other work.

69. Science helps us to understand our environment.

70. Scientific concepts and discoveries often bring about new sociological problems.

71. Scientists are against formal religion.

72. "Practical" politicians and business men disregard the advice of scientists.

73. Scientists often have physical deformities which render them unfit for other work.

74. Science and its inventions have caused more harm than good.

75. The social environment of the United States is hostile to the development of scientific talent.

76. One cannot have a normal family life and be a scientist.

77. The bulk of scientific research is carried on by devoted men and women without regard for their personal living or social relations.

78. Public interest in science is essential to the maintenance of scientific research.

79. Most of the basic scientific research done in our country is carried on by industry.

80. Many specific findings in science contradict the laws of God.

81. American scientists are largely responsible for our country's status among nations.

82. Scientists are essentially magicians, making two blades of grass where one grew before.

83. Industrial research is often carried on by teams of scientific workers.

84. Scientific work is monotonous.

85. The working scientist believes that nature is orderly rather than disorderly.

86. The modern world is dominated by science.

87. Scientists as a group are often condemned for the unpopular ideas and activities of a few fellow workers.

88. Scientists are often willing to sacrifice the welfar(of others to further their own interests.

89. Scientists are usually unsociable.

90. Curiosity motivates scientists to make their discoveries.

91. The chief reward in scientific work is the thrill of discovery.

92. In high school, boys receive more encouragement to take science courses than do girls.

93. Americans place greater value on the practical applications of scientific discoveries than on the discoveries themselves.

94. Scientists and engineers should be eliminated from tl military draft.

95. Scientists display an almost irrational attachment tc their work.

Items of the Lennek Adaptation.

1. Scientists are seldom concerned with their working conditions.

2. The development of new ideas is the scientist's greatest source of satisfaction.

3. A science club is a good thing to belong to.

4. When my friends do not understand something in science, I am usually able to explain it to them.

5. Scientists should be looked upon as "subjects for suspicion."

6. To become a scientist requires above average ability.

7. Scientists are willing to change their ideas and beliefs when confronted with new evidence.

8. Scientists are often "squares."

9. I enjoy the study of science.

10. Scientists often are shy, lonely individuals.
11. For me, training for a career in science is not worth the time and effort required.
12. Science is primarily a method for inventing new devices.
13. Scientists are more emotional than other people.
14. Girls usually should not consider scientific careers.
15. Scientists are honored persons.
16. What helps me most in science is to be able to find out the principles by myself.
17. Scientists usually are an "odd" lot.
18. The work of scientists is necessary to keep our nation strong.
19. Public interest in science is essential to the maintenance of scientific research.
20. Scientists work mainly in order to become famous.
21. A scientist can never hope to become rich because of his work.
22. Science is a man's world; there is little room for women in it.
23. To be a scientist requires long years of hard study.
24. Important scientists do not care whether their work is of real use or not.
25. Famous scientists care mainly about their own ideas.
26. Big scientific discoveries are usually made by people who are looking to become rich.
27. Newspapers and magazines give too little space to news about science.
28. A scientist enjoys his work.
29. A scientist's life is full of adventure.
30. Science helps us to understand our environment.

31. Science and its inventions have caused more harm than good.

32. One cannot have a normal family life and be a scientist.

33. Most scientists go about their work without caring about themselves or others.

34. Scientists are essentially magicians, making two blades of grass where one grew before.

35. I believe that scientific work is dull.

36. The modern world is ruled by science.

37. Scientists usually are selfish.

38. Scientist are usually unfriendly,

39. Scientists work because they are filled with curiosity.

40. The chief reward in scientific work is the thrill of discovery.

41. Science is a systematic way of thinking.

42. Scientist is likely to be described as a non-conformist.

43. Scientific findings always lead to final truths.

44. Scientific concepts and discoveries often bring about new problems for society.

45. The working scientist believes that nature is orderly rather than disorderly.

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ALLISON

THE ALLISON ADAPTATION OF THE ALLEN SCALE

OR

THE ALLISON SCIENCE ATTITUDE SCALE

Roy William Allison, Sr. The effect of three methods of treating motivational films upon the attitudes of fourth, fifth and sixth grade students toward science, scientists, and scientific careers. Unpublished Ed. D. dissertation, Pennsylvania State University, 1966. (DAI: vol. 28, p. 994)

Instrument characteristics

Format:	95 item Likert Scale.
Population:	Grades 4-6.
View of Attitudes:	Not available.
Subscales:	Impact of science on society, scientist and his work in a social setting, stereotypes of scientist, positive nature of science, motivations of the scientist.
Validity:	39 high school seniors, $r = .81$. A high degree of content and construct validity is claimed.
Reliability:	Grade 4, $r = .93$ and .9. Grade 5, $r = .96$ and .92. Grade 6, $r = .97$ and .93. (All $K\text{-}R_{20}$)

Analysis

Cognitive Items: (63)	2, 3, 4, 5, 7, 9, 10, 14, 16, 17, 18, 19, 20, 21, 22, 25, 29, 32, 33, 35, 38, 39, 41, 43, 47, 48, 49, 50, 51, 52, 53, 55, 56, 57, 58, 59, 61, 66, 67, 68, 70, 71, 72, 73, 74, 75, 77, 78, 79, 81, 82, 83, 84, 85, 87, 88, 89, 90, 91, 92, 93, 94, 95,
Value Items: (26)	1, 6, 8, 11, 12, 13, 15, 23, 24, 26, 27, 28, 30, 34, 36, 40, 44, 45, 60, 62, 63, 64, 65, 69, 76, 80.
Attitude Items: (5)	31, 37, 42, 54, 86.
Self report dispositions:	46.
View of Science:	Explicit - Realist, items 32, 48, 82. - Instrumentalist, items 2, 58, 71. Implicit - Realist, items 61. - Instrumentalist, items 4, 19

Additional
Characteristics: Items which are unclear or ambiguous, or which contain grammatical or spelling errors: 21, 22, 24, 30, 34, 35, 57, 72, 73, 74, 77.

Research Studies

Allison, Roy William. (See above reference)

Three groups of grade 4, 5, 6 pupils given different treatments. Attitudes to science were changed favorably as a result of all treatments using film. Changes in attitude not related to mental age, grade level, sex, science achievement scores, plans to elect science, science training of parents, economic status.

Bell, Paul. An exploration of alternative methods for teaching large sections of general education biology. ED 037 356. 1970.

Post test only design for 400 students divided into 6 treatment groups revealed no significant differences in attitude between treatments.

Suksringarm, Paitool. An experimental study comparing the effects of BSCS and traditional biology on achievement, understanding of science, critical thinking ability, and attitude toward science of the first year students at the Sakon Nakorn Teachers College, Thailand. Unpublished Ph.D. dissertation, Pennsylvania State University, 1976. (DAI: vol. 37, p. 2764)

Reliability of the Allison scale, for three groups, was .94, .73, .91. Attitude was defined as "A set of emotionally toned ideas about science and scientific method and related directly or indirectly to a course of action. This term implies such qualities of mind as intellectual curiosity, passion for truth, respect for evidence, and an appreciation of the necessity for free communication in science." No significant differences in attitude were found. (The scale was translated into Thai, with "God" appearing as "Buddha".)

Commentary

The number of poorly worded items suggests that the scale is weak in this form. In other respects, it suffers from some of the problems of the Allen scale. That is, it contains a large number of cognitive items, whose relationship to attitudes is ambiguous, but which should correlate with the amount of information about science which is available.

Items of the Allison Scale*

1. Science is not understood enough by most people.
2. Science is an orderly way of thinking.
3. Scientists are not often bothered with the places in which they have to work.

4. The development of new ideas pleases the scientist most.
5. Friends often discourage girls from taking high school science courses.
6. Science and the use of findings of science are necessary to the development of present day living together in the world.
7. Increased "atomic fall-out" or radiation resulting from bomb tests is a threat to the world.
8. Scientists are too narrow in their views.
9. The business world uses research as a means to make more money.
10. The use of what is known in science to make new businesses makes the world better.
11. The President's cabinet should be made larger by having a Secretary of Science.
12. Scientists and engineers should not be drafted into the Army, Navy, Marines, or Air Force.
13. The scientist will make more and greater discoveries when he has freedom to work on problems which interest him.
14. A scientist might well be thought of as a man who does not follow the ways of most people.
15. Scientists should be looked upon as people who can't be trusted.
16. Scientific experiments are carried on as a means to make more money.
17. To become a scientist you must be a very smart person.
18. Science requires creative activity.
19. Scientists are willing to change their ideas and thinking when shown new facts.
20. Scientists have very smart mothers.
21. Scientists are not modern in their views on music, art, and other things, so they are called "longhairs."
22. Since science is so hard to understand, we do not see how much it helps all the people in the world to come closer together.
23. Modern science is too hard for the average citizen to understand.
24. Scientists have too much power in our society.
25. Most things decided in the world are greatly due to science.
26. It is not fair to other people to favor the leading scientists.

27. The money won by a Nobel Prize winner in Physics should be at least the same as that given to T. V. stars and movie stars.

28. Dangers created by the increased use of atomic-bomb ("radio-active") materials make scientific work less attractive than before.

29. Scientists are shy, lonely people.

30. Loyalty checks and security clearances, to see if he is a spy, have seriously slowed down the work of many scientists.

31. For me, training for a career in science is not worth the time and effort required.

32. Science is first of all a method for inventing new things.

33. Scientists show their feelings more than other people.

34. Girls know little about fixing or working with machines, and therefore should not think of becoming scientists.

35. Scientists are honored persons who stand very high in popular fame.

36. To understand modern society fully, a person must understand the importance of science.

37. Scientists are an "odd" lot.

38. Science without mathematics is impossible.

39. Science is the greatest way to bring nations together.

40. Keeping up scientific work is needed to keep our nation alive.

41. The use of scientific findings is often held back by selfish people.

42. Scientific work is boring.

43. Scientific work in a country is greatly shaped by the amount of education the people of the country have had.

44. The free flow of scientific information among scientists is important to scientific progress.

45. Scientists show too much interest in their work.

46. I don't have the brains to have a successful scientific career.

47. The winning of the praise of the people he works with is one of the main aims of the scientist.

48. Scientific findings always lead to final truths.

49. Scientists are as concerned as are other groups with the rules and ways of the company for which they work.

50. Things done in the business world are based on what happens every day than on laboratory research.

51. The scientist can expect to gather little wealth as payment for his work.

52. Science is a man's world; there is little room in it for women.

53. Science is the greatest reason for the changes that happen so often in our way of living.

54. Scientists are "eggheads."

55. Scientific work requires long years of labor and giving up some pleasures.

56. A great research scientist gives little thought to how the things he discovers can be used in daily life.

57. Scientists are communists or "reds," which means they are friendly to Russia.

58. Science is a way of thinking about life and the places in which we live.

59. Our top scientists care most about their own thoughts and ideas.

60. Science has done little for the average citizen.

61. Scientific truths are usually found by persons trying to make money.

62. Not doing much basic scientific research would be the same as "killing the goose that laid the golden eggs."

63. Science receives too little serious attention on T. V., radio, and in the newspapers.

64. Scientists today are under too many rules by the government.

65. The engineer serves a more useful place in the world than does the research scientist.

66. There is much self-satisfaction to be received from work as a scientist.

67. A scientist's life is full of adventure.

68. The average American home discourages girls from scientific careers.

69. Colleges or universities do little scientific research that is of everyday use now.

70. Scientists do not need the physical strength needed for most other work.

71. Science helps us to understand the place in which we live.

72. Scientific ideas and discoveries often bring about new problems of different peoples living together in the world.

73. Scientists are against formal religion.

74. "Practical" politicians (government workers) and business men do not pay attention to the advice of scientists.

75. Scientists often have physical things wrong with them which make them unfit for other work.

76. Science and things invented by science have caused more harm than good.
77. The people and the way people live in the United States are against more people becoming scientists.
78. One cannot have a normal family life and be a scientist.
79. Most of the scientific research is carried on by loyal men and women without regard for their personal living or having friends and parties.
80. Public interest in science is needed to keep scientific research going.
81. Most of the basic scientific research done in our country is carried on by business.
82. Many of the findings in science go against the laws of God.
83. Our country's place among nations is largely due to American scientists.
84. Scientists are mainly magicians, making two blades of grass grow where one grew before.
85. Business research is often carried on by teams of scientific workers.
86. Scientific work is dull.
87. The working scientist believes that nature is orderly rather than not orderly.
88. The modern world is run by science.
89. Scientists as a group are often blamed for the unpopular ideas and activities of a few fellow workers.
90. Scientists are often willing to give up the good of others to further their own interests.
91. Scientists are usually not friendly.
92. Being curious or nosy is what stirs or inspires scientists to make their discoveries.
93. The chief reward in scientific work is the thrill of discovery.
94. High schools try harder to get boys to take science courses than they do girls.
95. Americans place greater value on the everyday uses made of scientific discoveries than on the discoveries themselves.

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AMERICAN INSTITUTE OF PHYSICS

STUDENT OPINIONNAIRE

American Institute of Physics, New York. High school physics teaching: a report on current practices. ED 077 862, 1972.

Instrument characteristics

Format: 18 item Likert Scale.

Population: High school students.

View of attitude: Not available.

Subscales:

1. Is science responsible for today's problems? (Items 1-4)
2. Could we do without science? (Items 5-6)
3. Should scientists care about the consequences of their work? (Items 7-10)
4. Do students have a clear picture about science as a profession? (Items 11-13)
5. Does scientific work attract or repel students? (Items 14-18)

Validity: Not available.

Reliability: Not available.

Analysis

Cognitive items: (8) 1, 2, 3, 11, 13, 15, 16, 17.

Value items: (9) 4, 5, 6, 7, 8, 9, 10, 12, 14.

Attitude items: (1) 18.

View of science: None explicit or implicit.

Additional characteristics: None.

Research Studies

American Institute of Physics. (See above)

Distributed to 20.9% of grade 12 physics students in 42 schools in the north eastern states, Washington D.C., Maryland, and Rhode Island. It is reported that, overall, students are very positive and supportive of science.

Commentary

There is insufficient information to suggest that this scale is useful, reliable, and valid.

Items of the American Institute of Physics Scale

1. Science does not cause problems, the misuse of science does.
2. Industrial profits, not science are responsible for the pollution problem.
3. Modern Science is incapable of solving today's problems.
4. The world problems would have been better off without some of the recent products of science.
5. It might be well to retard scientific activities for a time.
6. Research in some fields should be given much more support.
7. A good scientist considers the consequences of his professional activity.
8. A scientist ought to be free to do whatever experimental work he feels is important.
9. Regardless of how the results of science are used, the scientist himself must share a major part of the responsibility.
10. Some kinds of experimental work should be prohibited.
11. Few professions offer opportunities superior to those a scientist might encounter.
12. Much of scientific work is dull routine.
13. Secrecy is an important positive influence upon American science today.
14. A scientific career offers a chance to do something really worthwhile.
15. The rewards of a scientific career would not repay the effort involved.
16. Scientific work is usually pretty far removed from everyday reality.
17. Only a small percentage of the population could qualify to become scientists.
18. I would like to become a scientist.

ARNTSON

THE ATTITUDE TOWARD SCIENCE TEST

Wayne Warren Arntson. The effect of an interdisciplinary course in futuristics on attitudes toward science among students in a two year college. Unpublished Ed.D. dissertation, University of Northern Colorado, 1975. (DAI: vol. 36, p. 7318)

Instrument characteristics

Format:	40 item Likert Scale.
Population:	College students.
View of Attitude:	Attitudes toward science are covert feelings but are expressed in overt opinions and actions.
Subscales:	Personal involvement. 11 items (1, 5, 7, 10, 13, 16, 19, 28, 32, 35, 38.)
	Science and scientists are strange. 6 items (4, 9, 17, 20, 26, 27.)
	Science and money. 11 items (3, 8, 12, 14, 15, 24, 25, 31, 33, 34,36.)
	Personal involvement. 12 items (2, 6, 11, 18, 21, 22, 23, 29, 30, 37, 39, 40.)
Validity:	A panel of 11 science educators selected best 30 items. The top 25 items, having 90% or more agreement were chosen. These were given alternate forms for a scale of 50 items in the pilot study. The ten least discriminating items were removed.
Reliability:	Test-retest for the control group (n=40), r=.68.

Analysis

Cognitive items: (3)	9, 19, 27.
Value items: (31)	1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 13, 14, 15, 16, 17, 18, 20, 22, 24, 25, 26, 28, 31, 32, 33, 34, 35, 36, 37, 38, 40.
Attitude items: (6)	11, 21, 23, 29, 30, 39.
View of science:	Explicit - Instrumentalist, item 10.
	Implicit - Realist, items 6, 13, 32.
Additional characteristics:	Ambiguous items 4, 36.
	Grammatically incorrect item 6.

Research Studies

Arntson, Wayne Warren. (See above)

No significant attitude change over one semester between experimental (n=40) and control (n=40) groups. Significant positive correlation (r=.347) between attitude change and score on American College Test (Science).

Commentary

Generally, this appears to be an unambiguous instrument, with only minor problems.

Items of the Arntson Scale*

1. Our lives are generally improved by science.
2. Scientists are less useful to society than most other professionals.
3. We spend too much school money on science subjects.
4. Knowledge of science is interesting but unnecessary for most people.
5. People would be happier with fewer of the "benefits" of science.
6. A search for answers to natural phenomena is a worthy career.
7. We would be better off without science.
8. A non-scientist should be willing to spend money on scientific research.
9. Our lives are not directly involved with science.
10. Some occurrences in nature should be explained by something other than science.
11. I would like to belong to a science club.
12. We should give more science scholarships than we do now.
13. It is usually not advisable to investigate the secrets of nature.
14. Our government should help finance scientific research.
15. We should spend more school money on science subjects.
16. Everyone should have a basic understanding of science.
17. Knowledge of science is necessary for most people.
18. Being a laboratory assistant should be interesting.
19. Scientific discoveries usually make people happier.
20. Most scientists are extremely narrow-minded.
21. I would not encourage any friend of mine to enter science.

22. A career in science is not usually worthwhile.
23. I enjoy reading articles about science.
24. Money spent for scientific research is money wisely spent.
25. Non-scientists should oppose spending tax money on scientific research.
26. Scientists should stay out of politics.
27. Science is interwoven with all facets of our lives.
28. Science has helped man more than it has hindered.
29. Science clubs have no interest for me.
30. I would enjoy a science related hobby.
31. There are too many science scholarships now available.
32. Man must continue to investigate all of Nature's secrets.
33. Too much money is spent on scientific research.
34. Scientific research should not rely on any government funds.
35. Basic science is not necessary for everyone.
36. Scientific research should continue even though positive results are never assured.
37. Assisting in the laboratory is probably a dull job.
38. Science has hindered man more than it has helped.
39. Hobbies related to science are dull.
40. Students should not be encouraged to become scientists.

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BALDWIN AND BOEDEKER

GENERAL ATTITUDE SURVEY

T.O. Baldwin and R.R. Boedeker. Nonscience student attitudes toward science, physics and two introductory physical science courses. Journal of College Science Teaching, 1975, 4, 179-182.

Approximately one third of the survey addressed attitudes toward science, and this is reported below. The remainder of the survey sampled views about physics courses and is not included in the present report.

Instrument characteristics

Format:	5 item True/False Scale.
Population:	College freshmen.
View of attitude:	Not stated.
Subscales:	Three subscales are implicit: science courses (item 3), scientists (item 2), science (items 1, 4, 5).
Validity:	Not stated.
Reliability:	Not stated.

Analysis

Cognitive items: (1)	4.
Value items: (4)	1, 2, 3, 5.
View of science:	Not evident.

Research Studies

Baldwin, T.O. and Boedeker, R.R. (See above)

Random surveys of freshmen conducted at Southern Illinois University (Edwardsville) in 1971-72 (n=770) and fall 1972 (n=265). No significant differences are found, and it is concluded that "there is no anti-science attitude among these students."

Commentary

An instrument of this length whose characteristics are unknown does not give cause for confidence in the results obtained from its use.

Items of the Baldwin and Boedeker Scale*

1. Science has been overemphasized in our society.
2. Scientists have a greater moral responsibility than nonscientists in relation to technology caused problems.
3. Some science courses should be required of all college students.
4. There is currently a youth revolution against science.
5. Science is justifiably being blamed for many of society's ills.

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BAUMAN

SCIENCE INTEREST MEASURE

Daniel Joseph Bauman. Measurement and analysis of science interest in a school district. Unpublished Ph.D. dissertation, University of Colorado, 1970. (DAI: vol. 31, p. 4573)

Instrument characteristics

Format:	Three formats were used, each employing the same 40 items. Semantic differential, Likert, and Q-sort.
Population:	Grade 10, 11 and 12 students
View of attitude:	Not explicitly stated. Items are selected from those in 19 available attitude measures.
Subscales:	Thinking of being a scientist (Items 1-8)
	Working on science problems (Items 9-16)
	Reading science investigation reports (Items 17-24)
	Following a scientific procedure (Items 25-32)
	Working in a science laboratory (Items 33-40)
Validity:	Factor analysis of items showed internal validity.
Reliability:	Semantic differential, r=.94
	Likert, r=.94 Q-sort, r=.81

Analysis

Attitude items:	All 40 items are attitude items.
View of science:	Not evident.

Research Studies

Bauman, Daniel Joseph. (See above)

The purpose of this study was to compare relationships among science interest data collected by three formats of the same instrument: semantic differential, Likert, and Q-sort. 600 students were tested, 200 for each format. Teacher ratings of students were also obtained. Factors compared to recommending the course to others, selecting favorite subject, teacher rating, reported grade and self rating in terms of grades. Correlations between scales and teacher ratings all less than .4. It is concluded that the science interest measure is influenced by the testing format.

Commentary

The instrument was devised to investigate the format's influence on attitude measure and may not itself be attractive as an attitude measure. Yet its characteristics suggest that it is quite sound.

Items of the Bauman (Likert) Scale*

1. Thinking of being a scientist is interesting.
2. Thinking of being a scientist is enjoyable.
3. Thinking of being a scientist is useful.
4. Thinking of being a scientist is exciting.
5. Thinking of being a scientist is complex.
6. Thinking of being a scientist is active.
7. Thinking of being a scientist is good.
8. Thinking of being a scientist is easy.
9. Working on science problems is interesting.
10. Working on science problems is enjoyable.
11. Working on science problems is useful.
12. Working on science problems is exciting.
13. Working on science problems is complex.
14. Working on science problems is active.
15. Working on science problems is good.
16. Working on science problems is easy.
17. Reading science investigation reports is interesting.
18. Reading science investigation reports is enjoyable.
19. Reading science investigation reports is useful.
20. Reading science investigation reports is exciting.
21. Reading science investigation reports is complex.
22. Reading science investigation reports is ac[illegible]
23. Reading science investigation reports is [illegible]
24. Reading science investigation reports is [illegible]
25. Following a scientific procedure is intere[illegible]
26. Following a scientific procedure is enjoyable.
27. Following a scientific procedure is useful.
28. Following a scientific procedure is exciting.
29. Following a scientific procedure is complex.
30. Following a scientific procedure is active.

31. Following a scientific procedure is good.
32. Following a scientific procedure is easy.
33. Working in a science laboratory is interesting.
34. Working in a science laboratory is enjoyable.
35. Working in a science laboratory is useful.
36. Working in a science laboratory is exciting.
37. Working in a science laboratory is complex.
38. Working in a science laboratory is active.
39. Working in a science laboratory is good.
40. Working in a science laboratory is easy.

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BELT

SCIENCE AND SCIENTISTS

KNOWLEDGE TEST AND OPINION SURVEY

Sidney Leon Belt. Measuring attitudes of high school pupils toward science and scientists. Unpublished Ed.D. dissertation, Rutgers University, 1959. (DAI: No. 20, p. 3625)

Instrument characteristics

Format:	Part I, 30 items, multiple choice. Timed, 20 minutes. Part II, 30 items, Likert type. Timed, 20 minutes.
Population:	College bound high school students.
View of attitude:	Allport's definition of "readiness to respond" is cited.
Subscales:	A. Science as an institution (10 items per subscale) Scientific methodology. (Items 4, 8, 13, 17, 24, 32, 36, 40, 44, 58) Science as a contributor to human welfare. (Items 1, 3, 19, 23, 28, 39, 43, 47, 50, 54) Limitations of Science. (Items 7, 12, 16, 18, 22, 31, 35, 49, 53, 57) B. The scientist Characteristics of the Scientist (Items 6, 11, 15, 26, 27, 34, 38, 42, 46, 60) The scientist at home and in the community. (Items 2, 10, 14, 21, 30, 33, 45, 48, 52, 56) Limitations of scientists in activities other than their own specialties. (Items 5, 4, 20, 25, 29, 37, 41, 51, 55, 59)
Validity:	The items of Part I "Test of Knowledge of Science and Scientists" were taken from the files of Educational Testing Service. Two items of Part II "Opinion Survey on Science and Scientists"

were taken from Poll 45 of the Purdue Opinion Poll, 23 came from Poll 50, and 5 were developed by Belt.

Reliability: Boys, .65; girls, .579.

Analysis

Only items in Part II "Opinion Survey on Science and Scientists" are analyzed here. Items in Part I, "Test of Knowledge" are all cognitive items.

Cognitive items: (20) All but 10 items are cognitive items.

Value items: (7) 32, 39, 40, 49, 50, 51, 53.

Attitude items: (2) 38, 60.

Self-Report Dispositions: (1) 44.

View of science: Implicit - Instrumentalist, items 55.

Realist, items 57, 58.

Research Studies

Belt, Sidney Leon. (See above)

279 boys and 237 girls (all college-bound seniors) were surveyed. Boys and girls achieved essentially the same mean scores on both tests. Although a significant positive correlation was observed between the attitude and perception tests, the intercorrelation was too low to consider them measures of the same function. When rank in class was partialled out of the intercorrelations between attitude and perception tests, the intercorrelations dropped only slightly. The results agreed with those of the Purdue Opinion Poll.

Commentary

The two parts of this scale are very interesting. Part I, a knowledge test, contains items that seem to be similar to items which appear later in attitude scales. Part II, the opinion survey, has a large number of cognitive items in it, and it is sometimes hard to see why Belt placed some items in Part I and others in Part II.

Items of the Belt Instrument*

Part I: Knowledge of Science and Scientists Test

(Although this is a knowledge test, the items are included here so that they may be compared with attitude items in other scales.)

1. More scientific progress has been made in the last fifty years than in any similar period. It is reasonable to conclude that

   (A) new discoveries will be less frequent since so much is known already

   (B) the rate of new discoveries will be about the same for the next fifty years

   (C) the rate of new discoveries will continue to increase

2. Among scientists as a group you would expect to find

   (A) an unusually large proportion of highstrung, emotional persons

   (B) about the same proportion of highstrung persons you would find in most groups

   (C) an unusually small number of highstrung persons

3. In the long run, the increased use of automatic machines in factories will tend to

   (A) put people out of work

   (B) make more jobs

   (C) increase the cost of the product

4. Which one of the following is the best way of aiding pure science?

   (A) Providing well-equipped laboratories

   (B) Setting up a system for classifying new facts

   (C) Choosing very competent men to do the work

5. The reason that very few scientists run for political office is that

   (A) they have difficulty speaking to the average voter

   (B) they are not interested in the problems discussed during election

(C) their training and experience is in a different area

6. Which of the following characteristics would it be most helpful for a scientist to have?

   (A) Aggressiveness

   (B) Thriftiness

   (C) Curiosity

7. Science has shown that

   (A) a person's fate is determined by the arrangement of the stars at the time of his birth

   (B) people generally die of the same diseases as their parents

   (C) identical twins always have the same color eyes

8. Some scientific theories must be discarded because

   (A) recent scientific discoveries have proven them untrue

   (B) they are dangerous to the welfare of man

   (C) they are found to have no practical use

9. Few chemists choose to work in the advertising departments of the companies for which they work because

   (A) chemists make more money

   (B) chemists are not trained for advertising work

   (C) chemists would not agree with the advertisements

10. Which one of the following is the most common reason why children of scientists enjoy spending time with their fathers?

    (A) Most children enjoy spending time with their fathers.

(B) Scientists are able to tell their children exciting stories.

(C) Scientists are able to help their children build things.

11. Bill always makes good grades in school but is a practical joker. Frank also makes good grades but has no sense of humor. Which of the boys probably could become a scientist?

(A) Bill

(B) Frank

(C) Both Frank and Bill

12. Which of the following problems is NOT a legitimate subject for scientific study?

(A) Who is the better painter, Picasso or Renoir?

(B) Does smoking cause lung cancer?

(C) Is it possible to read another person's mind?

13. Of the following, which is the most important characteristic of science?

(A) As many facts as possible are acquired and classified.

(B) Statements are not made unless absolutely true.

(C) Science discovers and corrects its own mistakes.

14. It has been shown that the early childhood of most scientists is

(A) less exciting than that of most children

(B) less happy than that of most children

(C) very much like that of most children

15. If a person hopes to be an outstanding scientist, he probably will need to be

(A) average in intelligence

(B) above average in intelligence

(C) a genius

16. Scientific discoveries sometimes cause trouble. The best solution is to

    (A) stop all scientific work until the trouble is corrected

    (B) ask scientists to help write laws to correct the difficulty

    (C) ask scientists, as well as other persons, to study the problem

17. A good scientist

    (A) recognizes problems that need to be solved

    (B) waits until a problem presents itself

    (C) accepts only those problems of practical value to people

18. Modern scientific weather devices help us to

    (A) predict hurricanes, tornadoes, and cyclones

    (B) prevent hurricanes, tornadoes, and cyclones

    (C) live without fear of major damage from storms

19. So many advances in science have been made that

    (A) there are not many opportunities for qualified people

    (B) there is a growing need for qualified people

    (C) there is a growing need for government control

20. In a certain chemical company Mr. Jones, who was both vice-president and treasurer, retired. Which one of the following employees would probably be best qualified to succeed him?

    (A) The chief chemist

    (B) The head accountant

    (C) the director of research

21. Most scientists would probably prefer to spend a day off

    (A) reading science journals

(B) planning their next experiment

(C) in activities with their families

22. One of the reasons why dropping germs over enemy territory in time of war is not outlawed is because scientists

(A) do not feel responsible for the effects their discoveries have on people

(B) do not have control over how their discoveries affect people

(C) recognize that survival of the fittest is a law of nature

23. Which one of the following is the reason that scientists most often give for enjoying their work?

(A) Their fellow workers are pleasant to work with.

(B) They feel that what they are doing is important for society.

(C) Their work gives them a steady, secure income.

24. Most of the recent discoveries in atomic physics are the result of the work of

(A) American physicists

(B) European physicists

(C) physicists of many nationalities

25. A scientist and a banker were running for public office. In deciding how to vote, which statement would you consider most accurate?

(A) The scientist probably is a radical and the banker a conservative.

(B) The banker probably is a radical and the scientist a conservative.

(C) A man's job does not indicate whether he is a conservative or a radical.

26. The main difference between scientists and other people of equal intelligence is that scientists

(A) have received special training

(B) are less interested in enjoying life

(C) believe that right is might

27. Three men work for the same company. The first is in the research division, the second is a plant foreman, and the third is in the sales department. The answer to which of the following questions would help you most in selecting the man from the research department?

    (A) Which man has the most college degrees?

    (B) Which man is the hardest worker?

    (C) Which man is the most serious-minded?

28. Which one of the following is the best reason for taking science courses in school?

    (A) Studying science enables us to solve problems of democracy more efficiently.

    (B) Studying science makes life more interesting.

    (C) Studying science improves one's vocabulary.

29. It has been suggested that scientists and other well-educated people be given more than one vote in elections. Which of the following is the best argument for opposing this?

    (A) Such people are often unrealistic and impractical.

    (B) Such people are often disloyal to American ideals and the American way of life.

    (C) Such people should have the same rights as other citizens.

30. More security risks have been discovered among scientists than among historians because

    (A) a greater number of scientists have been investigated

    (B) scientists are more easily influenced by subversives

    (C) many scientists have been educated abroad

Part II: Opinion Survey on Science and Scientists

The 5-point response scale is:

Agree
Undecided, probably agree
Indifferent
Undecided, probably disagree
Disagree

31. Things like the development of the atom bomb indicate that scientists have little regard for humanity.

32. One of the best ways to advance science is to allow individual scientists to work on problems that interest them.

33. Most scientists, as children, led normal lives.

34. Most scientists are geniuses.

35. Science has its place, but there are many things that can never be understood by the human mind.

36. The willingness of the scientist to reject traditional beliefs

37. Scientists are likely to be more radical about matters outside their own field than non-scientists.

38. Most scientists are more than a little bit "odd".

39. The goal of science is to benefit mankind.

40. Money should be given for scientific research even though the results may not be of immediate practical value.

41. Scientists are more likely than most people to listen to both sides of an argument.

42. Scientists are more truthful than most people.

43. Scientific training leads to good citizenship.

44. I would view with suspicion any findings reported by a scientist of certain other countries.

45. The scientist is not able to have a normal family life.

46. Scientists are more willing than nonscientists to sacrifice the welfare of others to further their own interests.

47. If it were not for science, we would still be living in ignorance and disease.

48. The scientist is likely to be more patriotic than other people.

49. Scientific methods should be applied to human problems, like segregation and poverty, as well as to machines and modern conveniences.

50. Science has now reached the state where future major discoveries can only destroy mankind.

51. Scientists are the most important people in our society.

52. Scientists are more likely to be mentally ill than people who are engaged in other types of work.

53. All scientists should be employed by the government so that control can be maintained on their findings.

54. Scientists who work in colleges and universities are so removed from everyday life that they have little to contribute to practical problems.

55. Scientists tend to be as successful as businessmen.

56. Scientists, in general, make good husbands and fathers.

57. Even though every person is different, it is possible to establish scientific laws of human action.

58. The scientist seeks to find out the truth with no thought of the consequences of his work.

59. Scientists are usually impractical in the way they try to solve the problems of everyday living.

60. There is something evil about scientists.

BERKLAND

SCIENCE ATTITUDE QUESTIONNAIRE

Terrill Raymond Berkland. An investigation of the understanding of science processes and attitudes toward science of prospective elementary teachers from an unstructured science foundations course and nonscience students from a structured earth science course. Unpublished Ph.D. dissertation, University of Iowa, 1973. (DAI: vol. 34, p. 5741)

Instrument characteristics

Format:	20 item Likert-type scale. (A five point scale is given, but the poles change as shown below.)
Population:	College students.
View of attitude:	Not available.
Subscales:	Three implicit subscales can be detected Attitude to science. (Items 1, 2, 5, 13, 14, 15, 17) Attitude to science course. (Items 3, 4, 6, 7, 8) Instructional Preference. (Items 9, 10, 11, 12, 16, 18, 19, 20)
Validity:	Not stated.
Reliability:	Not stated.

Analysis

Cognitive items: (1)	12.
Value items: (7)	6, 8, 11, 15, 16, 17, 20.
Attitude items: (12)	1, 2, 3, 4, 5, 7, 9, 10, 13, 14, 18, 19.
View of science:	None evident.
Additional characteristics:	The instructions are unclear for the example fails to indicate which response is meant to indicate a "moderate no".

Research Studies

Berkland, Terrill Raymond. (See above)

An experimental group (n=49) takes a science foundations two-semester course, while the control group (n=137) takes an earth science course. Only item 12 showed a significant change from

from pre- to post-testing, although a change from "agree" or "disagree" to "no opinion" (or vice versa) was scored as "no change".

Commentary

The design of the instrument probably deters from its usefulness, and information about its reliability and validity are needed before results can be viewed with any confidence.

Items of the Berkland Scale*

As noted above, the poles in the five point scale change: in some items the poles are YES/NO, in others Student/Instructor, Friendly/Aloof, as shown below in parentheses.

1. Is science one of your favorite subjects (Yes/No)
2. Would you consider pursuing a career in science? (Yes/No)
3. Would you be taking a science course in college if it were not required? (Yes/No)
4. Did you find this course interesting? (Yes/No)
5. Does the study of science seem important to you? (Yes/No)
6. Will what you learned from this course ever be useful? (Yes/No)
7. Did you enjoy this course? (Yes/No)
8. Do you find science difficult or easy? (Difficult/Easy)
9. Would you rather have an instructor discuss the material with you individually or in a group? (Individually/In a group)
10. Would you prefer to have a prepared set of laboratory and discussion topics or to do individual projects and reports (activities) of your own choosing? (Prepared/Own choosing
11. Who should do more talking in discussions, students or instructor? (Students/Instructor)
12. Can students make investigations in science without knowing much about the subject? (Yes/No)
13. Do you watch T.V. specials that pertain to science? (Yes/No)
14. Do you read books, magazines, or newspaper articles on topics related to science when you come across them? (Yes/No)

15. Are scientists more likely to be friendly or aloof? (Friendly/Aloof)

16. Is it more important that your instructor be a good teacher or be good in science? (Good teacher/ Good in science)

17. Should students be required to take at least one year of science in college? (Yes/No)

18. Do you prefer to be actively involved (ask questions, discuss, work independently) in your science classes or to listen to lectures on the subject? (Active/Listen)

19. Do you prefer laboratory work or readings? (Laboratory/Readings)

20. Do you work better in small groups or alone? (Small groups/Alone)

BILLEH AND ZAKHARIADES

THE SCIENTIFIC ATTITUDE SCALE

Victor Y. Billeh and George A. Zakhariades. The development and application of a scale for measuring scientific attitudes. Science Education, 1975, 59, 155-165.

Instrument characteristics

Format:	36 item Thurstone Scale.
Population:	Grade 10 and 12 students, sophomores and science teachers.
View of attitude:	Scientific attitude has six components: rationality, curiosity, openmindedness, aversion to superstitions, objectivity-intellectual honesty, suspended judgment. It depends on exposure to science.
Subscales:	6, the item numbers for each are not identified. Rationality (7 items), curiosity (5 items), openmindedness (6 items), aversion to superstitions (5 items), objectivity (6 items), suspended judgment (7 items).
Validity:	Face validity determined by having 45 scientists sort 87 statements into 11 piles. The Q value was found by calculating the interquartile range of the distribution. Scale value is found from the median of distribution of judgments for each statement.
	Content validity determined from a pilot study of 88 grade 10 and 12 students. 10 items eliminated for low discrimination indices.
	Construct validity determined from the study (below). It was predicted that the greater the exposure to science, the greater the attitude score.
Reliability:	Split half, r=.55 to .74

Analysis

Cognitive items: (13)	1, 5, 6, 7, 8, 9, 20, 24, 27, 28, 30, 32, 34.
Value items: (4)	11, 14, 23, 35.
Attitude items: (1)	3.

Test of Possession-Disposition: (18)	2, 4, 10, 12, 13, 15, 16, 17, 18, 19, 21, 22, 25, 26, 29, 31, 33, 36.
View of science:	Explicit - Instrumentalist, item 31.
	Realist, items 10, 11, 15.
	Implicit - Instrumentalist, items 1, 2, 4, 13, 20, 22, 25, 26, 36.
	Realist, item 7.
Additional characteristics:	Ambiguous item, 29.

Research Studies

Billeh, V.Y., and Zakhariades, G.A. (see above)

Instrument administered to grade ten and twelve students, to university sophomores and seniors, and to science teachers with science degrees. Except for the differences between grade 12 and sophomores, and between seniors and science teachers, those groups with more science exposure outperformed those with less on the attitude scale at a statistically significant level. Science grades were correlated with attitude scores for grade 10 and 12 students, giving r=.247 and .248, respectively, which are significant at the .01 level.

Commentary

Many items of the scale depend on (or ask for) a philosophical position on the nature of science, providing a different view of an attitude to science. This is partly reflected in the titles of the subscales, and this is consistent with the large number of items measuring the possession of scientific attitudes rather than attitudes to science. While correlations with science grades are significant, they account for less than 7 per cent of the variance, raising questions about the validity of the scale.

Items of the Billeh and Zakhariades Scale*

	S	Q
1. Knowledge is promoted if every new idea in a field is accepted immediately after it is reported.	1.6	1.8
2. Whenever there is insufficient evidence either for or against a proposition, the wisest thing is neither to accept it nor to reject it.	9.9	1.7

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3.	Listening to new ideas is a very interesting and pleasing activity.	9.7.	2.1
4.	If one of our ideas is poor, we should hold this idea although it is proved to be poor.	1.8	1.8
5.	Students who are keen to learn new ideas despite their inadequate knowledge are likely to become scientists.	7.0	2.9
6.	The records of the observations of a scientist reflect the personal feelings of the scientist.	2.7	2.2
7.	In unscientific discussions one may hear that someone is willing to prove that a certain idea or opinion is absolutely correct.	8.1	3.0
8.	Experimental testing of a new idea is mainly carried out to satisfy the person who first suggested the idea.	3.0	3.0
9.	Fortune tellers usually flourish in scientific communities.	1.3	1.7
10.	Knowledge, once accepted, is not subject to change.	1.2	1.2
11.	Scientific explanations should be preferred to the romantic stories of astrologers and magicians.	9.9	2.3
12.	Dr. E., a very famous scientist, presented a new theory and Dr. A., a young scientist who had graduated two years before, had some doubts about this theory. Dr. A should accept the theory because it was presented by Dr. E.	1.4	1.4
13.	People should be willing to change their ideas if enough evidence shows that their ideas are poor.	10.5	1.7
14.	In interpreting the results of his work, a scientist should not be affected by external social conditions.	9.9	2.1
15.	If a few facts agree with some ideas it can be concluded that these ideas are true.	2.7	2.2
16.	A questioning attitude should dominate the approach to any novel situation.	9.5	2.3
17.	Explanations can only be made if observable data can be collected.	9.4	1.9
18.	One should not criticize the work of others.	2.2	2.4

19.	Novel situations which cannot be explained with the existing body of knowledge are undesirable.	2.7	2.9
20.	Questioning opinions and ideas has nothing to do with scientific behavior.	2.5	2.6
21.	One should express one's judgement about new ideas and new discoveries immediately after one learns of them.	3.3	2.5
22.	Newly discovered ideas should be reported unchanged even if they contradict existing ones.	10.6	1.3
23.	The editor of a well-known journal should not accept for publication research studies of beginners.	1.5	1.7
24.	Meteorologists can predict the weather with high probability.	8.5	1.9
25.	When traditional beliefs are in conflict with scientific discoveries, it is better to accept the traditional beliefs.	2.4	1.7
26.	It is worthless to listen to a new idea unless all people accept it.	1.2	0.8
27.	A successful scientist is more objective than a politician.	9.8	2.2
28.	Knowledge in a country is promoted if local publications include the writings of famous and unknown writers.	8.6	1.9
29.	The largest attendance at cinemas occurs on Saturday evenings and the largest attendance at church occurs on Sunday mornings. Whenever there are many people watching a film, the following day many people should go to church.	1.2	1.2
30.	Astrology is a science which contributes to the better understanding of people.	1.4	1.5
31.	Knowledge should be considered tentative.	8.8	2.5
32.	Seeking further information about a novel situation is considered a sound approach to begin with.	9.8	2.3
33.	Criticism benefits the advancement of knowledge.	10.3	1.1
34.	Intelligence is the main factor that contributes to the advancement of knowledge.	7.7	2.6
35.	For weather predictions, magicians and astrologers should be consulted.	1.3	1.3
36.	Enough evidence supporting a certain idea should be provided before the idea is accepted.	10.2	2.0

PUBLIC OPINION QUESTIONNAIRE

James Edward Bixler. The effect of teacher attitude on elementary children's science information and science attitude. Unpublished Ph.D. dissertation, Stanford University, 1958. (DAI: vol. 19, p. 2531)

The instrument appears to be adapted from Franklin P. Kilpatrick A technique for the measurement of attitudes. Unpublished M.Sc. thesis, University of Washington, 1947.

Instrument Characteristics

Format:	14 item, six-point, Likert-type Scale.
Population:	Intermediate grade level teachers.
View of attitude:	Not available.
Subscales:	Not available.
Validity:	Not available.
Reliability:	Not available.

Analysis

Cognitive items: (3)	5, 11, 12.
Value items: (11)	1, 2, 3, 4, 6, 7, 8, 9, 10, 13, 14.
View of science:	None explicit or implicit.
Additional characteristics:	Ambiguous item, 13.

Research Studies

Bixler, James Edward. (See above)

The science attitudes of 62 teachers were found, and the pre- and post-test scores of their 1481 pupils were obtained (over 5 months) on the California Test of Mental Maturity and the Brown's California Elementary School Science Information and Science Attitude Test. The effect of teacher attitude on pupil science information was not significant, but there was a significant effect on pupil science attitude. Pupil science attitude was inversely related to intelligence at a significant level.

Commentary

Too little information is available on this scale to make any judgment other than that information about its performance is nee tems of the Bixler Scale*

1. Science cannot be trusted to work for human welfare.
2. It would be wise to support science to a greater extent.
3. If all the scientific discoveries of the last twenty years had not taken place, the world would be better off.
4. I doubt that science would be helpful in solving any of our social problems.
5. Science is making life too complicated.
6. Science spends too much time on worthless investigation.
7. We should attempt to develop science to its full capacity.
8. The rapid development of science should be encouraged.
9. The world should spend more money on scientific investigation than it does.
10. We should limit the freedom of scientific research.
11. One result of science has been to lower the general intellectual level through mass production of facts.
12. Science has a system of thought that is rigid and unproductive.
13. Science ought to be encouraged because of its progressive attitude.
14. Children should be encouraged to appreciate the value of science in everyday life.

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BROWN

ATTITUDE TO SCIENCE SCALE

Sally A. Brown. Affective objectives in an integrated curriculum. Unpublished Ph.D. dissertation, University of Stirling, 1975. (DAI: Not available.)

Sally Brown. Attitude goals in secondary school science. Stirling Educational Monographs No. 1. University of Stirling, 1976. ED 120 019

Sally A. Brown and Terence N. Davis. The development of an attitude to science scale for 12-14 year olds. Scottish Educational Studie 1973, 5, 85-94.

Instrument Characteristics

Format: 60 item Likert Scale.

Population: 12-14-year-olds.

View of attitude: Attitudes may range from highly cognitive to highly affective, they are multidimensional

Subscales: Five are identified, 12 items in each:

1. Inter-relationship of different science disciplines. (Items 2, 8, 17, 19, 22, 25, 27, 32, 50, 54, 55, 59.)
2. Relationship of science to other school disciplines. (Items 3, 5, 7, 9, 12, 15, 23, 37, 42, 43, 53, 60.)
3. Social and economic implication for scienc and community. (Items 11, 14, 20, 21, 26, 38, 44, 45, 49, 51, 56, 58.)
4. Interest and enjoyment. (Items 4, 18, 24, 30, 31, 33, 35, 36, 39, 41, 47, 57.)
5. Objectivity. (Items 1, 6, 10, 13, 16,28, 29, 34, 40, 46, 48, 52.)

Validity: Items collected from first and second year comprehensive school pupils. 150 items submitted to a panel of 8 judges. Those 100 items on which judges agreed were selected and administered to 49 primary pupils, 64 first yea and 63 second year comprehensive school pupils. Final scale of 60 items composed from the 100 items on the basis of a statistically significa (.01) "t" for the difference between high and low means of groups of items. Inter-subscale correlations significant at .001 level.

Reliability: Test-retest for the above pupils, r=.93, .86, .92 respectively, for total scale. (Lowest value of r=.55 for subscale 1, primary pupils.) Split-half reliability for total test, r=.93.

Analysis

Cognitive items; (29)	2, 3, 5, 7, 9, 11, 12, 15, 17, 19, 20, 21, 23, 25, 26, 37, 42, 43, 44, 46, 49, 50, 51, 52, 54, 55, 56, 59, 60.
Value items: (10)	1, 8, 14, 22, 27, 32, 38, 45, 53, 58.
Attitude items: (12)	4, 18, 24, 30, 31, 33, 35, 36, 39, 41, 47, 57.
Test of Possession - Disposition: (9)	6, 10, 13, 16, 28, 29, 34, 40, 48.
View of science:	Explicit - Instrumentalist, items 16, 48. Realist, items 13, 40. Implicit - Realist, items 6, 29, 52
Additional characteristics:	Half of the items are scored positively, the remainder negatively.

Research Studies

Brown, Sally A. and Davis, Terence N. (See above)
(This study was performed on the data used to establish the initial reliability and validity of the scale.)

Two-way ANOVA, and subsequent "t" tests on data obtained on 49 primary pupils, 64 first year and 63 second year comprehensive pupils. Significant relationship between "awareness of the interrelationship of the different disciplines of science" and intelligence for first year but not second year pupils. No relationship between intelligence and "interest". Some sex differences are noted.

Brown, Sally. Attitude goals in secondary schools. (See above)

Reports a regression analysis of scores obtained from 2815 pupils, by subscale. Characteristics of schools and science class account for little variance. Sex, social class, intelligence and initial attitude account for more variance, from 13 to 36 per cent.

Brown, S.A. Affective objectives in an integrated curriculum. (See above)

Factor analysis of post-test responses obtained from 2815 pupils. First four factors are of subscales 1, 2, 4 and 5 respectively, confirming their validity.

Commentary

This is a polished attitude scale with well differentiated subscales. The present analysis of attitude items exactly corresponds with the author's items in subscale 4, "interest and enjoyment." Subscale 5, "objectivity", is largely a test of this disposition. Of the three items not presently analyzed as belonging in this subscale, items 1 and 46 do not load unambiguously and substantially on the factor associated with this scale (item 52 does) in both 5 factor and 7 factor analysis. This is a small problem in an otherwise excellent instrument.

Items of the Brown Scale

1. "Scientists should criticize each others' work".
2. "Chemical reactions are of interest only to those who learn chemistry".
3. "A knowledge of acids and alkalis is useful in cooking".
4. "I would enjoy doing scientific work when I leave school".
5. "Mathematics is a great help to science".
6. "If the teacher and I do the same experiment but get different results, the teacher's result is the right one".
7. "Science is very useful to several of my other school subjects".
8. "Biologists studying plants and animals do not need to know anything about electricity".
9. "Science is of no use to anyone who is going to be a physical education teacher".
10. "If a famous scientist and an unknown scientist disagree we accept the opinion of the famous scientist".
11. "Scientists do nothing for me".
12. "Geography provides examples of things we learn about in science".
13. "Science teachers know the scientific truths".
14. "Only people who are going to do scientific work should have to learn science".
15. "Science does not help someone to learn geography".
16. "A good scientific theory does not supply the final answer to scientific questions".
17. "Biologists, chemists and physicists work in quite different ways from each other".
18. "Science is only for brainy folk".
19. "If you were interested in studying animals' eyes you would need to know some physics".
20. "Everyone can help to prevent science endangering our lives".

21. "Space research is no use to ordinary people".
22. "Energy is important to the study of biology and chemistry as well as physics".
23. "Science would be very difficult if we had no mathematics".
24. "I am not interested in science".
25. "There are very clear boundaries separating physics, chemistry and biology".
26. "Science is so difficult that only highly trained scientists can understand it".
27. "To study pond life you have to work like a physicist, chemist and biologist all combined".
28. "Experiments which give answers that disagree with what the teacher expects are useful".
29. "If a good scientist says that a theory is true all other scientists will believe him".
30. "I enjoy science".
31. "I would not like to be a scientist".
32. "To understand the human body a biologist must know a lot of chemistry".
33. "I would rather be a famous scientist than the Prime Minister"
34. "Lots of information we get from science now will be changed in the future".
35. "Scientists are boring people".
36. "I wish we had more science in school".
37. "Science does not help you to learn anything about music".
38. "Science needs the understanding and support of ordinary people".
39. "Science is boring for me".
40. "Scientific theories supply the true answers to scientific questions".
41. "I hate science".
42. "Science lessons are no use to an athlete".
43. "Science does not help us to understand weather and climate that we learn about in Geography".
44. "Science does not affect my daily life at home".
45. "Science should be left to those who are scientists or who are going to be scientists".
46. "Science teaches us not to believe everything we are told".
47. "Scientists are very interesting people".
48. "A useful scientific theory may not be entirely correct".

49. "New discoveries in science are important to everyone".
50. "Physics, chemistry and biology are all part of the same subject".
51. "I make use of science every day".
52. "Good scientists know the true laws of science".
53. "People who plan school dinners need to know a lot of science".
54. "Biology, chemistry and physics are all called science but are not connected in any other way".
55. "Chemistry is no help to physics".
56. "Science can help man to live more comfortably".
57. "Science is one of my favourite subjects".
58. "Everyone in the modern world needs to learn science".
59. "Chemical energy is important to physics".
60. "An artist has no need to learn science".

BROWN

CALIFORNIA ELEMENTARY SCHOOL SCIENCE ATTITUDE TEST

Stanley B. Brown. Science information and attitudes possessed by California elementary school pupils. Journal of Educational Research, 1954, 47, 551-554.

Instrument Characteristics

Format:	20 item Likert Scale.
Population:	Elementary school pupils, grades 1-9
View of attitude:	Not available.
Subscales:	Not available.
Validity:	Face validity of initial 35 items established by 25 teachers, supervisors, consultants and experts in science education. Items then submitted to 270 grades 5 and 8 pupils. Correlations of .34 - .54 obtained between the items and the science information test. 25 items finally selected.
Reliability:	Obtained from testing 2,901 grades 5 and 8 pupils, r=.73, Spearman-Brown prophecy formula

Analysis

Cognitive items: (11.5)	2, 3, 5.1, 6, 7, 8, 10, 16, 17, 18, 19, 20.
Value items: (8.5)	1, 4, 5.2, 9, 11, 12, 13, 14, 15.
View of science:	Explicit -- Realist, items 2, 16.
Additional characteristics:	Ambiguous items 5, 13, 15, 20.

Research Studies

Bickel, Robert Frederick. A study of the effect of television instruction on the science achievement and attitudes of children in grades four, five and six. Unpublished Ed.D. dissertation, Syracuse University, 1964. (University Microfilms, order number 65-3447)

Over one school year a treatment group (n=213) received 3 blocks of 20 minutes of T.V. and a 10 minute follow up, while the control group (n=219) received an equal amount of teacher directed science instruction. No significant differences in attitude to science by group, grade or sex were found.

Bixler, James Edward. The effect of teacher attitude on elementary children's science information and science attitude. Unpublished Ph.D. dissertation, Stanford University, 1958 (DAI: vol. 19, p. 2531)

The science attitudes of 62 teachers were found, and the pre- and post-test scores of their 1481 pupils were obtained over 5 months on the California Test of Mental Maturity and the California Elementary School Science Information and Science Attitude Test. Teacher attitude was significantly related to pupil science attitude, and the latter was significantly and inversely related to intelligence.

Brown, Stanley B. (See above)

No significant difference between the science attitudes of 2901 grades 5 and 8 pupils.

Commentary

Some of the items, especially the ambiguous ones may be too complicated for the lower grades. Although over half the items depend on knowledge of science (they are analyzed as cognitive items), score on science attitude appears unrelated to grade and instructional format, which could raise doubts about the scale's validity.

Items of the Brown Scale*

1. Girls need outdoor exercise as much as boys.
2. Diseases are sometimes caused by evil (bad) spirits.
3. We have gone as far as we can go in scientific discoveries.
4. Our civilization owes a great deal to scientists.
5. Because of the large number of deaths caused by machines (automobiles, airplanes, factories, etc.) we should do away with them.
6. Science has brought us more evils (harm) than good.
7. The discoveries we study in science have been produced by men of many nations.
8. America has the only great scientists in the world today.
9. Peoples of the white race are superior to other races because of the differences in blood.
10. Other living things are necessary for man's existence.
11. We should concentrate completely on developing atomic power as a destructive weapon.
12. Our scientific achievements should not make us disregard other nations.
13. Because of scientific progress it is not important to be concerned about the soil and water supply in New York State.

14. The government should provide more inspection of food products.
15. More attention should be given to the development of atomic power to improve our living conditions.
16. Our feelings are more reliable than scientific facts.
17. The causes of tornadoes, electric storms and lightning are known to scientists.
18. Science can do something to prevent floods and fires that destroy much property.
19. Homemade medical practices are usually the most effective.
20. Scientists study accurately what they see and do not allow personal opinion to influence their reports.

BRUVOLD

ATTITUDE SCALE

William H. Bruvold. Attitudes toward science and accompanying beliefs. Journal of Social Psychology. 1974, 94, 269-274.

William H. Bruvold. Public attitudes toward reuse of reclaimed water. University of California Water Resources Center, Contribution No. 137, 1972.

Only one part of this scale deals with attitudes toward science, and is described below.

Instrument characteristics

Format:	Open-ended interview question, and an eight point Guttman scale.
Population:	Adults.
View of attitude:	Not stated.
Subscales:	Technically there are none. Open-ended responses were categorized as follows: health, space age, air pollution, general living, industry, war.
Validity:	Not determined.
Reliability:	Less than 10 per cent disagreement between two trained coders.

Analysis

Value item:	The single item is a value item.
View of science:	None evident.

Research Studies

Bruvold, William H. Attitudes toward science and accompanying beliefs. (See above)

A three-stage cluster sample technique is used to sample 10 different communities for a total sample of 972.

Affective responses to science were:

Extremely positive	29.3 per cent
Moderately positive	40.7 per cent
Slightly positive	12.1 per cent

with slightly, moderate and extremely negative responses accounting for 8.7 per cent.

Commentary

Insufficient technical data is available to assess the usefulness of this instrument.

Items of the Bruvold Scale*

Read statement and probe for reasons:

Recently there has been discussion of the general value of science for modern life. Some believe that science has produced many more bad effects than good effects in our modern world, such as air pollution. Others, however, believe that science has produced many more good effects such as medical advancement. Would you describe your feelings about the value of science?

Hand card to respondent

Would you now summarize your feelings on the following scale: Do you feel that the good effects of science (READ ALTERNATIVES)

greatly outnumber	1
moderately outnumber	2
slightly outnumber	3
are about equal	4
are slightly outnumbered by	5
are moderately outnumbered by	6
are greatly outnumbered by	7
NO ANSWER	0

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BULLETIN OF ATOMIC SCIENTISTS

ATTITUDES ON SCIENCE

Bulletin of Atomic Scientists. Student attitudes on science. 1971, 27, 31-35.

Instrument characteristics

Format:	3 open questions and 1 Guttman type.
Population:	University science majors.
View of attitude:	Largely cognitive.
Subscales:	Technically, there are none. Questions imply science and survival, progress, government policy, and research priorities.
Validity:	Not determined.
Reliability:	Not determined.

Analysis

Value items:	The questions represent value items.
View of Science:	None evident.

Research Studies

Bulletin of Atomic Scientists. (See above)

Random sample of 20 undergraduate and 5 graduate science students. Results are reported in percentages. None give further information about the scale.

Commentary

The scale has little technical data to support it, and the research study is very questionable.

Items of the Bulletin of Atomic Scientists Scale*

1. Do you believe science (and its application, technology) is the answer to the survival of mankind? Are the directions of science today relevant to the major concerns of mankind?
2. Has progress in the physical and biological sciences in the 20th century been too rapid? Has it been funded by government at the expense of social and economic problems?
3. In what order would you list the following research programs on a priority basis:
   a. "clean" fossil fuels (coal & oil),
   b. new sources of energy, such as solar and thermal (earth's heat) power and nuclear fusion,

c. birth control and family planning,

d. cancer and molecular diseases,

e. space research,

f. ocean science and its potential,

g. high energy physics research,

4. In a tight budget situation, do you favor a government policy emphasizing applied research, which promises immediate benefits, at the expense of basic research which may not have specific goals or benefits in view?

CLARK

POST-EXPERIMENTAL ATTITUDE SCALE

B.M. Clark. An experiment in cultivating critical thinking abilities in the classroom. Unpublished Ph.D. dissertation, Iowa State University, 1968. (DAI: vol. 29, p. 1158)

Instrument Characteristics

Type:	5 item, Likert type scale.
Population:	Grade 8.
View of attitude:	Implicitly affective responses.
Subscales:	None.
Validity:	Not reported.
Reliability:	Not reported.

Analysis

Attitude items:	All 5 items.
View of science:	Not evident.

Research Studies

Clark, B.M. (See above)

An experimental group of 93 grade 8 pupils were given the Suchman Inquiry Development program, while the control group (111 pupils) were given traditional science instruction. Pre and post-tests administered for science achievement and creativity. The attitude scale was administered as a post-test. Analysis of variance and multiple comparisons of least significant differences showed no difference in attitude.

Commentary

The instrument is of little value.

Items of the Clark Scale*

HOW MUCH DO YOU LIKE

1. science class?

   LIKE A LITTLE 1 2 3 4 5 6 7 LIKE A LOT

2. to participate in discussion in science class?

   LIKE A LITTLE 1 2 3 4 5 6 7 LIKE A LOT

3. to participate in science class experiments and demonstrations?

   LIKE A LITTLE 1 2 3 4 5 6 7 LIKE A LOT

4. reading magazines and books about science?
   LIKE A LITTLE 1 2 3 4 5 6 7 LIKE A LOT
5. to do extra for science class?
   LIKE A LITTLE 1 2 3 4 5 6 7 LIKE A LOT

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CLARK

ATTITUDE SCALE

William Austin Clark. An identification of the gap between the scientific culture and the humanistic culture in the secondary school. Unpublished Ph.D. dissertation, University of Connecticut, 1970. (DAI: vol. 31, p. 6272.)

Instrument characteristics

Format:	28 item Likert scale.
Population:	Science and humanities teachers.
View of attitude:	Not stated.
Subscales:	None are identified.
Validity:	Items juried by 4 professional educators. Following a try out on 62 teachers, 2 items were removed and 5 were improved.
Reliability:	Not stated.

Analysis

Cognitive items: (18)	3, 4, 5, 7, 8, 9, 11, 12, 14, 16, 18, 20, 21, 22, 24, 25, 26, 28.
Value items: (9)	1, 2, 6, 10, 13, 15, 17, 19, 27.
Attitude items: (1)	23.
View of science:	None evident.
Additional characteristics:	Ambiguous item 13.

Research Studies

Clark,W.A. (See above)

Scale was administered to 75 humanities and 45 science teachers, matched for population to give 45 pairs. Responses analyzed by non parametric sign test. Both groups agree that a gap between science and humanities exist. Science teachers significantly different in promoting objective measures as the criterion of learning. Both groups feel that science is more prestigious than the humanities. No difference found in attitudes toward science teaching. Science teachers saw themselves as more practical (.01), but both groups saw themselves and each other in the same light.

Commentary

The instrument is composed largely of cognitive items. There is a lack of detail about the validity and reliability of the scale, which renders its usefulness doubtful.

Items of the Clark Scale*

1. Teaching the classics is very important in this day and age
2. Objective tests are better measure of student achievement than subjective or "essay" tests
3. Science is thought of by the students in this school as the subject with the most prestige
4. English teachers are not doing a very successful job of teaching students how to write
5. Science as it is taught is basically a specific body of subject matter to be imparted to students
6. A good understanding of science is very necessary in this day and age
7. The administration in this school thinks that science is the most prestigious subject offered
8. There is a significant difference in the way science teachers look at the world and the way humanities teachers do
9. Humanities teachers are brighter than science teachers
10. English should be basically a "skills" course (reading, writing, etc.)
11. This community thinks that science is the most prestigious subject in the school
12. Science teachers are more practical and down-to-earth than humanities teachers
13. It does not matter at all which facts are taught in school; other considerations, such as values, attitudes and learning how to think, are more important

14. You can't tell whether a student is progressing unless you have objective measures

15. English teachers should find more scientific ways of teaching their subject -- especially in reading and composition

16. Humanities teachers are more old-fashioned than science teachers

17. There is a deplorable gap between science and the humanities today

18. Science teachers consciously or unconsciously condition their students to be scornful of humanistic subjects

19. Today more money (from the government, board of education, etc.) should be pumped into the humanities than into science education

20. Considering the really important problems in the world today, most science courses deal with trivial things

21. Science teachers can easily get good-paying jobs outside the teaching field

22. It is extremely difficult to understand science today

23. Painting and music are no more than pleasant diversions

24. English is primarily a "service" course, in that it provides the tools students need to carry on their work in other courses

25. A student's progress is best measured by how well he performs on tests

26. Science teachers are more narrow-minded and rigid than humanities teachers

27. We should not spend very much time with problems that don't have definite solutions

28. The faculty as a whole in this school thinks that English is the most prestigious subject.

CUMMINGS

ATTITUDES TOWARD SCIENCE AND SCIENTISTS

J.R. Cummings. Development of an instrument to measure attitudes toward science and the scientist. Unpublished Ph.D. dissertation, Ohio State University, 1970. (DAI: vol. 30, p. 2877.)

Instrument characteristics

Format:	67 item Likert scale.
Population:	Elementary science methods students
View of attitude:	Reference is made to the definition by Shaw and Wright. Attitude to science is defined as "a set of emotionally toned ideas about science, scientists, scientific methods and related directly or indirectly to a course of action."
Subscales:	There are seven subscales, but items are not identified with these: scientist, science in general, value of science, science as a school subject, science's impact on society, the nature of science, society's impact on science.
Validity:	Two scales of 70 and 69 items were derived from an initial pool of 150 items drawn from eight other scales, and were submitted to 65 elementary science methods students. Following item and factor analysis, 99 items were retained. (Factor analysis gave a "factor structure too complicated to be useful in further refinement of the scale.") A second administration to 349 methods students gave a final scale of 67 items. Construct validity determined by comparing the second administration with 24 participants in the NSF Academic Year Institute at Ohio State University. A high interval consistency is reported, $K\text{-}R_{20} = .9214$.
Reliability:	.915, $K\text{-}R_{20}$. Obtained from the 349 methods students.

Analysis

Cognitive items: (37)	1, 4, 5, 7, 11, 13, 15, 19, 21, 22, 26, 27, 29, 30, 31, 33, 35, 36, 38, 41, 42, 43, 45, 46, 48, 51, 52, 53, 55, 56, 57, 58, 62, 63, 64, 65, 66.

Value items: (15)	3, 6, 8, 10, 14, 18, 24, 25, 28, 40, 44, 54, 59, 60, 61.
Attitude items: (14)	2, 9, 12, 16, 17, 20, 23, 34, 37, 39, 47, 49, 50, 67.
Self-report disposition (1)	32.

View of Science: ~~Explicit - instrumentalist, item 15.~~

Implicit - Realist, items 13, 46.

Research Studies

Moore, Byron F. and Moore, Arnold J. Possible influences on student attitudes toward involvement with science: curricular, demographic, and personal factors. ED 104 665, 1975.

373 students from grades 10, 11 and 12 were given scales measuring attitude toward involvement with science (AIS) perceptions of scientists (PS), and academic self concept. (The first two scales consisted of items from the Cummings' instrument which had face validity.) Other personal data were collected. A regression model shows that GPA and IQ are poor predictors of AIS and PS. Availability of BSCS - yellow, CHEMS, HPP, and PSCC explained significant amounts of variance of AIS and PS scores, but the direction is not determined. Perception of self, perception of the physics teacher and sex were designated as important as the science curricula available.

Studdard, Amos Lee. A study comparing a regular semester and an interim college level physical science course based on changes in student attitudes and understanding of science processes. Unpublished Ph.D. dissertation, University of Alabama, 1975. (DAI: vol. 36, p. 7979.)

40 students in an interim term are compared with 5 sections of a semester course. Pre and post measures of grade, science attitude, and science processes were obtained and subjected to analysis of variance. Attitude is not affected by semester, sex or instructor.

Commentary

The unusable factor structure suggests a problem in this scale. Also, the measure of construct validity used by Cummings is a measure of the relationship between the scores of two groups on the same test. The subscales are in need of investigation before this test can be considered satisfactory.

Items of the Cummings Scale*

1. The majority of scientists are irreligious.
2. I am very strongly attracted to scientific activities.
3. More science should be taught in the elementary school.
4. Science has caused chaos in our world.
5. Theories and laws of modern science are apt to remain in their present form.
6. Science is essential in this technological age.
7. Most scientists make few friends other than their fellow scientists.
8. Those girls who are not mechanically inclined should not contemplate becoming scientists.
9. I am enthusiastic about learning more scientific information.
10. Educators attach too much importance the study of science.
11. Science will enable me to think more clearly in most other subject areas.
12. Science is less interesting than most other school subjects.
13. Scientific methods will find the solutions to our social problems such as crime.
14. Science causes our way of life to change too rapidly.
15. Science aids us in comprehending our surroundings.
16. Scientific work is boring.
17. I would not like to be a research scientist.
18. People possessing creative imaginations should not pursue science as a vocation.
19. Most scientists are little concerned about the harmful consequences of later applications of their research findings.
20. Scientific research problems are intriguing.
21. The study of science enables one to reason more clearly in other areas such as politics.
222. Science has not been very beneficial to the average citizen.
23. Science is a very fascinating subject.
24. High school science ought to be compulsory only for those students who wish to become scientists.
25. Science is irrele·ant in present-day society.

26. Scientists have a potent influence over the significant economic, political and social processes.
27. Most scientific investigations are performed in the laboratory rather than in the everyday world.
28. An education in science is imperative in present-day society.
29. Government favoritism toward extraordinary scientific talent is undemocratic.
30. Most scientific research is conducted by scientists who have little concern for their own personal physical welfare.
31. Most scientists are very creative thinkers.
32. Scientific knowledge is hard for me to understand.
33. Science is little related to everyday living.
34. I enjoy solving science problems in the school laboratory.
35. Only students of better than average ability can be successful in school science courses.
36. Science helps society by using recently discovered scientific information to develop new industries.
37. I wouldn't like to pursue a science research project.
38. Scientists' attempts to solve their personal problems of everyday living are often unrealistic.
39. Science information which is not related to school work frequently interests me.
40. An education in science contributes toward good citizenship.
41. The study of science benefits people socially.
42. The methods of science are not applicable to understanding human behavior.
43. The methods of science will not enable the human mind to comprehend many aspects of our universe.
44. A comprehension of the significance of science is necessary to thoroughly appreciate present-day society.
45. Scientists are often eccentric in their personal behavior.
46. Scientific truths are normally discovered by individuals seeking financial gain.
47. I enjoy doing science investigations.
48. The difficulties involved in learning science often exceed its usefulness.

49. To me science classes are very uninteresting.
50. I enjoy doing science laboratory experiments.
51. Great improvement in all areas of human endeavor could be accomplished by the application of scientific methods.
52. Most of the science worth knowing can be read in books.
53. Most scientific discoveries were accidental.
54. A comprehension of science is essential for my everyday living.
55. The majority of scientists are not interested in the practical value of scientific information.
56. The nation's top scientists are mainly interested in their own current of thought.
57. Science is chiefly a program of action for originating new gadgets.
58. An education in science frequently helps one make more logical decisions in everyday living.
59. Science is not as important as other school subjects such as English.
60. Science appears to be necessary in our present-day society.
61. Public interest in science is necessary for the continuance of scientific research.
62. In pursuit of their interests, scientists often consent to sacrifice the well-being of others.
63. I would not recommend high school science to beginning high school students.
64. The advancement of science makes possible the control of our lives by a few people.
65. Most great discoveries of the world were found through careful observation rather than by accident.
66. Scientists have shown their lack of consideration for the welfare of mankind by participating in such research as the development of nuclear weapons.
67. I would prefer not to take any college science courses.

DUTTON AND STEPHENS

ATTITUDES TOWARD ELEMENTARY SCHOOL SCIENCE

Wilbur H. Dutton and Lois Stephens. Measuring attitudes toward science. School Science and Mathematics, 1963, 63, 43-49.

Instrument characteristics

Format:	20 item Thurstone scale.
Population:	Prospective elementary school teachers.
View of attitude:	An emotionalized feeling for or against science
Subscales:	None are explicit.
Validity:	100 education students sorted the original statements obtained from 200 prospective elementary school teachers. The scale was constructed using the Thurstone and Chave technique.
Reliability:	226 female prospective teachers who had not taken a methods course in elementary science but had maintained a C+ average. Test-retest, r=.93.

Analysis

Cognitive items: (6)	1, 2, 7, 13, 14, 16.
Value items: (4.5)	5, 12, 15, 17.2, 20.
Attitude items: (7.5)	3, 8, 9, 10, 11, 17.1, 18, 19.
Self-report dispositions: (2)	4, 6.
View of science:	None evident.
Additional characteristics:	Ambiguous items, 8, 17.

Research Studies

Cook, Charles Frederick. An analysis of change in open and closed-mindedness and attitude toward science of pre-service elementary education majors. Unpublished Ph.D. dissertation, Indiana State University, 1971 (DAI: vol. 32, p. 6260)

The Oshima version of the Dutton and Stephens scale (see below) is administered (pre and post) to a control group (n=130) and an experimental group (n=51), the latter having exposure to teaching children as part of their methods course over one semester. Attitude to science is not related to open-mindedness. Experimental group had a significantly different (and positive) attitude to science when compared with the control group.

Dutton, Wilbur H. and Stephens, Lois. (See above)

Reports responses on the validation data. A large number of students express favorable attitudes, especially on items 1, 3, 5, 7, 12, 15, 9, 10, 14 and 19. Items 13 and 20 were neutral. Unfavorable attitudes center around items 8 and 11.

Hinde, Augusta Louise. Relationships between prospective elementary teachers' science knowledge and attitude toward science and their criticisms of college science education. Unpublished Ph.D. dissertation, University of Missouri, 1971. (DAI: vol. 32, p. 2506)

160 female elementary education majors were given the Dutton and Stephens Scale and the Cooperative Science Advanced General Science Test, and a measure of criticisms of college science education. No significant correlations between attitude and criticisms, and high or low attitude and science scores. There was a significant correlation ($r=.37$) between low attitude and low science achievement scores.

Leake, John Benjamin. A study of attitudes of elementary teachers toward science. Unpublished Ed.D. dissertation, Oklahoma State University, 1966. (DAI: vol. 27, p. 4155)

A group of 285 elementary teachers was divided into control and experimental groups. The former received no instruction, the latter received science instruction (2½ hours per week) for six months. There were no significant differences, pre and post, between the groups. (The scale is modified in this study, as given below.)

Oshima, Eugene Akio. Changes in attitudes toward science and confidence in teaching science of prospective elementary teachers. Unpublished Ed.D. dissertation, Oklahoma State University, 1966. (DAI: vol. 27, p. 4157)

A control group of 23 female elementary majors received a lecture demonstration course, while an experimental group of 54 undertook individual science investigations. Groups were pre- and post-tested on the modified Dutton and Stephens scale, the Evans confidence scale, and the Read General Science Test. No significant differences in attitude were found.

Commentary

The studies reviewed suggest that this scale fails to discriminate. This may be a function of the number of items, and of the various attitudinal objects represented in the scale. An inspection of the items suggests the presence of multiple subscales, giving a scale of questionable overall validity. None of the studies reviewed gives further information about the performance of the scale.

Items of the Dutton and Stephens Scale*

1. Field trips to such places as botanical gardens or observatories make science an interesting subject.
2. Science is unrelated to life experiences.
3. I wish I had been given more science instruction in elementary school.
4. I never could see anything through a microscope.
5. It is very helpful to know the basic facts about animal life.
6. Science seems to be "over my head."
7. Possibilities for student participation make science an interesting subject.
8. The study of science doesn't bore me, but I would never pursue it independently.
9. It is fascinating to study live specimens in the classroom.
10. I am always interested in learning more about science.
11. I just hate mice, worms, bugs, and any other small, crawling thing.
12. Science education is a "must" at this time.
13. Scientists are people who invent something to improve everyday living.
14. Science learnings are often the basis of a good hobby.
15. Science is very important in this scientific age in which we live.
16. A lizard is an interesting and attractive classroom pet.
17. Science is interesting, but not as important as other subjects.
18. Science is boring.
19. I like to do science experiments.
20. Elementary school science should be taught to groups of children with approximately the same I.Q.

Modifications of the Scale

In the Leake and Oshima study, the following items are modified as shown:

3. I could have been given more science instruction in elementary school.

4. I have difficulty seeing anything through a microscope.

10. I am interested in learning more about science.

11. I find it objectionable to work with mice, worms, bugs, and any other small crawling thing.

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EGGLESTON

SCIENCE PUPIL OPINION POLL

National Foundation for Educational Research in England and Wales, Publishing Company, Windsor, Berks, England. 1968.

This scale appears to be referred to in the literature in several different ways: Eggleston's Science Pupil Opinion Poll, the opinion poll originally developed by Skurnik, and so forth. Since NFER publishes the scale as the Eggleston scale, that accreditation is used here. NFER publishes also the Science Attitude Questionnaire developed by Skurnik and Jeffs, which is reviewed later for comparison.

Instrument characteristics

Format:	68 item, Likert-type scale.
Population:	High school pupils.
View of attitude:	Not available.
Subscales:	5 subscales are identified in the manual of instructions, to give a total of 68 items. The manual is referring to a modified version of the Science Pupil Opinion Poll which differs considerably from the scale received from NFER which contains only 33 items. The subscales reported here are from the modified version. It should be noted that the scale received has three forms, one for each of the sciences physics, chemistry and biology. The forms are identical, with the words chemistry, physics or biology appearing in the stem of each question as appropriate. 1. Science interests (20 items) 2. Science in Society (13 items) 3. Learning activities (7 items) 4. Science teachers (8 items) 5. School (10 items)
Validity:	Validity is confirmed by factor analysis
Reliability:	By Spearman-Brown Scale 1, .94 Scale 2, .80 Scale 3, .65 Scale 4, .90 Scale 5, .73

Analysis

Since the 33-item scale is replaced by the 68 item scale, it is not useful to provide an analysis.

Research Studies

Lloyd, Gerald. An experiment with the teaching of science to non-streamed classes. School Science Review, 1976, 58, 355-360.

Lloyd uses the original 33-item version of the science Pupil Opinion Poll and the Science Opinion Poll of Laughton and Wilkinson. His analysis of the results by subscale fails to distinguish to which of the scales each belongs.

A control group (n is unstated) and an experimental group (n=30) working with the Nuffield Combined Science Scheme were compared over one school term. No significant differences in attitude were found.

Commentary

No commentary can be made in the absence of the current and modified scale.

Items of the Eggleston Scale

A sample of items from the modified scale is available in the manual. Some of these are reproduced here.

4. Biology/Chemistry/Physics lessons are a waste of time.

24. It is fun to guess the outcome of Biology/Chemistry/Physics experiments.

15. I would like to work with people who make discoveries in Biology/Chemistry/Physics.

This instrument has been developed into the Science Attitude Questionnaire, published by NFER-NELSON Publishing Company Limited, Windsor, England. (See page 440, below.)

ESTES

ESTES ATTITUDE SCALES

Thomas H. Estes, University of Virginia, 1975. Published by Virginia Research Associates Ltd., Charlottesville, Virginia.

Instrument characteristics

Format:	The scale has a total of 75 Likert items measuring attitudes to English, mathematics, reading, science, and social studies. 15 items (46-60) concern science.
Population:	Grades 7-12.
View of Attitude:	"Attitude toward a content area is here defined as a liking for or dislike of a given subject. Thus favorable attitude is evidenced by verbal statements of that nature, tendency to choose and apply one self conscientiously in subject-related activities, and belief in the value of the subject. Avoidance behaviors indicate unfavorable attitude toward a subject."
Subscales:	None given.
Validity:	30 items having content validity assessed by the "intuitive rational method" administered to 600 secondary school students. 20 items discriminating most highly were retained. 629 students given these items and scores subjected to cluster analysis and factor analysis. 15 items finally selected for each subject area. Convergent validity determined with self-rating (.65), peer nominations (.23), teacher ranking (.23), course grades (.22), achievement score (.22), and extra curricular participation tallies (.14).
Reliability:	.88 and .85, with a coefficient of factor similarity of .93. Means of 51.25 and 51.17 and standard deviations of 10.43 and 9.15 respectively.

Analysis

Cognitive items: (5)	47, 49, 57, 58, 60.
Value items: (3)	50, 53, 59.

Attitude items: (7) 46, 48, 51, 52, 54, 55, 56.

View of science: None evident.

Additional characteristics: Ambiguous item 53.

Research Studies

None were identified.

Commentary

The scale may have too few items to satisfy research into student attitudes to science. Yet the extensive (and unusual) efforts to find the convergent validity of the scale of well documented characteristics. Yet, given the low correlations of convergent validity, the validity of the scale is not too plain.

Items of the Estes Attitude Scales

46. Field trips in science are more fun than those in other school subjects.
47. An understanding of how the earth changes helps make a better world.
48. Studying science is a waste of time.
49. A deeper love of nature comes from the study of science.
50. There is too much memory work in science.
51. Science is interesting.
52. Science classes are usually fun.
53. Science courses are worth the time and effort they take,
54. Cutting up animals in class is silly.
55. It is fun to figure out how things work.
56. Books about science are boring.
57. Many good hobbies come from the study of science.
58. Science teaches people to think.
59. Students should not be required to take science courses.
60. Exploring outer space may prove useful to mankind.

FANCHER AND GUTKIN

SCIENCE QUESTIONNAIRE

Raymond E. Fancher and Daniel Gutkin. Attitudes toward science, insight therapy, and behavior therapy. *Journal of Clinical Psychology*, 1971, *27*, 153-155.

Instrument characteristics

Format:	52 item true/false, and 4 item double-choice.
Population:	University students.
View of attitude:	Not stated.
Subscales:	None explicit.
Validity:	Items possessed a "reasonable amount of face validity". Also, there is a significant relationship for 131 students between attitude and choice of major field. ($r = .42$, $p < .001$).
Reliability:	Not stated.

Analysis

Cognitive items: (25)	3, 4, 5, 6, 9, 12, 13, 14, 15, 16, 17, 19, 22, 25, 29, 30, 32, 38, 42, 43, 44, 45, 47, 49, 52.
Value items: (12)	7, 11, 20, 23, 24, 31, 35, 41, 46, 48, 50, 51.
Attitude Items: (16)	8, 10, 18, 21, 26, 27, 28, 33, 36, 37, 39, 40, 53, 54, 55, 56.
Self-report dispositions: (2)	2, 34.
View of science:	Explicit - Instrumentalist, items 5, 9, 19, 23, 24, 31, 52.
	- Realist, items 6, 37, 42, 49.
	Implicit - Instrumentalist, items 14, 48.
Additional characteristics:	Ambiguous item, 49.

Research Studies

Fancher, Raymond E. and Gutkin, Daniel. (See above)

145 students were presented information about 4 types of therapy, and then required to rank them. Attitudes to science not related to preference for therapies.

Commentary

The instrument is without thorough validity and reliability data, yet it is an interesting collection of items designed to measure a student's orientation to science or non science ways of treating human beings. There is a considerable mixture of items, as the analysis has shown.

Items of the Fancher and Gutkin Scale *

(item 1 is omitted from the scale received.)

2. Logical thinking plays a large part in my life.
3. Scientists have contributed more to society than artists.
4. Most people can be counted on to act with a fair degree of decency and humanity.
5. Science gives men a greater mastery over the world than could be provided by any other discipline.
6. Chairs, tables, sealing wax, and kings, these sort of things constitute the real world.
7. There is more to admire than to despise in men.
8. The universe and nature are sacred.
9. Personality is too complex to be studied scientifically.
10. Ordinary life is sacred.
11. Art is not very important.
12. All knowledge ultimately comes from sense experience.
13. What cannot be measured accurately can hardly be discussed meaningfully.
14. All of human behavior can be fully described in terms of observables.
15. A great poet is dangerously close to an understanding of reality.
16. If we limit ourselves only to what we observe we will never be able to fully understand what people do.
17. The main purpose of philosophy is the clarification of the meaning of words, concepts, and propositions.
18. The universe fills me with awe.
19. Mysticism can supply us with important truths.
20. We would be better off with less technology.
21. Science dehumanizes people.
22. Science has contributed greatly to our knowledge of the world.
23. Metaphysical and moral knowledge are superior to scientific knowledge.

24. Artists possess a deeper truth than scientists.
25. Science has made life meaningless.
26. There is not much hope for mankind.
27. "Time is a Man, Space is a Woman, and her Masculine Portion is Death." This quotation seems profound and important to me.
28. The above quotation (27) seems to me to be meaningless rhetoric.
29. Only misguided people study literature.
30. Mathematics is not useful to me.
31. Mystic religions contain more insight into the nature of things than does science.
32. Human behavior could be predicted by science.
33. Mathematics is dull.
34. Fantasy plays a large part in my life.
35. The study of literature is relatively unimportant.
36. Science destroys the beauty of nature by taking everything apart.
37. Spirit, the Absolute, and Pure Being are the sort of things that constitute the real world.
38. Not much good can be expected from people.
39. Life is very important.
40. Nothing makes much difference really.
41. Science has caused more harm than good.
42. Science and everyday observation are the only means for obtaining knowledge about the world.
43. Artists have contributed more to society than have scientists.
44. The application of scientific thinking to social problems will be useful.
45. Some important types of knowledge do not come from sense experience.
46. The humanistic studies (English, foreign languages, Classics) are relatively unimportant.
47. Science has contributed greatly to our well-being.
48. Human behavior should be studied scientifically,
49. By its steadfast dedication to truth, science has contributed greatly to human life.
50. Poets are important.

51. Art is not scientific enough to be of much value.

52. The main purpose of philosophy is the discovery of transcendent truths that will reveal the ultimate nature of reality.

For the following questions circle 1 or 2 on your answer sheet to indicate which completing phrase you prefer.

53. People are (1 Mammals.

(2 Beautiful

54. A kiss is (1 Bliss.

(2 The juxtaposition of the upper ends of two gastrointestinal tracts.

55. A human being is (1 Wonderful

(2 Worth a certain amount in chemicals.

56. Love is (1 The overestimation of the differences between your girl (boy) and all other girls (boys)

(2 Wow!

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*Reproduced with permission from the Journal of Clinical Psychology, 27: 153-155, 1971.

FEERST

ATTITUDE INVENTORY

Frances Feerst. A comparison of two methods of enriching a science curriculum so as to change the attitudes of children towards the relevance of science. Unpublished Ph.D. dissertation, New York University, 1973. (DAI: vol. 34, p. 663)

Instrument characteristics

Format:	23 item Likert-type scale.
Population:	Grade 4 pupils.
View of attitude:	A combination of beliefs a person holds about an object or situation and which disposes him to a particular response. It is relatively enduring, but may be changed. Attitudes are based on knowledge, emotions and expressions of feelings.
Subscales:	None explicit.
Validity:	Items were submitted to a panel of three judges.
Reliability:	K-R 20, r=.78, n=28 and r=.93 for n=80, with a test-retest, r=.7 for grade 4. For grade 6, r=.80 and .91.

Analysis

Cognitive items: (11)	1, 3, 4, 5, 6, 7, 9, 11, 20, 22, 23.
Value items: (1)	19.
Attitude items: (6)	2, 8, 15, 17, 18, 21.
Self-report dispositions: (5)	10, 12, 13, 14, 16.
View of science:	None evident.

Research Studies

Feerst, Francis (see above)

12 grade 4 science classes used the Conceptually Oriented Program in Elementary Science for 5 months. The experimental group (n=149) were given an emphasis in application, the control group (n=149) were not. Reading level, pre-test achievement, classroom size and facilities, teacher attitude to science, teaching ability were held constant. No significant differences in attitude were found.

Commentary

The scale presents a very mixed bag of items, and its validity is therefore suspect. Reliability appears to fluctuate. The response continuum may be considered unevenly distributed about a "no opinion" option.

Items of the Feerst Scale*

Responses to all items except 6, 20, and 21 are on the continuum: almost never, few times, sometimes, often, very often. For item 6 it is: hardly anybody, a few people, some people, many people, me. And for items 20 and 21 it is: very good, good, can't decide, bad, very bad.

1. Mathematics is useful.
2. Reading is interesting.
3. I tell somebody at home about science
4. Science helps to solve problems, such as pollution.
5. Science is useful.
6. Being a scientist is a good job for
7. It takes a genius to be a scientist.
8. Doing science is fun.
9. Science is dangerous.
10. I can do science myself at school.
11. I find science too hard for me.
12. I think of science outside of school.
13. I feel uncomfortable or nervous doing science.
14. Science can help me solve problems outside of school.
15. Science is boring.
16. Studying science makes me smarter.
17. Science experiments are interesting.
18. Science is confusing.
19. Science is important to me.
20. Most science inventions are
21. Considering everything, science is
22. Explosions happen in science experiments.
23. My teacher likes to teach science.

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FELLERS

SCIENCE STUDENTS ATTITUDE INVENTORY

William Oscar Fellers. The change in attitudes toward science upon completion of a one semester general education physical science course at the junior college level. Unpublished Ed.D. dissertation, University of Northern Colorado, 1972. (DAI: vol.33, p. 1038)

Instrument characteristics

Format:	55 item Likert scale.
Population:	Junior college students.
View of attitude:	A relatively constant tendency to act. It encompasses those values which a person holds which govern his thoughts perceptions and actions.
Subscales:	Economic, education, morality, political, religion, science, social.
Validity:	An attempt was made to correlate the attitudes and behavior of 281 students, giving a correlation of .076. The validity, is admitted to be unestablished.
Reliability:	Parallel forms, r=.839. Split-half, r=.659 - .745 Test-retest, r=.63 -.79

Analysis

Cognitive items: (24)	1, 2, 4, 6, 9, 11, 14, 16, 18, 20, 25, 27, 30, 32, 37, 39, 41, 44, 46, 48, 49, 52, 53, 54.
Value items: (30)	3, 5, 7, 8, 10, 12, 13, 15, 17, 19, 21, 23, 24, 26, 28, 29, 31, 33, 34, 35, 36, 38, 40, 42, 43, 45, 47, 50, 51, 55.
Self-report dispositions: (1)	22.
View of science:	Explicit - Instrumentalist, item 2. Realist, items 1, 4, 18, 20, 25, 32. Implicit - Realist, items 39.

Research Studies

Fellers, William Oscar. (See above)

An experimental group (n=510) participated in the physical science course, and were compared with a control group (n=180) of history students. There was an overall significant difference favoring the science students (.05). When the data were analyzed by class, groups and by subscale, few significant differences were found. Significant differences were found for older students over younger ones, but not for achievement groups.

Commentary

The validity of the scale is acknowledged to be unestablished.

Items of the Fellers Scale*

1. Science can find the answers to all the problems of manking.
2. Science and religion are incompatible.
3. The government should control all scientific research.
4. The laws of science, which we now know, are fixed and will not need to be changed in the future.
5. Research about or involving sex should not be permitted.
6. Most scientists do not make good teachers.
7. Scientists should be allowed to patent and to receive royalties on discoveries and inventions they make, even though they were financed by government or business.
8. All scientific findings should be made public, even though the findings would be detrimental to society.
9. Most women could not be good scientists.
10. The government should provide scholarships for science students.
11. The Biblical story of the creation of the world is in direct contradiction to the findings of modern science.
12. Persons who have been convicted of felonies or who have served time in prison should not be trusted to work in scientific laboratories.
13. Scientists should have free rein to investigate any subject they wish.
14. Most scientists do not make good businessmen.
15. The reputation of a college or university from which a scientist graduated must not be considered when evaluating the research of that scientist.
16. Science has given the world more knowledge than the populace can handle.
17. Science must be kept free of political influence.
18. A true scientist cannot believe in God.
19. Sexual deviates (homosexuals etc.) should not be trusted to do scientific research.
20. The results of scientific investigation are invariably valid.

21. The results of scientific research should not be used in advertising a specific product.

22. Science is the most difficult subject in school.

23. A moratorium should be declared on all scientific research until the humanities and social sciences "catch up."

24. Research in communist countries is inferior to that in the U.S.A.

25. Science has proven there is no God.

26. Scientific research which requires immoral conduct should be prohibited.

27. Science is the most important influence in today's society.

28. Scientists should be paid on a par with the executives of the corporations for which they work.

29. In this age of technology, everyone should be taught a basic understanding of science.

30. Scientific inventions and discoveries have been more beneficial than harmful to mankind.

31. Scientists should not enter into politics.

32. When scientific and religious beliefs are in conflict, the scientific beliefs are the correct beliefs.

33. If scientific research proves marijuana to be unharmful, it should be legalized.

34. Scientific medical experiments should not be permitted on human subjects.

35. Colleges and Universities should not do research for private industries.

36. A course in a laboratory science should be required of all students prior to graduating from college.

37. Scientific methods could be applied to find solutions to social problems.

38. College and University administrators should fire scientists who are communists.

39. A person with deep religious convictions will probably not be objective in collecting and analyzing scientific data.

40. Drugs, medicines and foods which scientific research proves harmful in any way should be outlawed.

41. Most of the important scientific discoveries have already been made.

42. Highly intelligent students should be channeled into scientific careers.

43. Mankind would be better off without science.

44. The results of scientific research do not depend upon the researcher.

45. Science students should not be required to take courses in the humanities.

46. Most scientists are not very sociable.

47. The government should finance scientific research.

48. Most scientists have little knowledge of the arts or literature.

49. Scientists are narrow minded.

50. War related research should be prohibited.

51. Vivisection (experimentation on live animals) should not be allowed.

52. Most scientists have little artistic or esthetic sense.

53. Scientific research is of no value unless it produces something useful.

54. The miracles of the Bible have a scientific explanation.

55. The money spent on landing a man on the moon would have been better spent on eliminating poverty.

FISHER

SCIENCE OPINIONNAIRE

Thomas H. Fisher. The development of an attitude survey for junior high science. School Science and Mathematics, 1973, 73, 647-652.

Instrument Characteristics

Format:	20 item Likert scale.
Population:	Junior high school pupils.
View of attitude:	Not stated.
Subscales:	None are given explicitly.
Validity:	6 science curriculum specialists provided 5 items each. These were refined and reduced to "what was felt to be the best twenty". An open-ended question was added to the scale: "I think science class . . . " Responses were not rated but "subjective evaluation of (these) seems to indicate that such a technique would yield a good correlation." Correlations between each item and total scores are given (those for items 5, 7, and 10 are not significant.) as a measure of internal consistency.
Reliability:	Test - retest, n=43, r=.793.
	Split - halves, r=39, r=.833.

Analysis

Cognitive items: (8)	4, 5, 10, 11, 16, 17, 18, 20.
Value items: (1)	2.
Attitude items: (3)	6, 8, 13.
Self-report dispositions: (8)	1, 3, 7, 9, 12, 14, 15, 19.

Research Studies

None identified.

Commentary

There is too little information available to suggest that this scale is usefull. Also the analysis and an inspection of the items shows that a number of subscales are implicit here. This is further evident in the nonsignificant item correlations noted under validity.

Items of the Fisher Scale*

1. Reading science is difficult.
2. We spend too much time doing experiments.
3. I am learning a lot in science this year.
4. What we do in class is what a real scientist would do.
5. In science class we study "Today's Problems."
6. I dislike coming to science class.
7. I read more science materials than I did in sixth grade.
8. I enjoy doing the science experiments.
9. I can solve problems better than before.
10. My friends enjoy doing science experiments.
11. What I am learning in science will be useful to me outside school.
12. I think about things we learn in science class when I'm not in school.
13. I do not want to take any more science classes than I have to take.
14. Reading science is more fun than it used to be.
15. Experiments are hard to understand.
16. Science is dull for most people.
17. The things we do in this class are useless.
18. The kinds of experiments I do in class are important.
19. I learn a lot from doing my science experiments.
20. Most people like science classes.

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FRASER

TEST OF SCIENCE RELATED ATTITUDES

Barry J. Fraser. Development of a test of science-related attitudes. Science Education, 1978, 62, 509-515.

The Test of Science Related Attitudes is the final form of a scale whose development from subscales in existing instruments is described in earlier research reviewed below.

Instrument characteristics

Format: 70 item Likert scale (scoring reviewed on half the items)

Population: Grades 7 - 10.

View of attitude: Not stated.

Subscales: 7 subscales are explicitly given, 10 items in each scale.

1. Social implications of science.
2. Normality of scientists.
3. Attitude toward scientific inquiry.
4. Adoption of scientific attitudes.
5. Enjoyment of science lessons.
6. Leisure interest in science.
7. Career interest in science.

Validity: The early version of the scale (reported below) was enlarged by two subscales, and 14 items per subscale were produced. Initial item analysis reduced the items to 10 per subscale. Field testing on 1,337 grade 7-10 pupils provided data for scale statistics. Range for each scale is 10-50, with means ranging around 33, and standard deviations around 6.5. The mean discriminant validity of scales was .33.

Reliability: α reliability =.80 - .84 for grades 7 - 10. Test-retest reliability =.78.

Analysis

Cognitive items: (13) 3, 10, 17, 22, 24, 31, 38, 44, 45, 52, 58, 59, 66.

Value items: (11) 2, 8, 15, 18, 27, 28, 30, 36, 50, 62, 64.

Attitude items: (33)	1, 4, 5, 6, 9, 11, 13, 14, 16, 20, 21, 23, 25, 29, 32, 34, 37, 39, 41, 42, 43, 46, 47, 48, 51, 53, 55, 57, 60, 63, 65, 67, 69.
Test of Possession Dispositions: (1)	12.
Self-Report Dispositions: (12)	7, 19, 26, 33, 35, 40, 49, 54, 56, 61, 68, 70.
View of science:	None evident.
Additional characteristics:	Ambiguous item 62.

Research Studies

Fraser, Barry J. Some attitude scales for ninth grade science. School Science and Mathematics, 1978, 78, 379-384.

A battery of items was developed from the following subscales: Enjoyment of Science lessons and interest in Science outside lessons from the Schools Council revised version of Laughton and Wilkinson's "Science Pupil Opinion Poll" (7 and 6 items respectively); fluidity of science from Gardner's "Physics Attitude Index (7 items); and ten social implications subscale of Ormerod's "Brunel SOCATT Scale" (8 items). The battery was administered to 302 grade nine pupils. The scale and reliabilities were found to range from .65 to .87. Intercorrelations ranged from .25 to .59, indicating that the subscales "do not measure the same thing". There were significant sex difference favoring boys on all but the social implications subscale.

Fraser, Barry J. Selection and validation of attitude scales for curriculum evaluation. Science Education, 1977, 61, 317-329.

Klopfer's classification scheme for science education aims was used as a framework for developing the instrument out of subscales of existing instruments, as follows:

Social implications of science (8 items) from Ormerod's "Brunel SOCATT Scale"; Attitude toward inquiry (8 items) from Meyer's "A Test of Interest"; Adoption of scientific attitudes (11 items) from White and Mackay's "Tests of Perception of Scientists and Self"; and Enjoyment of science lessons (7 items) and Interest in science outside lessons (6 items) from the School's Council version of Laughton and Wilkinson's "Science Opinion Poll". These scales were selected after a literature search on desirable attitudinal aims in science education. All items were checked by a panel of experts, and the battery was administered to 165 grade 7 pupils to determine internal consistency, discriminant validity and sensitivity. A cross validation study employed a sample of 1,158 pupils. Internal Consistency: α coefficients from .63 to .85, and from .50 to .81. Discriminant validity: among scales, from .01 to .69. Sensitivity: by distribution of scores in each scale, showed that the available range of scores was used. Correlations of subscales with type of instruction, SES, sex and IQ range from -.04 to .37. Sex is significantly related to Adoption of scientific attitudes, Enjoyment of Science lessons and Interest in science outside lessons.

Commentary

This is an exceptionally well developed scale.

Items of the Fraser Scale*

1. Science lessons are fun.
2. Money spent on science is well worth spending.
3. Scientists usually like to go to their laboratories when they have a day off.
4. I would like to belong to a science club.
5. I enjoy reading about things which disagree with my previous ideas.
6. I would dislike being a scientist after I leave school.
7. I would prefer to find out why something happens by doing an experiment than by being told.
8. Science is man's worst enemy.
9. I get bored when watching science programs on TV at home.
10. Scientists are about as fit and healthy as other people.
11. I dislike science lessons.
12. Doing experiments is not as good as finding out information from teachers.
13. I would like to work with people who make discoveries in science when I leave school.
14. I dislike repeating experiments to check that I get the same results.
15. Public money spent on science in the last few years has been used wisely.
16. I would like to be given a science book or a piece of scientific equipment as a present.
17. Scientists do not have enough time to spend with their families.

18. School should have more science lessons each week.
19. I am curious about the world in which we live.
20. I would dislike a job in a science laboratory after I leave school.
21. I would prefer to do experiments than to read about them.
22. Scientific discoveries are doing more harm than good.
23. I dislike reading books about science during my holidays.
24. Scientists like sport as much as other people do.
25. Science lessons bore me.
26. I would rather agree with other people than do an experiment to find out for myself.
27. Working in a science laboratory would be an interesting way to earn a living.
28. Finding out about new things is unimportant.
29. I would like to do science experiments at home.
30. The government should spend more money on scientific research.
31. Scientists are less friendly than other people.
32. Science is one of the most interesting school subjects.
33. I like to listen to people whose opinions are different from mine.
34. A career in science would be dull and boring.
35. I would prefer to do my own experiments than to find out information from a teacher.
36. Too many laboratories are being built at the expense of the rest of education.
37. Talking to friends about science after school would be boring.
38. Scientists can have a normal family life.
39. Science lessons are a waste of time.
40. I would rather find out about things by asking an expert than by doing an experiment.
41. I would like to teach science when I leave school.
42. I find it boring to hear about new ideas.
43. I would enjoy having a job in a science laboratory during my school holidays.
44. Science helps to make life better.
45. Scientists don't care about their working conditions.
46. I really enjoy going to science lessons.
47. In science experiments, I like to use new methods which I haven't used before.

48. A job as a scientist would be boring.

49. I would rather solve a problem by doing an experiment than be told the answer.

50. This country is spending too much money on science.

51. Listening to a talk about science on the radio would be boring.

52. Scientists are just as interested in art and music as other people are.

53. The material covered in science lessons is uninteresting.

54. It is better to ask the teacher the answer than to find it out by doing experiments.

55. A job as a scientist would be interesting.

56. I am unwilling to change my ideas when evidence shows that the ideas are poor.

57. I would enjoy visiting a science museum at the weekend.

58. Science can help to make the world a better place in the future.

59. Few scientists are happily married.

60. I look forward to science lessons.

61. In science experiments, I report unexpected results as well as expected ones.

62. I would dislike becoming a scientist because it needs too much education.

63. I would prefer to do an experiment on a topic than to read about it in science magazines.

64. Money used on scientific projects is wasted.

65. I dislike reading newspaper articles about science.

66. If you met a scientist, he would probably look like anyone else you might meet.

67. I would enjoy school more if there were no science lessons.

68. It is better to be told scientific facts than to find them out from experiments.

69. I would like to be a scientist when I leave school.

70. I dislike listening to other people's opinions.

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GARDNER

PHYSICS ATTITUDE INDEX

Paul Leslie Gardner. A study of personal and environmental influences in the attitudes of high school physics students. Unpublished Ph.D. dissertation, Monash University, 1972.

Instrument characteristics

Format:	40 item Likert scale. (Scoring reversed on half the items)
Population:	Grade 11 physics students.
View of attitude:	Not available though the attitudes measured conform to attitudinal objectives of PSSC physics.
Subscales:	4 subscales of 10 items each. (Titles in parentheses are those used in later research, see below.) 1. Authoritarian/Non-authoritarian. (Non-authoritarian learning) 2. Closed/Open. (Openness) 3. Eccentric/Normal. (Scientists) 4. Antipathy/Commitment. (Enjoyment)
Validity:	30 science teachers, college instructors and researchers acted as judges of the initial 129 items. Statements obtaining a small range in rating were divided into two trial forms and submitted to a sample of high school students. Item analysis and a check for monotonicity left 40 items. An unpublished confirmatory factor analysis "provides good support for the uniqueness and unidimensionality of scales 3 and 4. Scales 1 and 2, however appear to be bidimensional, and their negative items load on a common factor." (Personal communication)
Reliability:	Corrected split-half, r=.78.

Analysis

Cognitive items: (18)	3, 4, 13, 14, 15, 22, 23, 25, 27, 30, 31, 32, 33, 34, 35, 37, 38, 39.
Value items: (4)	1, 5, 20, 36.
Attitude items: (8)	2, 12, 17, 18, 21, 24, 26, 40.

Test of Possession Dispositions: (9)	6, 7, 8, 9, 11, 16, 19, 28, 29.
Self Report Dispositions: (1)	10.
View of Science:	Explicit - Realist, item 20.
	Implicit - Instrumentalist, item 36.
	Realist, items 7, 33.

Research Studies

Mackay, Lindsay D. Changes in affective domain objectives during two years of physics study in Victorian schools. *Australian Science Teachers Journal*, 1971, *17*, 67-71.

A random sample of secondary school physics students (n-271) were administered the Gardner scale at the beginning and end of grade 11, and at the end of grade 12. Significant negative differences on enjoyment of physics and scientists, and positive difference on Non-authoritarian learning.

Gardner, Paul L. Deterioration of high school students' attitudes to physics. *Nature*, 1974, *250*, 465-466.

1,014 grade 11 students (in the first year of a 2-year PSSC program) were administered the Gardner scale at the beginning and end of the school year. View of physics as an open discipline declined significantly, as did the view of scientists as normal. Enjoyment of physics was initially high, but declined sharply and significantly. The top group of students who were more competitive (Personal Preference Index) maintained its enjoyment of physics better than the other groups.

Gardner, Paul L. Change in attitudes of PSSC p 'sics students: A Second look. *Australian Science Teachers (rnal*, 1973, *19*, 71-78.

This study replicates Mackay's (see above) and compares it with the results obtained from the sample of 1,014 students. Significant declines reported as above, with the suggestion that Mackay's sample is not random.

Gardner, Paul L. Changes in attitudes of PSSC physics students: A third look. *Australian Science Teachers Journal*, 1974, *20*, 99-104.

The Gardner scale was administered to 1003 students. 553 had studied physics for the first time in grade 11 and continued in grade 12. The remaining 450 consisted of some who repeated grade 11 physics (100), some who transferred schools (60) and the remainder who dropped physics (290). Continuing students demonstrate more favorable attitudes than noncontinuing students on all four scales on both pre and post tests.

Lewis, Ramon. Changes in attitudes of PSSC physics students: A fourth look or a second look at a third look: Australian Science Teachers Journal, 1975, 21, 95-100.

Of the 38 schools used by Gardner, 21 were randomly selected, and from these the scale was administered to 288 form V students, and form VI students one year later to identify those students who had dropped physics. Concludes that all the studies confirm that increased exposure to PSSC physics decreases the likelihood of students choosing to maintain an interest in physics unless career plans necessitate it.

Gardner, Paul L. Attitudes toward physics: Personal and environmental influences. Journal of Research in Science Teaching, 1973, 13, 111-125.

This study investigates the relationships between scores on the Gardner scale, the Physics Classroom Index (measuring such dimensions as competitiveness, organization, warmth and compulsiveness) and the Personal Preference Index (measuring needs for achievement, deference, order, nurturance and so forth). The sample consisted of 1,014 students as reported in Gardner, Nature, above. Analysis of covariance was used to identify the main and interaction effects. The decline of physics enjoyment is not uniform, but is related to intellectual and achievement-motivated students with intellectual and achievement-pressing teachers.

Commentary

Despite the amount of work accomplished with this scale, the factor analysis should prompt concern for validity. Nevertheless, the scale has significance and, as Fraser has shown, can readily be adapted to an attitude to science scale.

Items of the Gardner Scale*

1. If a student was doing an experiment to investigate the effect of air speed on the amount of frictional force on a model aeroplane wing, the teacher should not tell him the results; rather, the teacher should let the student find out for himself.

2. I enjoy reading books about physics.

3. Scientists are about as healthy and as physically fit as other people.

4. Scientists are rather eccentric persons who live in a world of their own.

5. Physics is worth doing whether you want to be a scientist or not.

6. A physics experiment is best when the instructions are all laid out in the textbook.

7. The best way for students to learn about light is to listen to a teacher, who knows a great deal about the subject, summarize the facts known about light today.

8. Some laboratory textbooks written for physics students to use in their experimental work don't give very definite instructions about what to do; instead they state some problem and expect students to work out their own procedure; this approach is quite good.

9. It is reasonable to ask students to learn laws like Newton's Laws of Motion, but they should not be told the laws before they do experiments with moving bodies; they should try to discover the laws for themselves first.

10. I feel that it is a waste of time and effort for me to investigate any natural phenomenon for which explanations already exist.

11. Most experiments should be performed as demonstrations by the teacher because the teacher is likely to get a better result than the student, and the student would therefore learn more.

12. Physics is just a dull grind for me.

13. Scientists are less warm and friendly than other people.

14. People with imagination would certainly be more successful as writers and artists than as scientists.

15. Hardly any scientists believe that God exists.

16. A physics experiment is good when students are given apparatus and told to solve a problem without instructions of how to do it. That's a real experiment.

17. I don't see why a physicist would want to spend most of his life doing experiments and analysing results.

18. I like the way physics challenges us to find out why things happen.

19. When you learn a new law in physics it is very important to thoroughly learn the statement of it so that you know it word perfectly.

20. Once a law in physics is discovered it should not need changing.

21. I cannot see the point in studying topics like speed and acceleration in any greater detail.

22. For every research problem facing the practising physicist there is a well-defined procedure which allows him to obtain the answer.

23. Scientists are interested in religion to the same extent as other people.

24. I would enjoy having a job in a physics laboratory during one of my school holidays.

25. Men may have some of their most cherished ideas shattered by discoveries in physics.

26. Learning about the sort of thing that anyone can see happening makes physics boring for me.

27. Eventually all the laws of physics will be discovered, and little further research will then be necessary.

28. Some physics teachers occasionally give students problems to solve experimentally, even though the teachers do not know the answer to the problem themselves; this is quite a good idea.

29. The best physics teacher would be the one who tells you as many facts about physics as possible.

30. It is pretty well certain that physicists are reaching the limits of things a man can know.

31. Scientists are more devoted to their work than most people.

32. Scientists would not be interested in ordinary community activities.

33. In physics there are many problems for which physicists at present do not even know the procedure for obtaining the answers.

34. Scientists are less interested in art, music and literature than other people.

35. Scientists are peculiar people.

36. It is important for a physicist to be able to throw away widely accepted ideas and think without restriction.

37. The proportion of scientists that are happily married is about the same as in the rest of the population.

38. There is no end to the new things a physicist may discover.

39. In the future, people will be surprised at how much physics has changed since now.

40. I find learning about light most enjoyable.

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HACKETT

AFFECTIVE SELF-REPORT INSTRUMENT

ay K. Hackett. An investigation of the correlation between teacher observed and student self-reported affective behavior toward science. Unpublished Ed.D. dissertation, University of Northern Colorado, 1972. (DAI: vol. 33, p. 1078)

nstrument Characteristics

Format:	42 item Likert-type scale, (4-point)
Population:	Grade 8 pupils.
View of attitude:	Attitude to science is inferred behavior from personal opinions and emotional values held or expressed toward the scientific process and scientists.
Subscales:	Four are built into the scale to correspond with Krathwohl's affective objectives hierarchy: interest, appreciation, attitudes, and values.
Validity:	3 judges (members of the thesis committee) determined the consistency of the instrumen with behavioral objectives as a measure of content validity.
Reliability:	Pilot study, (n=154), corrected split-half reliability =.92. For 647 pupils, =.90.

nalysis

Cognitive items: (6)	17, 18, 20, 22, 30, 42.
Value items: (4)	26, 31, 32, 37.
Attitude items: (14)	1, 3, 4, 8, 9, 12, 16, 21, 23, 24, 28, 29, 33, 38.
Test of Possession Dispositions: (2)	35, 41.
Self-Report Dispositions: (16)	2, 5, 6, 7, 10, 11, 13, 14, 15, 19, 25, 27, 34, 36, 39, 40.
View of science:	Explicit - Instrumentalist, items 37, 42.
	Realist, item 18.
	Implicit - Instrumentalist, item 13.

Research Studies

Hackett, Jay K. (See above)

647 pupils and their 30 teachers were studied, the teachers completing an Observed Activity Checklist. Scores on the attitude subscales and checklist are correlated ($r = .29 - .43$) and found to be significant at the .01 level. There are no significant differences between rural and urban children.

Commentary

The analysis of the items suggests that the items may not correspond to the subscales. Yet, the research can be taken as a measure of convergent validity, showing the correspondence between expressed attitude and behavior to some extent.

Items of the Hackett Scale*

1. I would enjoy belonging to a science club (rocket club, ecology club, photography club, etc.).
2. I often do not complete science assignments.
3. I seldom bother to read science articles in the paper or magazines.
4. If I had a choice I probably wouldn't build a science fair project.
5. I usually do more than is asked for on science assignments.
6. I seldom use references other than my science textbook.
7. I never volunteer to write special reports or work on science projects.
8. I enjoy watching science programs on TV (Wild Kingdom, Cousteau Specials, Moon Walks, etc.).
9. Laboratory experiments are usually boring.
10. I often use books and materials other than the textbook on science assignments.
11. I often volunteer for special reports or projects in science.
12. Both at home and at school, science related things catch my attention.
13. New information often makes it necessary to change our ideas about why things happen in nature.
14. It is often more work than it is worth to collect and record data on experiments.
15. After we do things in class, I see examples of them around me that I hadn't noticed before.
16. It makes me feel good when I figure out why things happen.

17. Our class activities never relate to things in my everyday world.
18. Scientific explanations of why things happen in nature never need to be changed or abandoned.
19. I usually try to predict the outcome of experiments or investigations before I begin.
20. Science and technology have increased our country's wealth and leisure time.
21. The results of most lab experiments or teacher demonstrations are not very exciting.
22. Our society would probably have advanced equally as well without so much emphasis on science.
23. If science was an elective course, I would probably take something else.
24. A career in science would be very rewarding.
25. Science is very difficult.
26. We spent more money getting man to the moon than it was worth.
27. Science hasn't really helped me become a better person.
28. I would like to take more science.
29. I would never choose a career in science.
30. You don't have to be extra smart to do well in science.
31. Most scientific discoveries have been good for mankind.
32. Everyone should have some understanding of science.
33. I like to investigate new things or new ideas.
34. I never change my mind once I have made a decision.
35. Conclusions reached from a laboratory investigation must be based solely upon the data collected.
36. Most of the time I try to be very accurate in making measurements and observations.
37. Certain happenings in nature are best explained without using science.
38. Investigating things or ideas in science just doesn't turn me on.
39. I am usually willing to let others criticize my ideas.
40. It would be difficult for others to repeat an investigation using my recorded data and observations.
41. Observations and measurements are not always necessary in order to form conclusions from science investigations.
42. Most happenings in nature can be explained by scientific reasoning.

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HAGERMAN

ATTITUDE TOWARD SCIENCE AND SCIENCE TEACHING

Barbara Heine Hagerman. A study of teachers' attitudes toward science and science teaching as related to participation in a SCIS project and to their pupils' perceptions of their science classes. Unpublished Ph.D. dissertation, Indiana State University, 1974. (DAI: vol. 35, p. 5149)

Instrument characteristics

Format:	70 item Likert scale
Population:	Grades 1-6 science teachers.
View of attitude:	Not stated.
Subscales:	Not stated. The scale is adapted from that of Moore and Sutman.
Validity:	Not stated.
Reliability:	Not stated.

Analysis

Cognitive items: (34)	4, 7, 10, 11, 12, 14, 16, 17, 18, 20, 22, 24, 26, 27, 28, 33, 35, 37, 44, 47, 49, 50, 51, 54, 56, 57, 59, 60, 62, 64, 66, 67, 69, 70.
Value items: (24)	1, 2, 3, 6, 9, 13, 15, 19, 23, 25, 29, 31, 32, 39, 40, 43, 46, 48, 52, 53, 55, 61, 65, 68.
Attitude items: (3)	8.2, 21.2, 34, 42
Test of Possession Dispositions: (4)	5, 41, 45, 63.
Self-Report Dispositions: (5)	8.1, 21.1, 30, 36, 38, 58.
View of science:	Explicit - Instrumentalist, items 11, 18, 51, 69, 70
	Realist, items 35, 41, 47, 63, 67.
	Implicit - Instrumentalist, items 16, 56.
	Realist, items 5, 62.
Additional characteristics:	Typographical error, item 52.
	Ambiguous items 8, 21, 22, 34, 36, 39, 46, 58.

Research Studies

Hagerman, Barbara H. (See above)

3 groups of 30 grades 1-6 science teachers were as follows: attended SCIS workshop and used SCIS materials for teaching; attended SCIS workshop but used no SCIS materials for teaching; had neither the workshop nor the SCIS materials. Administration of the scale to teachers, and a measure of pupil interest following the workshop showed that: attendance at the workshop had no affect on teacher attitudes; no evidence that the use of SCIS effected teacher attitudes; pupils taught by teachers having a negative attitude to science held more positive attitudes to science classes than pupils taught by teachers with positive attitudes to science.

Commentary

Quite clearly, the scale is not unidimensional although it is treated as such. It is of little value without attention to its subscales and their validity and reliability. Lack of validity is suggested by the research study.

Items of the Hagerman Scale*

1. It is important for children to learn that the air is approximately 20% oxygen--at least by the sixth grade.

2. There is no need for the public to understand science in order for scientific progress to occur.

3. Most children should be able to design experiments--at least by the sixth grade.

4. Most people are not able to understand the work of science.

5. When something is explained well, there is no reason to look for another explanation.

6. A teacher should be a resource person rather than an information-giver in science.

7. The products of scientific work are mainly useful to scientists; they are not very useful to the average person.

8. I do not understand science, and I do not want to teach it.

9. A scientist must be imaginative in developing ideas which explain natural events.

10. After all is said and done, it is really the teacher who tells the children what they have to learn and know.

11. Some questions cannot be answered by science.

12. In teaching science, a teacher might spend more time listening to the children than talking to them.

13. Before one can do anything in science, he must study the writings of the great scientists.

14. Rapid progress in science requires public support.
15. Process skills are very important things to be developed in science.
16. Scientists believe that nothing is known to be true with absolute certainty.
17. A major purpose of science is to help man live more comfortably.
18. A new theory may be accepted when it can be shown to explain things as well as another theory.
19. Children must learn certain basic facts in elementary science so they can do well in science in junior high.
20. Scientists do not need public support, they can get along quite well without it.
21. I understand science and I want to teach it.
22. Every citizen should understand science because we are living in an age of science.
23. Children must be told what they are to learn if they are to make progress in science.
24. Science is so difficult that only high trained scientists can understand it.
25. A teacher has a responsibility to teach the basic processes of science.
26. His senses are one of the most important tools a scientist has.
27. Science may be described as being primarily an idea-generating activity.
28. Ideas are one of the more important products of science.
29. As children experiment, a teacher may give helpful hints. but not answer to a problem.
30. Science is pretty easy to understand.
31. The value of science lies in its theoretical products.
32. Process skills are the most important things to be developed by children in science.
33. A major purpose of science is to produce new drugs and save lives.
34. I like science, and I will probably will be (am) a better science teacher than most other teachers.
35. Science is devoted to describing how things happen.
36. I am afraid to teach science because I can't do the experiments myself.
37. Public understanding of science is necessary because scientific research requires financial support through the government.

38. I just never will understand science.
39. People need to understand the nature of science because it has such a great effect upon their lives.
40. A teacher has a responsibility to teach the basic facts of science.
41. Scientists discover laws which tell us exactly what is going on in nature.
42. The idea of teaching science scares me.
43. Demonstrations should be used frequently so the children will understand what their teacher tells them.
44. Scientists believe that they can find explanations for what they observe by looking at natural phenomena.
45. Scientific laws cannot be changed.
46. If an experiment does not come out right, the teacher should tell the children the answer so they will not be lost.
47. There are some things which are known by science to be absolutely true.
48. It is a teacher's responsibility to tell children which things are important for them to know.
49. I do (will) not teach very much science.
50. An important purpose of science is to help man to live longer.
51. A useful scientific theory may not be entirely correct, but it is the best idea scientists have been able to think up.
52. Today's electric applicances are examples of the really valuable products of science.
53. It is important for children to learn how to control variables in an experiment--at least by the sixth grade.
54. I am well-prepared to teach science.
55. The teacher should arrange things so that children spend more time experimenting than listening to her in science.
56. Scientists are always interested in improving their explanations of natural events.
57. The value of science lies in its usefulness in solving practical problems.
58. I think I understand the nature of science and science teaching pretty well.
59. Most people are able to understand the work of science.
60. Scientific explanations can be made only by scientists.
61. Most children should know that the blood carries oxygen to the cells--at least by the sixth grade.

62. We can always get answers to our questions by asking a scientist.
63. Scientific laws have been proven beyond all possible doubt.
64. Looking at natural phenomena is a most important source of scientific information.
65. A major function of the teacher in teaching science is to help children identify problems.
66. If a scientist cannot answer a question, all he has to do is to ask another scientist.
67. Anything we need to know can be found out through science.
68. It is important for children to know why iron rusts--at least by the sixth grade.
69. Scientific ideas may be said to undergo a process of evolution in their development.
70. Scientists cannot always find the answers to their questions.

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HOUSTON AND PILLINER

TEST OF ATTAINMENT IN THE AFFECTIVE DOMAIN

J.G. Houston and A.E.G. Pilliner. The effect of verbal teaching styles on the attainment of educational objectives in physics. British Journal of Educational Psychology, 1974, 44, 163-174.

Instrument characteristics

Format:	38 item Likert scale.
Population:	Third and fourth year high school students.
View of attitude:	The scale is based on affective objectives linked to Scottish Education Department Guidelines: Awareness of relationship of physics to other disciplines of knowledge. Awareness of the importance of physics in the working, leisure and social aspects of the community and society in general. An interest and a willingness to participate in physics-based leisure pursuits. An interest in gathering information about physics through all the media of communication. An attitude of objectivity to all decisions and assessments required of the individual. An enthusiasm for physics as an attractive and satisfying intellectual discipline.
Subscales:	1. Awareness of the significance of physics in everyday life. (11 items) 2. An attitude of objectivity learned from physics. (10 items) 3. An interest in and enthusiasm for physics. (17 items)
Validity:	An initial pool of items based on those of Sally Brown's scale was pilot tested; item analysis yielded the final 38 items.
Reliability:	Not stated.

Analysis

Cognitive items: (8)	3, 5, 7, 13, 19, 24, 32, 35.
Value items: (6)	1, 9, 11, 17, 21, 31.
Attitude items: (14)	2, 4, 8, 10, 14, 16, 20, 23, 25, 27, 29, 34, 36, 38.

Tests of Possession Dispositions: (9) — 6, 12, 15, 18, 22, 26, 30, 33, 37.

Self-Report Dispositions: (1) — 28.

View of science: Explicit - Instrumentalist items 18, 37.
Realist item 30.
Implicit - Instrumentalist item 33.
Realist items 6, 12, 15, 26.

Research Studies

Houston, J.G., and Pilliner, A.E.G. (See above)

The verbal interaction of 6 classes was compared with cognitive and affective attainment, over a one-year period. Teaching style and attitude of objectivity are unrelated. Pupils were generally less aware of the social implications of physics after one year of study. And there was evidence that pupils had lost interest in and enthusiasm for physics after one year of study.

Commentary

The scale is of unknown characteristics, largely, and the research results appear to substantiate this.

Items of the Houston and Pilliner Scale*

1. Physicists should criticise each other's work.
2. I would enjoy doing scientific work when I leave school.
3. Mathematics is a great help to physics.
4. I am not interested in physics.
5. Physics helps you to develop hobbies outside school.
6. If the teacher and I do the same experiment but get different results, the teacher's result is the right one.
7. Physics is very useful in several of my other school subjects.
8. The TV programme Tomorrow's World is boring.
9. Only people who are going to do scientific work should have to learn physics.
10. I enjoy physics.
11. Biologists studying plants and animals do not need to know anything about electricity.
12. If a famous physicist and an unknown physicist disagree we accept the opinion of the famous physicist.

13. Space research is no use to ordinary people.
14. Science clubs don't interest me.
15. Physics teachers know the scientific truths.
16. I would not like to be a physicist.
17. There should be more programmes on TV about physics.
18. A good scientific theory does not supply the final answer to scientific questions.
19. Physics does not help someone to learn geography.
20. Physicists are boring people.
21. Physics should be left to those who are scientists or are going to be scientists.
22. Experiments which give answers that disagree with what the teacher expects are useful.
23. I wish we had more physics in school.
24. New discoveries in physics are important to everyone.
25. Physics is boring for me.
26. If a good physicist says that a theory is true all other physicists will believe him.
27. I like tinkering with things like old clocks and radios at home in my spare time.
28. I make use of physics every day.
29. I hate physics.
30. Theories in physics supply the true answer to physics questions.
31. The school library should have a lot more books about physics.
32. Physicists are very interesting people.
33. Physics teaches us not to believe everything we are told.
34. I like listening to radio programmes which are concerned with physics.
35. Chemistry is of little help to physics.
36. Physics is one of my favourite subjects.
37. A useful theory in physics may not be entirely correct.
38. Pupils who enter for scientific competitions like Science Fair are wasting their time.

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IVANY

SCIENCE OPINIONNAIRE

George Ivany, et al. High School physics teaching: A report on current practices in the northeast, Part II. Physics Teacher, 1973, 11, 289-294.

Instrument characteristics

Format:	18 true-false items
Population:	High school physics students.
View of attitude:	Not available.
Subscales:	1. Is science responsible for today's problems? (Items 1-4)
	2. Could we do without science? (Items 5, 6)
	3. Should scientists care about the consequences of their work? (Items 7-10)
	4. Do students have a clear picture of science as a profession? (Items 11-13)
	5. Does scientific work attract or repel students? (Items 14-18)
Validity:	Not reported.
Reliability:	Not reported.

Analysis

Cognitive items: (7)	1, 2, 3, 7, 13, 16, 17.
Value items: (7)	4, 5, 6, 8, 9, 10, 11.
Attitude items: (4)	12, 14, 15, 18.
View of science:	None is evident.
Additional characteristics:	Ambiguous items 1, 2.

Research Studies

Ivany, George, et al. (See above)

The study surveys 42 schools in different settings and the 12th grade physics students in these schools. The results show positive attitudes to science, generally. There is no statistical analysis.

Commentary

The survey of attitudes toward science is part of a large survey on science teaching and students' perception of it. The scale itself appears not to be useful.

Items of the Ivany Scale*

1. Science does not cause problems, the misuse of science does.
2. Industrial profits, not science, are responsible for the pollution problem.
3. Modern science is incapable of solving today's problems.
4. The world would have been better off without some of the recent products of science.
5. It might be well to retard scientific activity for a time.
6. Research in some fields should be given much more support.
7. A good scientist considers the consequences of his professional activity.
8. A scientist ought to be free to do whatever experimental work he feels is important.
9. Regardless of how the results of science are used, the scientist himself must share a major part of the responsibility.
10. Some kinds of experimental work should be prohibited.
11. Few professions offer opportunities superior to those a scientist might encounter.
12. Much of scientific work is dull routine.
13. Secrecy is an important positive influence upon American science today.
14. A scientific career offers a chance to do something really worthwhile.
15. The rewards of a scientific career would not repay the effort involved.
16. Scientific work is usually pretty far removed from everyday reality.
17. Only a small percentage of the population could qualify to become scientists.
18. I would like to become a scientist.

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JAUS

HOW I FEEL ABOUT SCIENCE

Harold H. Jaus, Activity-oriented science: Is it really that good? Science and Children, 1977, 14, 26-27.

Instrument characteristics

Format:	10 item Likert-type scale. (The usual scale is replaced by 5 "happy-sad" faces.)
Population:	Grades 2-6
View of attitude:	Not stated.
Subscales:	None are given.
Validity:	Determined by a panel of 12 professors of science education. (Personal communication)
Reliability:	For 86 pupils in grades 2, 3 and 4, test-retest r=.93. With 625 grade 2 pupils,=.92. Range for grade 6 =.85, grade two =.95. (Personal communication)

Analysis

Cognitive items: (1)	7
Value items: (1)	5
Attitude items: (8)	1, 2, 3, 4, 6, 8, 9, 10.
View of science:	None evident.

Research Studies

Jaus, Harold. (See above)

154 pupils in grades 2, 3 and 4 are studied over 12 weeks. One class in each grade uses a traditional textbook course the others use an activity-oriented course. The attitude gain scores for the experimental group are significantly different from those of the control group in each grade.

Commentary

At issue here is, perhaps, what the children understand the items to be asking. Is it science lessons, science, and so on? The use of smiling or frowning faces may be helpful to pupils of this age.

Items of the Jaus Scale*

1. I like science.
2. Science is fun.
3. I like to do science experiments.
4. Science is exciting.
5. Science is important.
6. I look forward to science.
7. Science helps me learn more about the world.
8. I wish we had more time for science.
9. Science is a waste of time.
10. When I am grown, I would like to be a scientist.

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KIMBALL

NATURE OF SCIENCE SCALE

Merritt E. Kimball. Understanding the nature of science: A comparison of scientists and science teachers. Journal of Research in Science Teaching, 1967-68, 5, 110-120.

Instrument characteristics

Format: 29 item Likert scale.

Population: Science teachers.

View of attitudes: Strictly, there is none. (The scale is a cognitive scale, and is included with the attitude scales to provide a useful comparison between the items of cognitive and affective tests of science.)

Subscales: A theoretical model (consisting of 8 assertions) of the nature of science was developed from the literature on the nature and philosophy of science.

1. The fundamental driving force in science is curiosity concerning the physical universe.

2. In the search for knowledge, science is process-oriented.

3. Science aims at ever-increasing comprehensiveness and simplification in developing knowledge. The emphasis is on the precision afforded by mathematical language.

4. There is no one "scientific method". There are as many methods as there are practitioners.

5. Values, rather than techniques, characterize the methods of science, such as dependence on sense experience, insistence upon operational definitions, recognition of the arbitrariness of definitions and classification schemes, and the evaluation of scientific work in terms of reproducibility and usefulness.

6. A basic characteristic of science is a faith in the susceptibility of the physical universe to human ordering and understanding.

7. Science has the attributes of openness of mind and of the openness of the realm of investigation.

8. Tentativeness and uncertainty mark all of science. Nothing is ever proven.

Validity: A panel of 7 experts examined the initial 200 items. Those approved were submitted to 54 subjects. 31 items survived item analysis and were submitted to 97 new subjects. Two items were discarded for not showing sufficient discrimination.

Reliability: Spearman-Brown, .72.

Analysis

Cognitive items: (26.5) 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23.1, 24, 25, 26, 27, 28, 29.

Value items: (1.5) 14, 23.2.

Test of possession-dispositions: (1) 5.

View of science: Explicit - Instrumentalist, items 2, 16, 22.
Realist, items 5, 20, 26.

Additional characteristics: Ambiguous item 23.

Research Studies

Aikenhead, G.S. Learning about the scientific enterprise in Saskatchewan High school chemistry classes: An evaluation. Saskatchewan Journal of Educational Research and Development, 1975, 5, 4-29.

The effects of CHEMS study and a course using Modern Chemistry were studied by a pre and post test comparison of 122 grade 11 students and 133 grade 12 students on Korth's "Test on Social Aspects of Science" and the Kimball scale. No extraneous variables were controlled. (The Kimball scale was adapted for readability and one item was excluded.)

$K\text{-}R_{20}$ reliabilities for the Kimball scale were .15, .21, for grade 11 and .38 for grade 12. No significant differences obtained for the nature of science. The little gains which did occur were counterbalanced by an acquisition of misunderstandings.

Cossman, George W. The effects of a course in science and culture for secondary school students. Journal of Research in Science Teaching, 1969, 6, 274-283.

A pre-post control with matched pairs design is used to evaluate a science and culture course, the sample consisting of 21 grade 11 and 12 students. Pre and post testing on a number of scales revealed positive and significant changes. the Kimball scale was administered as a post test only. A significant difference favoring the experimental group was found.

Kimball, Merritt E. (See above)

712 responses from science and philosophy graduates were analyzed. A corrected split-half reliability of .54 was found. Data from science majors who taught science was retained. There was no significant difference in the understanding of the nature of science held by scientists and by qualified science teachers. Philosophy majors had a significantly better understanding than the science majors.

Munby, Hugh and Wilson, Robert. Convergent and discriminant validity of classroom observation instruments: Conceptual background, critique, and a case in point. Alberta Journal of Educational Research, 1978, 24, 69-80.

The Kimball scale was one of several written and observation measures used to establish convergent and discriminant validity of a new observation instrument in a study of 55 science teachers and their lessons. The corrected reliability of the Kimball scale was .69, and it was found to converge with the California F-Scale and Flanders' measure of directedness in teaching, but discriminate from written and observation measures of anxiety as a speaker.

Rockhill, Ronald Henry. The science and science education backgrounds and science attitudes of young teachers in elementary schools operated by congregations of the Lutheran Church -- Missouri Synod. Unpublished Ed.D. dissertation, Columbia University, 1972. (DAI: vol. 33, p. 204)

The Kimball scale was administered to synodically and non-synodically educated teachers, grouped as science majors and non-science majors. The synod science majors outperform other groups on the scale.

Rose, Ryda Dwarys. The relationship of attitudes, knowledge and processes to initial teaching behavior in science. Unpublished Ed. D. dissertation, University of Pennsylvania, 1971. (DAI: vol. 32, p. 6242)

13 students in an experimental multiple methods course were compared to 12 in a control class on Kimball's scale, Schwirian Science Support Scale, and Flanders Interaction Analysis. There were: 1. No significant relationships between pre and post test attitudes; 2. No significant relationships between attitude toward science and initial teaching behavior; and 3. No significant relationship between the scores on the Kimball and Schwirian Scales.

Commentary

The Kimball Scale, as the analysis shows, deals almost entirely with information and not attitudes. Its relationship to other variables appears mixed, as shown in the research studies.

Items of the Kimball Scale*

1. The most important scientific ideas have been the result of a systematic process of logical thought.
2. Classification schemes are imposed upon nature by the scientists: they are not inherent in the materials classified
3. Thanks to the discovery of the scientific method, new discoveries in science have begun to come faster.
4. The primary objective of the working scientist is to improve human welfare.
5. While a scientific hypothesis may have to be altered on the basis of newly discovered data, a physical law is permanent.
6. The scientific investigation of human behavior is useless because it is subject to unconscious bias of the investigator.
7. Science is constantly working toward more detailed and complex knowledge.

8. A fundamental principle of science is that discoveries and research should have some practical applications.

9. While biologists use the deductive approach to a problem, physicists always work inductively.

10. The ultimate goal of all science is to reduce observations and phenomena to a collection of mathematical relationships.

11. The best definition of science would be "an organized body of knowledge".

12. Science tries mainly to develop new machines and processes for the betterment of mankind.

13. Any scientific research broader than a single specialty can only be carried out through the use of a team of researchers from various relevant fields.

14. Investigation of the possibilities of creating life in the laboratory is an invasion of science into areas where it does not belong.

15. Team research is more productive than individual research.

16. Many scientific models are man-made and do not pretend to represent reality.

17. Scientific investigations follow definite approved procedures.

18. Most scientists are reluctant to share their findings with foreigners, being mindful of the problem of national security.

19. The essential test of a scientific theory is its ability to correctly predict future events.

20. When a large number of observations have shown results consistent with a general rule, this generalization is considered to be a universal law of nature.

21. The scientific method follows the five regular steps of defining the problem, gathering data, forming a hypothesis, testing it, and drawing conclusions from it.

22. One of the distinguishing traits of science is that it recognizes its own limitations.

23. The steam engine was one of the earliest and most important developments of modern science.

24. Scientific research should be given credit for producing such things as modern refrigerators, television, and home air-conditioning.

25. If at some future date it is found that electricity does not consist of electrons, today's practices in designing electrical apparatus will have to be discarded.

26. By application of the scientific method, step by step, man can solve almost any problem or answer almost any question in the realm of nature.

27. Scientific method is a myth which is usually read into the story after it has been completed.

28. Scientific work requires a dedication that excludes many aspects of the lives of people in other fields of work.

29. An important characteristic of the scientific enterprise is its emphasis on the practical.

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KORTH

TEST OF THE SOCIAL ASPECTS OF SCIENCE

William Willard Korth. The use of the history of science to promote student understanding of the social aspects of science. Unpublished Ph.D. dissertation, Stanford University, 1968. (DAI: vol. 29, p. 1477)

Instrument characteristics

Format:	52 item Likert scale
Population:	High school students
View of attitude:	Since this scale attempts to measure an understanding of the social aspects of science, there is no explicit view of attitude given. (The scale is included in this collection because many of the items are similar to those found in attitude scales, and so the scale provides a useful comparison.) Yet, according to Korth, understanding is related to attitude.
Subscales:	1. Interaction between science and technology (items 1, 6, 13, 17, 20, 21, 23, 26, 28, 29, 33, 34, 37, 38, 40, 44, 47, 48, 49.) 2. Social nature of the scientific enterprise (items 2, 3, 4, 9, 11, 14, 15, 18, 19, 22, 24, 27, 30, 35, 36, 39, 42, 43, 45, 46, 51.) 3. Social responsibilities of science and scientists (items 5, 7, 8, 10, 12, 16, 25, 31, 32, 41, 50, 52.)
Validity:	The following scales influenced the design of Korth's. Cooley and Klopfer TOUS, Stice's "Facts about Science Test", Allen's "Science Attitude Inventory". 20 items from TOUS were administered to locate areas of difficulty and to generate the initial item pool. Items were judged by a panel, and then submitted to 167 high school sophomores, to yield the final 52-item scale.
Reliability:	$K\text{-}R_{20} = .71$ Subscale 1, $r = .43$ Subscale 2, $r = .53$ Subscale 3, $r = .40$

Analysis

Cognitive items: (36)	1, 3, 4, 6, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 32, 33, 34, 35, 37, 38, 42, 43, 44, 46, 47, 50, 51.
Value items: (13)	5, 7, 8, 10, 21, 31, 36, 39, 40, 41, 48, 49, 52.
Self-report Dispositions: (3)	2, 30, 45.
View of science:	Explicit - Realist, items 2, 30.
Additional characteristics:	Ambiguous items 12, 25, 27, 38, 45, 52.

Research Studies

Aikenhead, G.S. Learning about the scientific enterprise in Saskatchewan high school chemistry classes: An evaluation. Saskatchewan Journal of Educational Research and Development, 1975, 5, 4-29.

The effects of CHEMS Study and a course using Modern Chemistry were studied by a pre and post-test comparison of 127 grade 11 students and 133 grade 12 students on the scales of Korth and Kimball. No extraneous variables were controlled. There were no significant differences on the Korth scale between pre and post-tests, nor between the scores of students in each course.

Korth, Willard William. (See above)

The scale was administered to 155 high school sophomores from six biology classes in a single school as follows: pretest, post-test (after 2 weeks), and delayed post-test (after 6 weeks). A 2 week unit "The cells of life" was taught between the pre and post-tests. There was a significant difference between the pre and post-test scores on the Korth Scale, but there was no significant difference between the post-test and delayed post-test scores.

Korth, Willard William. Test every science project: Understanding the social aspects of science. ED 028 087, 1969.

The scores on the Korth Scale of 865 science oriented students were compared with those of 628 non-science oriented students. Significant differences in favor of the science-oriented students were found for 34 of the 52 items. It is concluded that science oriented students have more positive attitude toward science, a better understanding, and a more realistic conception of characteristics of scientists.

Commentary

The validity of this scale is problematic because it contains items similar to those of attitude scales and because the analysis indicates that several items call for value judgments.

Items of the Korth Scale

1. The many changes our culture is undergoing today have largely been caused by advances in science and technology.
2. Statements are not accepted as scientific knowledge unless they are absolutely true.
3. Scientists have advanced knowledge by consistently following, step by step, a definite procedure called the scientific method.
4. The growth of science in America would be aided by increasing our security restrictions on scientific knowledge.
5. Scientists should be concerned with the potential harm that might result from their discoveries.
6. The most important requirement for the continued progress of science is larger sums of money for scientific research.
7. The judgment of scientists on political matters should be highly respected since they are likely to approach such problems with a scientific attitude.
8. It is extremely difficult to anticipate how new scientific knowledge may affect society.
9. The primary objective of the working scientist is to improve human welfare.
10. The scientist should attempt to report his findings to the general public in a manner that the layman can understand.
11. Winning the esteem of his associates is one of the main incentives for the scientist.
12. Much of the evil in the world today is the responsibility of scientists since they have developed the knowledge that has lead to such problems as nuclear weapons, air pollution, etc.
13. Scientists are strongly influenced by the attitude and interests of the general public.
14. A scientist is likely to be unbiased and objective, not only in his own field of work, but in other areas as well.

15. A scientist is expected to share the knowledge he discovers with other scientists rather than use it exclusively for his own profit.

16. Modern science is too complicated for the average citizen to understand and appreciate it.

17. The increased use of automation and computers will probably reduce the need for people trained in science.

18. Most scientists are not interested in public recognition for their discoveries.

19. Although advances in science and technology may improve living conditions they offer little help in solving today's social problems.

20. Since scientists are a rather select group, the educational level of the rest of the people has little effect on a nation's scientific achievements.

21. Because of the high cost of scientific research it would seem wise to cutdown on research that does not appear to have any practical value.

22. The principal aim of science is to provide the people of the world with the means for living better lives.

23. The economic prosperity of most nations today depends on their ability to discover and use scientific knowledge.

24. Science is primarily a method for inventing new devices.

25. Scientists are usually more poorly informed on political matters than other educated citizens since their work tends to isolate them from the rest of society.

26. In modern industrial societies science and technology have little to do with each other.

27. Scientists often question established social and political ideas. This is true because most scientists are political radicals and atheists.

28. The steam engine was one of the most important developments in the history of science.

29. Science would advance more efficiently if it were more closely controlled by the government.

30. Many of the scientific theories of the past have been disproved or modified as they have been found inadequate. However, the theories and laws of modern science are accurate and are likely to endure in their present form.

31. A scientist should withhold a discovery from the world if he thinks it may have undesirable social consequences.

32. A great research scientist is usually little concerned with the practical applications of his work.

33. Many of today's social, economic, and political problems require the use of science and technology for their solution.

34. The greatest accomplishments of science consist of the many useful products it has produced.

35. The principal function of scientific societies is to promote the exchange of ideas.

36. The free flow of scientific information among scientists is essential to scientific progress.

37. Researchers in science use the theories and laws discovered by workers in technology.

38. The political climate of a nation has little effect upon its scientists since they are pretty much isolated from the rest of society.

39. Scientists have no business investigating topics that may question people's religious beliefs.

40. Social and economic changes will probably be needed to keep pace with the rapid advance of science and technology.

41. Communication between scientists and the public is essential if the voting public and the national leaders are to make wise decisions on important issues.

42. Most scientists are reluctant to share their findings with foreigners because of the danger of exposing secret scientific information.

43. The aim of science is to increase man's knowledge of the physical and biological world.

44. Technology often provides the tools and techniques that lead to new discoveries in science.

45. The scientific investigation of human behavior is of little value since it must involve the personal opinions of the investigator.

46. The honesty and accuracy commonly attributed to scientist's reports of their work is largely due to the fact that scientists as a group tend to be more honest than other types of people.

47. New scientific knowledge affects society only through the practical use made of it.

48. In a democracy the public should ultimately control the support of science and the use of its achievements.

49. It would be a good idea to slow down science until society has had a chance to adjust to the changes science has brought about.

50. The scientist generally has little control over the use society may make of his discoveries.

51. A fundamental rule of science is that discoveries should have some practical use.

52. Many of today's social and political problems are related to science and technology. Since scientists are experts in this field we should accept their judgment in such matters.

LEAVERS

OPINION SURVEY

Donald R. Leavers. A course which changed the attitudes of students toward science. *Journal of Chemical Education*, 1975, *52*, 804.

Instrument characteristics

Format:	20 item multiple choice questionnaire.
Population:	College students.
Subscales:	Only 4 items are designed to measure attitudes.
Validity:	Not reported.
Reliability:	Not reported.

Analysis

Cognitive items: (2)	2, 3.
Attitude items: (2)	1, 4.
View of science:	None explicit or implicit

Research Studies

Leavers, Donald R. (See above)

The instrument was administered to 130 students enrolled in a chemistry course for nonscience majors. Responses to item 1 showed a significant improvement of attitude to science, and other responses showed a more favorable attitude to science.

Commentary

This scale is of very doubtful utility. It is weak conceptually and psychometrically.

Items of the Leavers Scale*

1. How would you describe your attitude toward science?

   a. great affection
   b. friendly tolerance
   c. calm indifference
   d. active dislike
   e. extreme hatred

2. Scientists are personally responsible for many of our problems

   a. strongly agree
   b. agree
   c. disagree
   d. strongly disagree

3. Scientists are able to help in the solution of many ecological problems

   a. strongly agree
   b. agree
   c. disagree
   d. strongly disagree

4. All chemistry courses are difficult

   a. strongly agree
   b. agree
   c. disagree
   d. strongly disagree

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LOWERY

PROJECTIVE TEST OF ATTITUDES

Lawrence F. Lowery. Development of an attitude measuring instrument for science education. School Science and Mathematics, 1967, 66, 494-502.

Instrument characteristics

Format:	This test is a projective test consisting of three parts: A word association test, an apperception test, and a sentence completion test.
Population:	5th and 6th grade pupils and their teachers.
View of attitude:	Not stated
Subscales:	Science, Process, Scientist.
Validity:	Established by the consistency of scores among the projective techniques. Percentage agreements in excess of 80 per cent are reported.
Reliability:	Inter-rater reliabilities for three judges are reported. Science .92, Process .87, Scientist .81. Pre- and post-test agreements are given as Science 92.5 - 97.6 per cent, Process 77.5 - 80.0 per cent, and Scientist 77.5 - 87.5 per cent. (These are for 335 grade 5 pupils.)

Analysis

The projective nature of the test pre-empts the analysis into statement types, and into the view of science implicit or explicit.

Research Studies

Deady, Gene M. The effects on increased time allotment on student attitudes and achievement in science. 1970. ED 039 126.

16 grade 4 classrooms (a total of 324 pupils) were studied. Eight classes received 20 minutes of science instruction each day, the other eight received 35 minutes a day. The projective tests were administered as pre and post tests. There were no significant differences in attitude attributed to increased time.

Feerst, Francis. A comparison of two methods of enriching a science curriculum so as to change the attitudes of children towards the relevance of science. Unpublished Ph.D. dissertation, New York University, 1973. (DAI vol. 34, p. 663)

12 grade 4 science classes (149 pupils) were studied. The 6 experimental classes were provided with the same course over 5 months as the control classes but received additional assignments on the application of science concepts. No significant differences were found in attitude and achievement.

Hovey, Larry Michael. Measuring Science Curriculum Improvement Study Teachers' attitudinal changes toward science. Unpublished Ph.D. dissertation, University of California, Berkeley, 1971. (DAI vol. 31, p. 6430)

36 K-6 teachers were trained in the use of SCIS in a 4-week program. Another 39 were introduced to SCIS in a one-day workshop or through a "buddy" system. A control group of 13 teachers had no training or experience in SCIS. It was concluded that neither these backgrounds nor the teaching experiences made a significant difference in attitude to science.

Johnson, Roger and others. Inquiry and the development of positive attitudes. Science Education, 1974, 58, 51-56.

108 6th graders were compared in three teaching situations: traditional textbook, textbook and laboratory work, and activity centered -- open-ended inquiry over a 6 week period. Analysis of variance in this posttest only design showed a significant difference in attitude at the .01 level favoring the activity-centered approach.

Lowery, Lawrence F. An experimental investigation into the attitudes of fifth grade students toward science. School Science and Mathematics, 1967, 67, 569-579.

Over eight weeks, an experimental group (N=165) received the Animal Coloration unit of ESSP, and the control group (N=170) received a traditional unit on animals. A significant difference (.01) in mean gain scores favoring the experimental group was reported. There was no significant pre-post difference for the control group. Some differences in views of science by socio-economic areas were found.

Commentary

This instrument is included in the present collection because it is the only projective instrument of its kind. (A projective instrument is not analyzable according to the present study's categories, so no further comment can be made.)

Items of the Lowery Instrument*

A. Word Association Test:

house, dog, car, science, pencil, experiment, book, scientist, room, chair.

B. Apperception Test:

3 pictures: a boy/girl looking at a newspaper headline;

a boy/girl looking at a bench upon which there is a microscope;

a boy/girl looking at an adult seated behind a desk.

C. Sentence Completion Test:

1. The field of science is ________________.
2. Most people like science whenever it ________
3. One thing that puts some people against science is ________________
4. Experimenting in science is ________________
5. Some people find experimenting enjoyable because ________________
6. Other people usually do not like to experiment because ________________
7. Scientists are people who ________________
8. People admire scientists because ____________
9. Some scientists are unpleasant people because ________________

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MANN

INTEREST IN SCIENCE

Eloise Ann Mann. A study of attitudes toward science of selected junior high school students (Sarasota, Florida) after exposure to an individualized science program (ISCS). Unpublished Ph.D. dissertation, Florida State University, 1972. (DAI vol. 33, p. 2195)

Instrument characteristics

Format:	A structured interview of 19 questions.
Population:	Grades 7, 8, 9.
View of attitude:	"A mental and neutral state of readiness organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related." (p. 8. This is Allport's definition)
Subscales:	Interest in science Nature of scientific knowledge Value of science
Validity:	Determined by a panel of 5 judges and 7 doctoral students. Face validity was assessed by 4 experts.
Reliability:	The reliability was not assessed.

Analysis

Cognitive items: (3)	11, 13, 16.
Value items: (5)	14, 15, 17, 18, 19.
Attitude items: (8)	1, 2, 3, 4, 5, 6, 7, 8.
Test of Possession-Dispositions: (3)	9, 10, 12.

View of Science: Explicit - Instrumentalist, item 10.
Realist, items 9, 11, 12.

Research Studies

Mann, Eloise Ann (See above)

The interview schedule was administered to 150 (grades 7, 8, 9) ISCS students and 150 non ISCS students. No significant differences were found.

Commentary

The analysis demonstrates that the interview questions ask for an array of rather different sorts of "attitudes". Since the validity and reliability of the instrument are unknown, this device is not useful.

Items of the Mann Instrument*

(Questions are not asked in the order below.)

Interest in Science

The student's response indicates that he tends to enjoy other activities more than those which are science related.	The student's response indicates that he tends to enjoy science related activities.

. . . .

1. Do you like science?

2. Here are the titles of six books. (Say the titles aloud as you show them on cards to the student.) From just looking at the titles of the books, decide which ones you think you'd like most to read. Arrange these cards with the titles in the order in which you'd like to read them. Put the one you'd like to read most first, the one you'd like next second, and so forth. OK?

How Clothes Have Changed	Sports Are Fun
What We Found on the Moon	How Elections are Won
Desert Plants and Animals	Chemical Changes All Around Us

3. Suppose your school is starting an anti-pollution campaign and everyone must take part. Which one of the following jobs would you rather do?

Do chemical tests on water samples to determine the amount of pollution or

Walk around town passing out anti-pollution posters.

4. OK. Now which of these two jobs would you rather do?

Speak at your school assembly about the need for student participation in the campaign

or

Count the number of birds in two areas - one polluted and one clean - to see which has the most.

5. If there were two TV specials on one evening and you could only watch one of them, which one would you choose?

Life in the Oceans or A Look at Crime Today

6. OK. Now which of these two would you choose?

The American Presidents or The Nuclear Energy Revolution

7. If you had a chance of going on a field trip with your class, which one of the following would you choose to do?

visit an art museum or visit a scientist's laboratory

8. OK. Now which would you choose between these two?

Would you rather

Look for fossils or attend a band concert

Nature of Scientific Knowledge

The student's response indicates that he views scientific knowledge as unchanging, consisting of absolute truths, always providing the <u>one</u> correct explanation.	The student's response indicates that he views scientific knowledge as temporary and changing, consisting of laws and principles which explain observations, allowing for many different correct explanations.

. . . .

9. What does it mean in science when something is "true"?

10. Suppose two scientists have two very different explanations of how something happens. Can we believe both of them? Why (Why not)?

11. No one has ever seen an atom, yet scientists can describe what they think atoms are like. Why can they do this?

12. I'm sure you've always heard that matter is made up of atoms. Suppose you read in the newspaper that a scientist has said that matter is <u>not</u> made up of atoms. How would you react to this? Why?

13. You've heard about science principles and explanations. How would you describe what these are?

Value of Science

The student's response centers upon the practical value of science.	The student's response centers upon the intellectual value of science.

. . . .

14. Do you see any use in scientists studying the migration of birds? Why (Why not)?

15. Many people feel that tax money should not be spent on research in science that doesn't help solve problems like disease, hunger and pollution. How do you feel about this? Why?

16. If you ask a scientist what the main purpose of his work is, what do you think he will say?

17. Do you think that the major aim of science is to seek new knowledge or to find ways to use knowledge to solve social problems like pollution and hunger?

18. Which do you think is the more important result of the work of scientists:

The explanation of how green plants make their own food

or

The more and bigger tomatoes that can now be grown.

19. OK. Now which of the following two is the more important result of the work of scientists?

Rockets which can carry men to the moon

or

Working out an explanation of gravity.

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MOORE AND SUTMAN

SCIENTIFIC ATTITUDE INVENTORY

Richard Moore and Frank Sutman. The development, field test and validation of an inventory of scientific attitudes. Journal of Research in Science Teaching, 1970, 7, 85-94.

Instrument characteristics

Format: 60 item Likert-type scale, with a 4-point response. (There is no neutral response.)

Population: High school students.

View of attitude: Attitudes are considered to be both psychological and emotional, and to vary in strength.

Subscales: There are six attitudes measured, each subscale has 10 items with an equal number of positive and negative items.

1. Laws and theories of science are approximations of truth. (Items 7, 10, 12, 16, 22, 23, 46, 53, 54, 56.)

2. Observation of natural phenomena is the basis of scientific explanation. (Items 2, 3, 11, 15, 19, 27, 29, 39, 43, 52.)

3. To operate in a scientific manner, one must display such traits as intellectual honesty, willingness to alter one's position. (Items 4, 5, 8, 18, 25, 26, 37, 38, 42, 51.)

4. Science is an idea-generating activity. It is devoted to providing explanations of natural phenomena. (Items 6,14, 24, 32, 33, 34, 41, 44, 47, 50.)

5. Progress in science requires public support. (Items 9, 13, 17, 28, 30, 31, 36, 40, 48, 58.)

6. Being a scientist or working in a job requiring scientific knowledge and thinking would be a very interesting and rewarding life's work.
(Items 1, 20, 21, 35, 45, 49, 55, 57, 59, 60.)

Validity: Face validity was established by submitting an original collection of 112 items to a panel of judges and to a group of high school students. Construct validity was established by field testing the instrument with three groups of low-ability 10th grade biology students. One group was taught by the regular teacher, another was taught lessons to develop positive attitudes, and the third group was taught lessons to develop negative attitudes. Groups receiving instruction relevant to instrument significantly outperform control group on post-test means.

Reliability: The control group of the above sample provided a test-retest reliability of .934.

Readability: The instrument is reported to have a reading level below grade 8, according to the Dale list of 3,000 familiar words.

Analysis

Cognitive items: (30)	2, 3, 6, 7, 9, 11, 12, 13, 14, 15, 17, 18, 19, 22, 23, 25, 27, 29, 30, 31, 35.2, 36, 40.2, 41, 43, 47, 48.2, 52, 53, 57, 58, 59.1.
Value items: (15)	4, 24, 26, 28, 32, 33, 34, 37, 38, 39, 40.1, 42, 44, 48.1, 50, 51.
Attitude items: (6.5)	1, 20, 35.1, 45, 49.2, 55, 59.2, 60.
Test of Possession-Dispositions: (7.5)	5, 8, 10, 16, 46, 49.1, 54, 56.
Self-Report Dispositions: (1)	21.

View of Science: Explicit - Instrumentalist, items 6, 7, 10, 19, 23, 26, 29, 34, 53, 56.

Realist, items 2, 4, 8, 11, 12, 15, 16, 22, 46, 47, 54.

Implicit - Instrumentalist, items 32, 33, 37.

Additional characteristics: Ambiguous items 1, 28, 35, 40, 48, 49, 59.

Research Studies

Allison, Robert David. An investigation into the attitudes toward science of college chemistry students as a function of laboratory experience. Unpublished Ed.D. dissertation, University of Northern Colorado, 1972. (DAI: vol. 33, p. 3422)

77 students (41 experimental and 36 control) were enrolled in 4 sections of the semester course in chemistry, two sections receiving differences in laboratory experience. There were no significant differences in attitude between pre- and post-testing.

Boes, R.J. The relation of selected student characteristics to understanding science. Unpublished Ph.D. dissertation, University of Iowa, 1973. (DAI: vol. 34, p. 4021)

32 undergraduate and graduate students, enrolled in "The meaning of Science" course were pre- and post-tested. The gains were significant at the .01 level. Very low correlations between the SAI and the Wisconsin Inventory of Science Processes (-.11 and -.09) and the Test on Understanding Science (.03 and .36) are reported.

Bowles, Anna and Boss, Marvin W. Extent of psychological differentiation as related to achievement in science and attitude toward science. ED 087978, 1974.

60 grade 9 students were divided equally into field-dependent and field-independent groups. When mental ability is controlled in the analysis of covariance it is found that field-independent students do better in science and have a significantly more positive attitude toward science than field dependent students. Field-dependence is defined according to the score on the Thurstone Concealed Figures Test.

Buckley, John Thomas. A comparative study of the relationship of the presence of the elementary school science specialist toward the science attitudes of teachers and students, and student achievement. Unpublished Ed.D.dissertation, Boston University, 1976. (DAI: vol. 37, p. 1367.)

The SAI was administered to 96 teachers, half of whom were in towns served by elementary-school science specialists. Teachers in the towns served by specialists had a significantly more positive attitude to science than the other teachers. In a pilot study of 29 elementary school teachers with varied science backgrounds, the test-retest reliability of the SAI was found to be .813.

Campbell, Richard L. and Martinez-Perez, Luis A. A study of relationships of science attitudes, achievement and self-concept of pre-service teachers. ED 125 898, 1976.

64 juniors and seniors enrolled in science methods courses were given instruction based on 4 modular packages for four hours per week in a quarter. Regression showed that attitude to science is not a predictor of performance. Scores on the SAI correlated significantly with Basic Science Process Skills (.54), Integrated Science Process Skills (.55), and Tennessee Self-Concept Scale (.76).

Costa, Joseph J. A comparison of achievement and attitudes in college chemistry classes having direct laboratory, vicarious laboratory, or written descriptive narrative laboratory experiences. Unpublished Ed.D. dissertation, University of West Virginia, 1973. (DAI: vol. 34, p. 3903)

104 first year students were divided into the three groups for different laboratory experiences. None of the variables tested achieve statistical significance.

Earl, Robert D. and Winklejohn, Dorothy R. Attitudes of elementary teachers toward science and science teaching. *Science Education*, 1977, *61*, 41-45.

This study compares 49 teachers in self-contained classrooms with 52 teachers in cooperative settings. The instrument contains scales from the SAI. No significant differences in attitudes to science are found.

Gadson, Melvin Franklin. A study of the effect of the thirteen-college curriculum program physical science course on the scientific attitude of college students. Unpublished Ed.D. dissertation, American University, 1976. (DAI: vol. 37, p. 7056)

The SAI was used as a pre-and post-test on 119 freshmen taking a traditional physical science course and on 112 freshmen enrolled in the thirteen-college program physical science course. A significant difference at the .05 level (which is reported as "highly significant") favors the thirteen-college program for total science attitude and for two subscales.

Gieger, Marie McKinnon. A study of scientific attitudes among junior college students in Mississippi. Unpublished Ph.D. dissertation, University of Southern Mississippi, 1974. (DAI: vol. 35, p. 5950)

50 students from 3 colleges are sampled for a large number of variables. For attitude to science, "the coefficient of multiple regression was significant at the .0002 level of confidence".

Giese, Ronald Norman. An analysis of selected aspects of the ISCS model of science teaching. Part 1: Relationships of selected characteristics and behaviors of teachers using the Intermediate Science Curriculum Study. Unpublished Ed.D. dissertation, Temple University, 1971. (DAI: vol. 32, p. 4466)

Science teachers with varied origins, science background, and teaching experience were divided into an experimental and control group (28 in each), the experimental group receiving 5 weeks of inservice training. The SAI was used as the pre- and post-test measure, and teachers were observed in their classes. There was no significant change in teacher attitudes after inservice. There is a significant negative correlation between SAI and time spent in laboratory management (-.474), and a significant positive correlation between SAI and teaching behaviors espoused by ISCS.

Gunsch, Leonhardt Maurice. A comparison of students' achievement, and attitude changes resulting from a laboratory and non-laboratory approach to general education physical science courses. Unpublished Ed.D. dissertation, University of Northern Colorado, 1972, (DAI: vol. 33, p. 6291)

Two groups of freshmen non-science majors were given a lecture-demonstration course (60) and a laboratory-oriented course. A significant positive change in attitude is found, favoring the experimental group. Sex differences within the groups were not significant, but the males in the control and experimental groups had significantly different scores.

LaShier, W.S. Jr., and Nieft, J.W. The effects of an individualized, self-paced science program on selected teacher, classroom, and student variables -- ISCS Level One. Journal of Research in Science Teaching, 1975, 12, 359-369.

In this two-year study, 900 7th grade pupils of 18 ISCS teachers were compared with 200 7th grade pupils of non-ISCS teachers. Among other instruments, subscales 1, 2, and 6 of the SAI were administered. There were significant relationships between cognitive achievement and attitudes in subscales 1 and 2 for the ISCS students.

Lauridsen, La Monte Irvy. An investigation of the effects of ISCS Level One on selected variables of students. Unpublished Ed.D. dissertation, University of Kansas, 1972. (DAI: vol. 33, p. 6747)

The gain scores of 100 students taught by teachers who had participated in an ISCS summer workshop are compared with 100 students taught by non-ISCS teachers. A modified version of the SAI (where reliability and validity are not given) is administered. There was no significant change for the control group, yet attitudes for the experimental group increased significantly. Correlations of .56 and .44 are found between attitude to science as a vocation and scores on a subject preference scale.

Lawrenz, Frances. The prediction of student attitude toward science from student perception of the classroom learning environment. Journal of Research in Science Teaching. 1976, 13, 509-515.

A stratified sample of 238 high school science classes from 12 states was surveyed, using the SAI and the Learning Environment Inventory. Student's perception of the learning environment is related to attitude toward science for biology students (23 per cent of the variance) and for chemistry students (27 per cent), but not for physics students.

Lawrenz, Frances. The relationship between science teacher characteristics and student achievement and attitude. Journal of Research in Science Teaching, 1975, 12, 433-437.

A stratified sample of 236 secondary science teachers and one of each teachers' classes were surveyed. Canonical correlations compared student and teacher variables. The canonical coefficients for student attitudes (-.14) and teacher attitudes (+.19) were not significant.

Lucas, Don Horace. The effect that participation in an instructional program at Fernbank Science Center has on upper elementary students' scientific attitudes. Unpublished Ph.D. dissertation, Georgia State University, 1974. (DAI: vol. 35, p. 6530)

The SAI was administered as a control to one class of each of 8 teachers. Another class of each of the teachers became the experimental group following a single visit to the science center. There were no significant differences on SAI scores. There was a significant correlation between SAI scores and attitude to learning science, but none between SAI scores and scores on the Stanford achievement test. Teacher and student attitudes did not correlate.

Martin, Bobby Ray. A study of the effect of the Blue, Green and Yellow versions of BSCS Biology on the scientific attitude of tenth-grade students. Unpublished Ed.D. dissertation, the American University, 1972. (DAI: vol. 33, p. 2079)

The SAI was administered as a pre- and post-test to 707 students enrolled in biology classes in which one of the three BSCS versions was taught. There were no significant differences for any version in total attitude and in each of the subscales.

Martinez-Perez, Luis A. A study of self-concept, attitudes toward science and achievement on a sample of seventh grade ISCS students versus seventh grade students in a non-individualized science class. Unpublished Ph.D. dissertation, Florida State University, 1973. (DAI: vol. 34, p. 4029)

A post-test only control group design was used to compare 110 ISCS grade 7 students, 110 non-ISCS grade 7 students, 110 non-ISCS grade 7 students, and 110 grade 6 students (giving baseline data). There were no significant correlations for any group between attitude and measures of achievement and self-concept.

McDuffie, Thomas Edward Jr. Relationships between selected personal characteristics and achievement, attitude and success on an audio-tutorial biology program. Unpublished Ed.D. dissertation, Temple University, 1973. (DAI: vol. 34, p. 1729)

A post-test only design was used to compare 119 students in the audio-tutorial program with the population of college students. Stepwise multiple regression was used to correlate predictor and criterion scores, and compare high and low achievement groups. Subscale 6 of the SAI accounts for 22.5 per cent of the variance, and subscale 3 accounts for 23.1 per cent. No variables accounted for more than 20 per cent of the variance in attitude scores. A split-half reliability of .648 for the SAI is reported.

Moore, Richard W. A profile of the scientific attitudes of 672 ninth-grade students. School Science and Mathematics, 1971, 71, 229-231.

672 ninth-grade students were sampled using the SAI. There was no strong acceptance or rejection of any of the scientific attitudes assessed.

Moore, Richard W. A two year study of a Cooperative College School Science groups' attitudes toward science and science teaching. School Science and Mathematics, 1975, 75, 288-290.

40 items of the SAI were used to measure the attitudes of 31 teachers five times over a two year period: at selection, before a workshop, after the workshop, after 1 year, and after 2 years. There was a significant positive difference in attitude between the pre and post-testing. Scores then declined to give a significant negative difference between the final two administrations of the test.

Nagy, Philip. Subtest formation by cluster analysis of the Scientific Attitude Inventory. Journal of Research in Science Teaching. 1978, 15, 355-360.

The scientific attitudes, achievement, IQ and subject choices of 97 grade 9 students were investigated. Only small but significant correlations were found between attitudes and student subject preferences, when the effects of IQ and grade point averages were removed. A cluster analysis of the SAI scores yielded clusters which did not correspond to the SAI's subscales. Subtests developed by the cluster analysis gave significant correlations with subject preference and achievement. The validity of the SAI's subscales was therefore questioned. A split-half reliability of .67 is reported for the SAI.

Novick, Shimshon and Duvdvani, Dina. The scientific attitudes of tenth grade students in Israel as measured by the Scientific Attitude Inventory. School Science and Mathematics. 1976, 76, 9-14.

The SAI, translated into Hebrew, was administered to 684 students. A Cronbach reliability of .58 was found. Means and standard deviations were comparable to those reported by Moore and Sutman. Acceptance of a positive attitude did not correlate significantly with rejection of the corresponding negative attitude, except for subscales 4 (-.156), 5 (.198), and 6 (.400).

Novick, Shimshon and Duvdvani, Dina. The relationship between school and student variables and the attitudes toward science of tenth-grade students in Israel. Journal of Research in Science Teaching, 1976, 13, 259-265.

684 tenth-grade students were surveyed. There were no significant attitude differences for sex, type of school, future stream (measured by grade averages), and type of curriculum.

Pinkall, Joseph E. A study of the effects of a teacher inservice education program on the fifth and sixth grade teachers and the students whom they teach in their knowledge of scientific processes, scientific content and attitude toward science and scientists. Unpublished Ed.D. dissertation, University of Nebraska, 1973. (DAI: vol. 34, p. 7608)

25 teachers (who had completed a workshop) and their classes were compared with 25 teachers who had no workshop. Students of the experimental group had significantly more positive attitudes than students of the control group.

Popowicz, Lorraine Ann. Interdisciplinary approach to biology integrated with art: A vehicle for changing attitudes toward science. Unpublished Ph.D. dissertation, Boston College, 1975. (DAI: vol. 35, p. 7143)

An experimental group of 117 high school students receiving a biology course integrated with art, was compared with a control group of 118 students receiving biology only. A further group of 120 students from another school was tested to examine "spillover" effects. There were no significant differences in attitude in the pre-test. A pre-post reliability of .7966 is reported for the SAI. There was a significant difference in

attitude on the post-test favoring the experimental group, and boys had significantly more positive attitudes than girls. Correlations of SAI and Biology scores range from .2130 to .2501.

Riley, Joseph P. The effect of science process training on preservice elementary teachers' process skill abilities, understanding of science, and attitude toward science and science teaching. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Los Angeles, 1975.

90 student teachers equally assigned to treatment levels: active-inquiry, vicarious inquiry, and control. No treatment effect could be discerned on the dependent variables, attitude toward science and science teaching, or on understanding science.

Ward, William H. Jr. A test of the association of class size to students' attitude toward science. Journal of Research in Science Teaching. 1976, 13, 137-143.

Data from approximately 230 schools were examined. There was no association of class size with attitude to science, independent of teacher attitude or student achievement. Partial correlations between student achievement and attitude and between class size and achievement were significant beyond the .01 level.

Welch, Wayne W. Evaluation of the PSNS course. II: Results. Journal of Research in Science Teaching. 1972, 9, 147-156.

425 PSNS students and 575 other physical science students were compared. There was no mean difference between the treatment groups on all 14 variables simultaneously. Significant differences existed on 6 of the 12 attitudinal measures. When compared to other physical science courses, PSNS students had more positive attitudes toward science as measured by the SAI.

Wilson, Roosevelt, L. An evaluation of the use of an anthology of articles on the understanding of science selected to improve students' attitudes toward science. Unpublished Ph.D. dissertation, University of Iowa, 1975. (DAI: vol.36, p. 7973)

The treatment was given to 31 college students over a single summer, with 20 students acting as a control group. There was a significant difference on the SAI subscales 3 and 6 favoring the experimental group. The SAI correlated insignificantly with the Purdue scale (.32), but subscale 3 of the SAI correlated significantly with the Test on Understanding Science (.57).

Commentary

This review has identified 30 studies in which the SAI is used. In only 6 of these is the reliability determined anew, always giving values lower than those originally reported. The results of the studies reviewed here give no clear indication about what the SAI scores correlate with, or how they are affected. Nagy's study suggests that validity is a problem, and the analysis performed at the beginning of the review tends to point in the same direction.

Items of the Moore and Sutman Instrument*

1. I would enjoy studying science and using this knowledge in some scientific field.

2. Anything we need to know can be found out through science.

3. Scientific explanations can be made only by scientists.

4. Once they have developed a good theory, scientists must stick together to prevent others from saying it is wrong.

5. It is useless to listen to a new idea unless everybody agrees with the idea.

6. Science may be described as being primarily an idea-generating activity.

7. Scientists are always interested in improving their explanations of natural events.

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

9. Science is so difficult that only highly trained scientists can understand it.

10. A useful scientific theory may not be entirely correct, but it is the best idea scientists have been able to think up.

11. We can always get answers to our questions by asking a scientist.

12. There are some things which are known by science to be absolutely true.

13. Most people are not able to understand the work of science.

14. Today's electric appliances are examples of the really valuable products of science.

15. Scientists cannot always find the answers to their questions.

16. When something is explained well, there is no reason to look for another explanation.

17. Most people are able to understand the work of science.

18. A scientific theory is no better than the objective observations upon which it is based.

19. Scientists believe that they can find explanations for what they observe by looking at natural phenomena.

20. The day after day search for scientific knowledge would become boring for me.

21. Scientific work would be too hard for me.

22. Scientists discover laws which tell us exactly what is going on in nature.

23. Scientific ideas may be said to undergo a process of evolution in their development.

24. The value of science lies in its usefulness in solving practical problems.

25. When one asks questions in science, he gets information by observing natural phenomena.

26. A good scientist doesn't have any ideas he is not willing to change.

27. Looking at natural phenomena is a most important source of scientific information.

28. Public understanding of science is necessary because scientific research requires financial support through the government.

29. Some questions cannot be answered by science.

30. Rapid progress in science requires public support.

31. Scientists do not need public support, they can get along quite well without it.

32. A scientist must be imaginative in developing ideas which explain natural events.

33. The value of science lies in its theoretical products.

34. Ideas are one of the more important products of science.

35. I do not want to be a scientist because it takes too much education.

36. There is no need for the public to understand science in order for scientific progress to occur.

37. When a scientist is shown enough evidence that one of his ideas is a poor one, he should change his idea.

38. All one has to do to learn to work in a scientific manner is to study the writings of great scientists.

39. Before one can do anything in science, he must study the writings of the great scientists.

40. People need to understand the nature of science because it has such a great affect upon their lives.

41. A major purpose of science is to produce new drugs and save lives.

42. One of the most important jobs of a scientist is to report exactly what his senses tell him.

43. If a scientist cannot answer a question, all he has to do is to ask another scientist.

44. An important purpose of science is to help man to live longer.

45. I would enjoy working with other scientists in an effort to solve scientific problems.

46. Scientific laws cannot be changed.

47. Science is devoted to describing how things happen.

48. Every citizen should understand science because we are living in an age of science.

49. I may not make many great discoveries, but working in science would still be interesting to me.

50. A major purpose of science is to help man live more comfortably.

51. Scientists should not criticize each other's work.

52. His senses are one of the most important tools a scientist has.

53. Scientists believe that nothing is known to be true with absolute certainty.

54. Scientific laws have been proven beyond all possible doubt.

55. I would like to work in a scientific field.

56. A new theory may be accepted when it can be shown to explain things as well as another theory.

57. Scientists do not have enough time for their families or for fun.

58. The products of scientific work are mainly useful to scientists, they are not very useful to the average person.

59. Scientists have to study too much and I would not want to be one for this reason.

60. Working in a laboratory would be an interesting way to earn a living.

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MOTZ

SCIENCE AND SCIENTISTS ATTITUDE INVENTORY

LeMoine Lee Motz. The development of an instrument to evaluate sixth and ninth grade students attitudes toward science and scientists. Unpublished Ph.D. dissertation, University of Michigan, 1970. (DAI: vol. 32, p. 1360)

Instrument characteristics

Format:	50 item Likert-type scale, 3 points (agree, undecided, disagree).
Population:	Grades 6 and 9.
View of Attitude:	Not stated
Subscales:	Science: items 1-21. Scientists: items 22-50.
Validity:	Original pool of items obtained from responses obtained from 525 individuals (at all educational levels) to open-ended questions. These were categorized giving 288 items in two forms. The forms were submitted to 25 science educators and returns were scored. Field testing gave a 68-item test, with a readability (according to the Flesch scale) of 6.2. Item analysis gave a final version of 50 items.
Reliability:	Subscale 1, .47; 2, .77. Total reliability was .78 for grade 6 and .79 for grade 9.

Analysis

Cognitive items: (45)	All items are cognitive items, except for the five listed as value items
Value items: (5)	11, 12, 33, 45, 46.
View of Science:	Explicit - Instrumentalist, items 6, 17, 18, 36, 43. Realist, items 10, 13. Implicit - Instrumentalist, items 16, 41. Realist, items 2, 5, 8, 9, 21, 29, 31, 37, 38, 46, 50.

Additional characteristics: Ambiguous items, 23, 30.

Research Studies

Brown, Talbert W. The influence of the Science Curriculum Improvement Study on affective process development and creative thinking. Unpublished Ph.D. dissertation. University of Oklahoma, 1973. (DAI: vol. 34, p. 3175)

43 grade 6 students who had experienced SCIS were matched with a control group of 63 other grade 6 students on sex, age, IQ, and socio-economic level. New reliabilities are found for the SASAI: subscale 1, .84; 2, .93; total .89. A significant attitude difference favoring the SCIS group was found. Factor analysis shows that the subscales correlate significantly.

Motz, Le Moine Lee. (See above)

The instrument was submitted to 981 6th and 9th grade students. Socio-economic background correlated significantly (.01) with subscale 1 ($r=.11$) and with subscale 2 ($r=.09$). Significant correlations were also obtained with IQ: subscale 1, $r=.27$, subscale 2, $r=.19$. There was a significant difference in attitude between rural and urban students. There was a significant difference on subscale 1 between grades 6 and 9, but not on subscale 2. No sex differences were found.

Pinkall, Joseph E. A study of the effects of a teacher inservice education program on the fifth and sixth grade teachers and the students whom they teach in their knowledge of scientific processes, scientific content and attitude toward science and scientists. Unpublished Ed.D. dissertation, University of Nebraska, 1973 (DAI: vol. 34, p. 7608)

The students of 25 teachers (who had attended a workshop) were compared with the students of 25 other teachers. The students of the former had significantly more positive attitudes to science and scientists than had the students of the latter group of teachers.

Starring, Ellsworth Arden. Effects of an experimental course for ninth grade science-shy students on their attitudes toward science and scientists. Unpublished Ph.D. dissertation, University of Michigan, 1972. (DAI: vol. 33, p. 6201)

The instrument was administered to 900 8th graders in April 71 and to 199 students in June 1972. The reliability for the 9th grade sample is .79; and split-half reliabilities are .90 and .92 for pre and post-tests. Pre and post-test means and analysis of variance (for all variables) is not reported as the author felt that item analysis is more important. The total student group improved significantly (.05) in attitude on 10 of the 50 items, and it is concluded that the treatment was effective. That students' scores on two items decreased significantly (.05) is ignored.

Wright, Ellsworth Keith. Influence of the Science Curriculum Improvement Study on attitudes and process skills of seventh grade students. Unpublished Ed.D. dissertation, University of Northern Colorado, 1976. (DAI: vol. 37, p. 425)

63 pairs of grade 7 pupils were matched on the Metropolitan Achievement Test. A t-test shows a significant difference on the attitude measure favoring the non-SCIS group.

Commentary

The analysis of the items shows that a large number deal with matters of information. Many of these ask implicitly or explicitly for views on the philosophical nature of science. Clearly, there are implicit subscales within the two subscales identified by the author. (It is hard to reconcile the evaluations of the SCIS program reported in the Brown and Wright studies.)

Items of the Motz Instrument*

1. Science is exploring the unknown.
2. The reason we study science is to find answers to questions and problems.
3. Science and industry work to provide a better way of living for us.
4. People doing work in science are interested in helping mankind.
5. Science helps man to control the forces of nature.
6. Man is not able to control the world around him completely.
7. Science is a never-ending road to discovery.
8. Understanding of science is the asking of questions and looking for answers.

9. Science tries to find out "how" and "why" something happens.

10. Science has the answers to the unsolved problems in our society.

11. The United States should stop sending men to the Moon and work to solve problems in our cities and towns.

12. Science is important to everyone, regardless of race, color, or belief.

13. Science is an accurate and orderly body of knowledge about the world in which we live.

14. People live longer now than they did 50 years ago because of science.

15. The future of our nation depends upon the careful use of our natural resources such as air, water, and soil.

16. Science has found ways to study plants and animals.

17. The facts of science do not explain "how" or "why" some things happen

18. Science cannot explain all that happens in our world and in space.

19. Feelings about science are due to what we have learned in school and at home.

20. Experiments done in science many years ago are <u>not</u> important now.

21. Science does <u>not</u> tell us right from wrong in our relations with people.

22. Scientists look for problems and try to solve them.

23. The scientist works hard and long hours but enjoys his work.

24. Scientists are eager to learn about the world in which they live.

25. Scientists are interested in making new and important discoveries.

26. The scientist learns about nature by doing experiments.

[illegible] ...sts use different methods to solve problems.

[illegible] ... a problem may take many years.

[illegible] A ...tist is willing to change his mind when new ...ts show he is wrong.

[illegible] ...ntists report the results of their experiments so they can be checked by other people or other scientists.

[illegible] ...e scientist is willing to let people test or question what he believes is true.

[illegible] The scientist is honest in doing his work even if his work will not be checked by others.

33. A scientist's job is the most important job in the world.

34. Scientists care about the ways their work might harm other people.

35. The scientific way of solving problems can be used to solve the problems of human beings.

36. The scientist knows that his ideas will change if new facts are found.

37. The scientist agrees with results when an experiment shows they are true.

38. The scientist bases his answers on tested facts and not his imagination.

39. The scientist wants to find out why strange things happen in our world.

40. Scientists believe that the number 13 is an unlucky number.

41. The scientist wants to know something about an idea before he tests it.

42. The scientist plans his experiments and does them with care.

43. The scientist looks for more than one reason why some things happen in nature.

44. Scientists may work for many, many years before they solve a problem.

45. Scientists should tell each other the results of their problems.

46. The scientist needs to find out from other scientists or by reading if his problem has already been solved.

47. The scientist uses the best information he can get to solve his problems.

48. The scientist checks carefully the place from which he gets his information.

49. The scientist gets much of his information by reading.

50. The scientist knows where to find the best information to help him in his careful hunting for facts or truth.

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MYERS

ATTITUDES TOWARD SCIENTISTS AND SCIENCE

Byron E. Myers. An appraisal of change of attitudes toward science and scientists and of student achievement in an introductory college chemistry course relative to the students' backgrounds in high school chemistry and physics. Unpublished Ed.D. dissertation, Pennsylvania State University, 1967. (DAI: vol. 29, p. 152)

Instrument characteristics

Format:	44 item Thurstone scale.
Population:	First year college chemistry students.
View of attitude:	The mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related.
Subscales:	Science (18 items) and Scientists (26 items).
Validity:	232 statements about science and scientists were obtained from science teachers at a summer institute. The edited 105 statements were rated by 73 raters, giving 32 statements covering the range with a small interquartile range. After the pilot study, the scale was increased to 44 statements to enhance reliability.
Reliability:	Pilot study: split-half .63 (N=212), test retest .60 (N=119). Final version: (split-halves), pretest .44, post .70 (N=467).

Analysis

Cognitive items: (37)	All but 7 items are cognitive items
Value items: (4)	18, 22, 23, 42.
Attitude items: (2)	5, 17.

Self-Report
Dispositions: 34
(1)

View of Science: Implicit - Instrumentalist, item 25

- Realist, items 36, 43.

Research Studies

Myers, Byron E. (See above)

The instrument was administered to 467 students at the beginning and end of a semester chemistry course. There was no significant correlation between attitude score and high school science background. The pre and post attitude scores correlate significantly. There was a significant correlation between verbal scores on college entrance and pre-test attitude scores.

Commentary

Evidently the instrument is carefully constructed. The reliability is low, despite the addition of extra items following the pilot study.

Items of the Myers Scale*

1. Discoveries in pure research often provide the basic understanding for the development of practical utilitarian devices.

2. Scientists are not interested in social affairs.

3. Scientists are willing to assume civic responsibilities.

4. The field of science is limited to the very best students.

5. Science is for squares.

6. Studying science in school enables us to make life more interesting.

7. Scientists are dedicated individuals.

8. Scientists do not form pressure groups to present their views and interests before the government.

9. Scientists are not practical people.

10. Science has cultural as well as technological implications.

11. Scientists do not take an active role in impressing upon the government how the discoveries should be used.

12. Scientists are odd people who wear strange clothes and eat unusual meals.

13. Scientists are generally amiable people.

14. Science is a practice of principles.

15. Scientists are unable to communicate effectively.

16. Knowledge of science is necessary to gain full benefits from any field of endeavor.

17. Science has no relation to my life and is just a waste of time.

18. Scientific careers require too much preparation.

19. The scientist today is totally remote from everyday reality.

20. Scientists possess a very logical analytical mind.

21. The main difference between a scientist and another equally intelligent person is the scientist is not interested in social affairs.

22. Preparation for a career in science is not worth the effort, time and money required.

23. Scientists spend too much time with small insignificant details.

24. Science is the main branch of inquiry.

25. Scientists are willing to discard their beliefs when new evidence demonstrates that these beliefs are in error.

26. A scientist is a person who recognizes the need for the solution of a problem and proceeds in an orderly fashion to attempt to solve it.

27. The scientific discoveries have been an asset to mankind.

28. A scientist is very dedicated.

29. Science is an esoteric discipline.

30. Scientists lack aesthetic appreciation.

31. A scientist is above average in intelligence.

32. Scientists neglect their families by giving too much time to their research.

33. Science is the main branch of inquiry.

34. Science is too hard.

35. Scientists lack a working knowledge of the English language.

36. Scientists take simple truths and garble them with mathematics and make the whole concept ununderstandable.

37. Science has done little to aid the average person.

38. A basic understanding of scientific principles should make our life more interesting.

39. Scientists are dedicated and devoted to their profession.

40. Scientists are out of touch with reality.

41. Scientists are mere technicians.

42. The achievements of scientists are to be admired.

43. Scientific facts are not applicable to practical applications.

44. Scientists are out of touch with the rest of the world.

NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

NATIONAL ASSESSMENTS OF SCIENCE

Reports on the National Assessments of Science are available from: National Assessment of Educational Progress, Education Commission of the States, 1860 Lincoln Street, Suite 700, Denver Colorado 80295.

The National Assessments of Science are mentioned in this study since they include far-ranging assessments of attitudes to science. Since reliability and validity data are not available in the published reports, these items are not discussed here. Also, because the attitude items (exercises) use various formats and appear in a large collection of items measuring different objectives, there is no attempt here to analyze them as other attitude instruments have been analyzed. Instead, sample items are provided below so that the reader can gather something of the sort of exercises comprising the test batteries.

1st. Assessment: 1969-1970

From: "Science: National results" (Report 1.) ED 055 786

Objective IV of this assessment is "Have attitudes about and appreciation of scientists, science, and the consequences of science that stem from adequate understandings."

Age 9 — Do you think that the number thirteen brings you bad luck?
(Correct response: No.)

Which of the following will cause you to have bad luck for several years?
(Correct response: None of these.)

Age 13 — Women can be successful scientists.
(Correct response: I believe this statement.)

Do you think that scientists always work in laboratories?
(Correct response: No.)

Age 17 (and adults) — Most scientists . . . want to know more about the world

. . . plan experiments as hastily as possible.

. . . believe that some things happen without causes.

. . . permit likes and dislikes to outweigh their observations.

. . . use facts gathered by their own experiments and observations and pay no attention to results of others.

United States scientists are ahead of scientists in other countries in every field of research. (Correct response: I don't believe this statement.)

2nd Assessment: 1972-1973

From: Selected results from the National Assessments of Science: Attitude Questions, 1975 (04-S-03) ED 127 200

Attitude questions are in two categories: Interest in and attitudes toward science; and, the philosophy of science.

Sample items on Interest in and Attitudes toward Science:

Age 13	Do you find science topics interesting? (Often, sometimes, never)
	Outside of school, how often do you read stories or articles about science or scientists; often, sometimes, or never?
Age 13 and 17	I believe that to become a scientist would require that I devote many years to my education. (Agree, disagree, neither agree nor disagree)
Age 13, 17 and adults	Semantic differential items (continua: harmful--beneficial, boring--interesting):
	Technology is
	Science is
	Scientific explanations of the world are

Age 17 (and adults) Indicate whether you approve or disapprove of pure scientific research in each area described (Yes, I approve of such research; No, I do not approve of such research; I don't know)

Modification of inherited traits in humans

Pesticides and herbicides

Air and water pollution

Heart transplants

Sample items on the philosophy of science:

Age 13 The methods of science are fine for scientists, but there is little in these methods to help people with everyday problems. (I agree, I do not agree, I have no opinion)

Age 17 (and adult) Laws in science are statements which are not subject to change. (Agree, disagree, neither agree nor disagree)

Theories are neither true nor false but are judged only in terms of whether they are useful in explaining natural events. (Agree, disagree, I don't know)

Theories exist in the form of words, mechanical models, and mathematical models. (Agree, disagree, I don't know)

3rd Assessment: 1976-1977

From: Released Exercise Set, The Third Assessment of Science, 1976-1977. ED 161 686

Affective items are arranged under the following subscales in the complete set of exercises:

1. Attitudes toward science classes.
2. Vocational and educational intentions.
3. Personal involvement.
4. Personal use of tools and attributes.
5. Confidence in science.

6. Support of research.

7. Controversial issues.

8. Awareness of methods, assumptions and values in science.

9. Experiences in science.

Sample items from subscale 2:

Would you like to work at some job that lets you use what you know about science?
(5 point response scale)

All of the following are "science-related" tasks. For each one, tell if <u>you</u> would be interested in doing it. (5 point response scales)

Working in a laboratory.

Sharing ideas with others.

For <u>me</u>, working in a science related field would
(5 point response scale)

be fun.

be too much work.

make me important.

Sample items from subscale 4:

Tell how much you agree or disagree with each of the following statements. (5 point response scale)

Science helps me to understand how my body works.

Science is not very useful to me outside of science class.

Science research has produced much information. Do you and your family use this kind of information to
(yes, no, I don't know)

decide what foods to eat?

decide how many vitamins to take?

Sample items from subscale 5:

How much do you think the application of science can help (none, some, very much)

prevent worldwide starvation?

find cures for diseases?

save our natural resources?

Sample items from subscale 6:

Do you think scientists should be given money to study (Definitely yes, probably yes, probably not, definitely not)

earthquake prediction?

how to make rain fall on farm land?

how people behave when they live in very crowded cities?

fire safety problems?

distant stars?

how genes control plant characteristics?

how bacteria and green plants live together?

Sample items from subscale 7:

Do you think scientists should be allowed to try (Definitely yes, probably yes, not sure, probably not, definitely not)

to grow exact copies of people?

to grow human babies from test tube beginnings?

to do any kind of research they want to do?

Sample items from subscale 8:

(Likert, 5-point response scale)

Scientists always find answers to their questions.

Scientists believe that some mysterious events do not have causes.

Theories are useful even though they may be incomplete.

One important use of a scientific theory is to predict future events.

If a researcher accurately reports his experimental results, other researchers should accept the results without question.

Different scientists may give different explanations about the same events.

NATIONAL SCIENCE FOUNDATION

ATTITUDES OF THE U.S. PUBLIC TOWARD SCIENCE AND TECHNOLOGY

National Science Foundation. Science Indicators, 1976. Report of the National Science Board, 1977. ED 154 990

Opinion Research Corporation. Attitudes of the U.S. Public Toward Science and Technology: Study III. Research Findings Prepared for the National Science Foundation. Princeton, New Jersey: Opinion Research Corporation, 1976.

Instrument characteristics

Format:	A structured interview of 18 questions.
Population:	2,108 men and women, 18 years of age or over, living in private households in the continental United States.
View of attitude:	Not available.
Subscales:	These are evident in the questions asked.
Validity:	Not available.
Reliability:	The reliability of the sampling technique is reported for various sample sizes. For the present sample it is significant beyond the .05 level.

Analysis

Cognitive items: (9)	2, 9A, 9B, 11A, 11B, 14, 15, 16, 17.
Value items: (3)	4, 12, 13.
Attitude items: (6)	1, 3, 5, 6, 7, 8.
View of Science:	None explicit or implicit.

Research Studies

Sadava, D. Attitudes toward science of nonscience major undergraduates: Comparison with the general public and effect of a science course. Journal of Research in Science Teaching. 1976, 13, 79-84.

30 male and 35 female nonscience majors were enrolled in a course, "Principles of Natural Science". There were nonrandom differences between these students and the general public. Prior to the course, students had more negative opinions of science and technology than did the general public. After the course, student opinions were even more negative than they had been when the course started.

Items of the National Science Foundation Scale

1. Please choose the statement that best gives your own personal opinion of the prestige or general standing that such a job has: (six-point response scale)

Businessman	Architect
Physician	Minister
Scientist	Engineer
U.S. Representative in	Banker
Lawyer	Accountant for a large business

2. For the most part, do you feel that science and technology will eventually solve most problems such as pollution, disease, drug abuse, and crime, some of these problems, or few if any of these problems.

3. Which one of these items best describes your general reaction to science and technology: Fear or alarm; Satisfaction or hope; Excitement or wonder; Indifference or lack of interest; No opinion?

4. Do you feel that science and technology change things too fast, too slowly, or just about right?

5. Do you feel that science and technology have changed life for the better or for the worse?

6. Do you feel that science and technology have caused most of our problems, some of our problems, few of our problems, or none of our problems?

7. When you say science and technology cause problems, who do you feel is most at fault: scientists, technologists and engineers, government decision makers, business decision makers, some other group, no opinion?

8. Overall, would you say that science and technology do more good than harm, more harm than good, or about the same of each?

9A. You've said that science and technology have done more good than harm. Can you tell me one of the good things? (First mention)

Development of machinery/industrialization

New products/inventions/research (general)

Man-made fibres

Preserving/putting natural resources to good use

Atomic research/nuclear science

Improved weather forecasting

Energy research

Advancement in education

Improves working/living conditions

Improvements in medicine/medical research

Development of electricity/products using electricity

Space research/moon trip

Foods research/processing

Improved travel/methods of transportation

Concern for environment

Agriculture

Improved communications

Other answers

Don't know

9B. You've said that science and technology have done more good than harm. Can you tell me one of the good things? (Second mention. The list in 9A is repeated.)

11A. You've said that science and technology have done good and harmful things. Please tell me one of the good things. (The list in 9A is repeated.)

11B. You've said that science and technology have done good and harmful things. Please tell me one of the harmful things.

Food additives

Lack of concern for the environment

Space program/moon trips

Nuclear/military

Overpopulation

Used up resources

Harmful medicines

Drugs/drug abuse

Caused personal problems/fears/tensions

Unemployment problems

None/nothing bad

Other answers

Don't know

12. Do you feel that the degree of control that science has over society and technology should be increased, decreased, or remain as it is now.

13. Do you believe that it is more important for society to control science, to control technology, to control both equally, or to control neither.

14. In your view, in which of these areas could science and technology make a major contribution toward solving the problems?

Reducing and controlling population

Finding better birth control methods

Weather control and prediction

Space exploration

Improving health care

Developing/improving weapons for national defense

Developing faster and safer public transportation for travel within and between cities

Discovering new basic knowledge about man and nature

Reducing crime

Improving the safety of automobiles

Finding new methods for preventing and treating drug addition

Improving education

Developing/improving methods of producing food

None of these

No opinion

15. In your view, in which areas could science and technology make little or no contribution? (The list in 14 is repeated?)

16. In which of the areas listed on this card would you most like to have your taxes spent for science and technology? (The list in 14 is repeated.)

17. Please tell me in which of these areas you would least like to have your taxes spent for science and technology. (The list in 14 is repeated.)

NORDSTROM AND FRIEDENBERG

Q-SORT SCALE

Carl Nordstrom and Edgar Z. Friedenberg. Why successful students of the natural sciences abandon careers in science. ED 002 936, 1971.

Instrument characteristics

Format:	32 Q-sort cards
Population:	College students
View of attitude:	Not stated
Subscales:	Not explicitly stated
Validity:	Not given
Reliability:	Not given

Analysis

Cognitive items: (25)	All but 7 are cognitive items
Value items: (7)	1, 7, 12, 22, 27, 29, 31.
View of science:	Explicit - Instrumentalist, item 20
	Implicit - Instrumentalist, items 27, 28, 30.

Research Studies

Nordstrom and Friedenberg. (See above)

119 science and engineering majors from three universities participated in the study. Those who had left science identified as the control group (73). Significant differences were found for cards 2, 3, 4, 5, 6, 8, 16, 23, 25 and 26. Follow-up interviews were used to obtain data which clustered students into eight types: eclectic, conventional, adolescent, societal, cool, old pros, anti-ideological, inscrutable. Most popular cards were 6, 9, 17, 18 and 27. The most rejected cards were 1, 4, 8, 21 and 30.

Commentary

With only a single study to go on, there is little that can be done to evaluate this instrument. The items call for some sophisticated thinking, and the sorting of the cards demands that the participants work carefully. It is unfortunate that this technique has not received wider use in the measurement of attitudes to science.

Items of the Nordstrom and Friedenberg Scale

1. Scientists make too little money in the course of a lifetime, compared to people in other professions, to justify the costs of getting a Doctor's degree.

2. Scientists' salaries may seem high enough usually, but since they usually work for a company or a university on a pure annual basis, they have much less chance than doctors, say, or lawyers, to do well for themselves.

3. Over a lifetime, perhaps, a person with a PhD in one of the sciences will earn about as much as other professionals; but it takes him so long to get up there with the others that he and his family have quite a struggle.

4. As professional people, scientists have to expect to move socially among people who earn just enough more than they do to keep them in a state of mild but unpleasant tension.

5. People are really pretty ambivalent toward scientists. Officially, they are highly respected, but the stereotype of the mad scientist is seldom wholly absent from the mind of the man in the street.

6. In modern bureaucratic life, line always pulls more weight than staff however competent or eminent. This means that scientists have to be prepared to accept having their most basic work subordinated to the demands of administrative policy.

7. For the word "professional" to have any real meaning, it has to imply that you can set up in private practice if you find your job turning trivial or harmful. A scientist today may be an expert--he has to be--but he can't hope to be a professional in this sense.

8. Scientists don't seem to live like other upper-middle class people even when they are quite successful. They tend to have fewer interests outside their work in things like the arts, or even in other people, so that life can get pretty dreary.

9. Scientists don't get much chance to participate in making the decisions that govern their work. Once the problem is set, they need all their creativity; but when it comes to having a say in where the whole project is going, they don't sit very high on the committee.

10. It is interesting the way, in all those discussions of Soviet education, the American people seem to equate the words "scientist" and "technician"--not a bad indication of how little the scientist is expected to have to say about running his own show.

11. Basically, a scientist's career depends on his capacity to do significant research; that is his career. But fundamental research is so costly that in order to do it he has to be just as talented at fund-raising as he is in his field. These two kinds of competence are so poorly correlated that many scientists who might do the most creative work get hardly any opportunity to do it.

12. Some of the satisfaction of success for a normal human being comes from being recognized as the responsible leader to whom subordinates turn for guidance. There is too little of this in the way scientific research is usually conducted today; what isn't strictly impersonal is teamwork.

13. Not many scientists can dare to lead a normal political life when they know that their career may be seriously set back, no matter how competent they are if they are charged with being a "security risk".

14. The career of all scientists has been made a little more difficult by a few disaffected "liberals" who have sapped public confidence through their political naivete. Most scientists are loyal, and recognized as such; but the attempt made by some to exploit the few misunderstandings and injustices that have inevitably occurred in order to harass the entire security system has left a bad odor that will not soon be dispelled.

15. There is not much room in science today for the true conservative. The climate of opinion in the scientific world is such that an individual who shared the American people's recognition of the need for vigilance imposed by the Cold War would be given a pretty hard time by his colleagues.

16. The career of the scientist has gradually become more insecure as the center of scientific activity has shifted from the university to industry and government. In industry and government, there are no such institutions as tenure and academic freedom. Even though he is, broadly speaking, an intellectual, the scientist can count on no safeguards of this kind.

17. The work of the laboratory scientist is less varied and engrossing than the image of the pioneer serving mankind in his laboratory would lead you to expect. Most scientists spend most of their time in rather dull, routine activity.

18. Most scientific work today is carried out on more or less of an assembly line basis. Only the top scientists in industry or a few in university work are able to get on top of an entire problem; the rest of the "team" have to hammer away at their particular part of the job without really getting much of a "feel" for its overall purpose.

19. Despite all you hear about automation and the atomic age, there is something peculiarly old-fashioned about the scientist's job. Socially speaking, science as an institution is back in the stage of inner-direction. Maybe nobody needs the glad-hand and three coffee breaks a day, but people do get used to having them, and the atmosphere of lab, library and seminar seems awfully austere by modern standards.

20. People who think of the scientist as a "seeker after truth" are likely to be disappointed because scientific truth has become something so different from anything that can be described or can make its validity felt intuitively. There is seldom any "shock of recognition" when a scientific proposition is verified; it is altogether too abstract.

21. While there are many exceptions, groups of scientists are generally not as pleasant to be among as other intellectuals. On the whole, they tend to be stiffer and somewhat less broad-minded and sophisticated; they hardly seem to know how to enjoy themselves.

22. Compared to other disciplines, the sciences seem to operate within a rather authoritarian tradition. Status is more heavily emphasized; professors are a little more pompous, graduate students tend to be more deferential. It isn't so important in itself, but it hardly adds up to an attractive style of life.

23. Contrary to what one usually expects, scientific training actually seems to offer little encouragement to independence of thought. There is more lecturing and less discussion than in other disciplines; the examinations tend to be rather petty and factual. Even the lecturer's jokes are listed in the syllabus.

24. Even persons who feel themselves ready to accept the traditional austerity of the laboratory are likely to underestimate the degree to which the scientist is expected in his work to detach himself from ordinary human concerns. It is not that scientists are less the prisoners of their own personality or less likely to be "operators" than members of other professions, but that the whole idea of using your skill to work with other people and serve them is held in low regard.

25. The scientific method, as it is taught in the classroom and thought of by the general run of scientists, actually hampers efforts to understand many problems. Insight into the way things develop and their unique, particular meaning are sacrificed to rigid experimental control and statistical generality in order to keep the research scientifically respectable.

26. The scientist's commitment to place objectivity first, while it has made science the instrument of empirical mastery of the environment, ultimately limits his power to penetrate to fundamental meanings. With so much of human experience tending toward depersonalization, it is just those perceptions that cannot be "consensually validated" that are often of crucial importance.

27. An interest in science is, to some extent, something many people in this culture ought to grow through. An American adolescent, if he has any spontaneous curiosity about the world he lives in at all, almost has to couch his interest in scientific terms, for these are the terms available. But when he gets far enough, he may well find that the questions science can answer are no longer the questions he must ask.

28. It is naive to assume that the scientific method leads to the discovery of the kind of truth that is of most fundamental importance. Empirical research is of the greatest value as the instrument of prediction and control of nature, but it is on untestable, transcendental or theological concepts that life ultimately depends for its meaning.

29. Scientists traditionally accept very little responsibility for the use finally made of their work. This was understandable and perhaps acceptable a century ago when human rationality and progress were generally assumed to be marching hand in hand with science. Today, in the atomic age, it is merely suicidal.

30. It is apparent that the conflict between science and the church, on which the Victorian Age reached a smug but workable compromise, has not really been resolved. The present role of science in the conduct of society suggests that when this compromise becomes unworkable through doubt about the essential humaneness of man, science is powerful enough to shove religion aside and ignore the questions that a responsible church must raise.

31. The costs of scientific research today have tied science so closely to the purposes of elite groups in society that it has abandoned most of its critical and skeptical function. When you are dependent on tax exemptions and foundation grants in order to get your work done, you get to be pretty careful never to catch Truth in embarrassing commerce with Mars or Mammon.

32. Science cannot really claim to have solved the social problems that stem from its own institutional framework. The very categories of thought into which the scientist must fit his data are colored by middle-class values. Data that do not fit his categories will tend to slip off his IBM cards and be edited out of his publications as sloppy.

NOVAK

SCIENTIFIC ATTITUDE TEST

Joseph D. Novak. A comparison of two methods of teaching a college general botany course. Unpublished Ph.D. dissertation, University of Minnesota, 1958. (University Microfilms order No. 58-2159.)

Instrument characteristics

Format:	35 item questionnaire. Respondents mark "P" if the item arouses pleasant or agreeable feelings, "U" if the item arouses unpleasant or disagreeable feelings, "O" if the item is definitely neither pleasant nor unpleasant.
Population:	College students.
View of attitude:	Attitude is defined as an emotional predisposition, and the scientific attitude was defined as the emotional responses of recognized scientists to a group of selected activities or ideas. (P. 142)
Subscales:	These are not identified explicitly.
Validity:	Judgments of college staff and students.
Reliability:	.53

Analysis

Cognitive items: (11.5)	7, 10, 12, 17.2, 18, 20, 21, 23, 25, 26, 27, 29.
Value items: (3.5)	3, 5, 17.1, 28.
Attitude items: (1)	8.
Test of Possession-Dispositions: (16)	1, 2, 4, 6, 9, 11, 16, 19, 22, 24, 30, 31, 32, 33, 34, 35.
Self-Report Dispositions: (3)	13, 14, 15.

View of Science:	Explicit -	Instrumentalist, item 20
		Realist, items 10, 22.
	Implicit -	Instrumentalist, items 5, 6, 21.
		Realist, items 9, 17, 19.
Additional characteristics:	Ambiguous item 17.	

Research Studies

Novak, Joseph D. (See above)

368 college students in a General Botany course were divided into sections for a project-centered approach and the regular course, for a randomized design. Attitude was found to correlate significantly with problem solving (r-.19). There were no significant differences between the groups of students on any of the variables measured.

Commentary

The scale has a comparatively low reliability. Also, the items are clearly tapping a number of subscales. Given this and the lack of thorough validation, the usefulness of the instrument is doubtful.

Items of the Novak Scale*

1. Reasoning on the basis of facts.
2. Explaining phenomena logically and systematically.
3. The best critic of a scientist is someone who is not a scientist.
4. Discard experimental information which conflicts with common sense.
5. The best way to study behavior of man is to do it with the methods of science.
6. Construct a theory before you try to solve a problem.
7. Knowledge is valuable whether or not commercial application of this knowledge can be made.
8. Too much knowledge is harmful.
9. Accept as true or probably true those things in science which you are not qualified to criticize.
10. Scientific methods supply us with the most dependable knowledge.

11. Record all the data you obtain when you do an experiment.

12. Scientists make guesses.

13. Reading books or articles on scientific topics.

14. Solving problems which have several possible answers.

15. Working out complex puzzles.

16. Giving preference to intuition over what appear to be cold facts.

17. The importance of science has been exaggerated because many events are due to pure chance rather than cause and effect relations.

18. The methods of science are flimsy at best.

19. One should never question the laws of science.

20. Some fortune tellers probably do give accurate fortunes.

21. The sudden flashes of insight one sometimes gets on a problem suggest a kind of divine guiding spirit.

22. The theory of relativity is probably true since Einstein proposed it.

23. A scientist is practically a magician.

24. One should not doubt what is commonly accepted.

25. Current evidence suggests that the world is 2 to 4 billion years old.

26. Some modern computing machines almost think.

27. The day will come when scientific knowledge will mean little.

28. Each day one should seek more sensible ways of doing things.

29. Home is where the heart is.

30. Being stuck in a search for a reasonable answer.

31. Finding answers to problems which bring new problems clearly to mind.

32. Searching for the best possible answers which require only clear cut facts.

33. Eliminating answers which have little basis in observable fact.

34. Selecting what appears to be the most reasonable answer rather than selecting answers which seem to be nice.

35. Taking a chance on an answer even though it contradicts the facts.

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ORMEROD

THE BRUNEL SOCATT SCALES

Ormerod, M.B. The characteristics and correlates of attitudes to science among English pupils in the middle years of secondary education. Unpublished Ph.D. dissertation, Brunel University, England, 1976.

Instrument characteristics

Format:	49-item Likert scale.
Population:	Secondary School pupils, age 14.
View of attitude:	Not available.
Subscales:	1. Aesthetic Humanitarian (items 10, 20, 24, 26, 28, 36, 38, 41, 48). 2. Practical (items 6, 7, 17, 21, 23, 33, 37, 43, 49). 3. Money, Pro (items 19, 21, 27, 29, 47). 4. Money, Anti (items 4, 5, 12, 14, 44). 5. Scientists (items 22, 32, 34, 42, 46). 6. Science as a school subject (items 1, 2, 3, 8, 9, 11, 13, 15, 18, 25, 31, 40). (Items 30, 35 and 39 are not identified in a subscale. Item 21 appears on two subscales.)
Validity:	50 of 200 statements were selected using the Thurstone method (60 judges), reduced to 20 items of the original scale (12 items relating to science as a school subject, and 8 relating to the social implications of science). Content validity established by correlating with science grades and science preference scores. Correlations range from .40 to .55. The

	scale is expanded to 49 items, the subscales determined by factor analysis.
Reliability:	Subscale test-retest reliabilities for 2100 pupils are:
	1. Aesthetic Humanitarian, .75
	2. Practical, .72
	3. Money, Pro, .62
	4. Money, Anti, .81
	5. Scientists, .80
	6. Science as a school subject, .90

Analysis

Cognitive items: (17)	2.1, 3, 6, 7.1, 10, 17, 20, 22, 24, 28, 30, 34, 36, 37, 39, 41, 43, 45.
Value items: (17.5)	4, 5, 7.2, 9, 12, 14, 19, 23, 27, 29, 33, 35, 38, 44, 46, 47, 48, 49.
Attitude items: (14.5)	1, 2.2, 8, 11, 13, 15, 16, 18, 21, 25, 26, 31, 32, 40, 42.
View of science:	Implicit - Realist, item 22.
Additional characteristics:	Ambiguous items 2, 7, 18, 45.

Researc h Studies

Ormerod, M.B. The social implications factor in attitudes to science. British Journal of Educational Psychology. 1971, 41, 335-338.

261 boys and 264 girls were surveyed using the original 20-item scale. There are significant relationships between the attitudes toward science as a subject and the subjects chosen, and (for girls) the attitudes toward the social implications of science and the subjects chosen. The number of significant relationships between attitudes toward social implications and science option is significantly different for boys and girls.

Ormerod, M.B. Social and subject factors in attitudes to science. School Science Review, 1973, 54, 645-659.

The construction and validation of the original 20-item scale is described. The correlation between social implications of science and subject choice for girls is .36. Subject preference scores and attitude to science as a subject correlate (.66 for boys and .64 for girls).

Ormerod, M.B. Pupils' attitudes to the social implications of science. Unpublished manuscript, Brunel University, England, nd.

The 49-item scale is submitted to 2100 pupils, together with a subject preference instrument. The study confirms that physics and chemistry are "male" subjects. Correlations of attitude to science as a school subject with biology preference are significantly lower than with chemistry and physics preference, except in the case of coeducated girls. Correlations of social implications with subject preferences are low or negligible.

Commentary

While the instrument has been constructed with care, validity determinations appear to have been restricted to factor analysis. The instrument has considerable potential in spite of this.

Items of the Ormerod Instrument*

1. I see a scientific career as being the most rewarding and satisfying imaginable.

2. Apart from the ways in which science has increased my comfort, I could not care less about it.

3. Science is the most useful subject of all.

4. Too many laboratories are being built at the expense of the rest of education.

5. It is stupid to spend so much on sending people to the moon while millions suffer and starve.

6. Problems are being solved in science nowadays which will lead to a bettering of life for mankind.

7. People have long managed without the scientific discoveries we now have, and we too should be able to do without them.

8. Science is the most boring subject on the timetable.

9. More science is needed.

10. Scientific discoveries have spoilt the peace and quiet of this world.

11. Studying science gives me enormous pleasure.

12. Money used on scientific projects could be put to better use.

13. I am glad that I am able to take science subjects at school.

14. This country is spending too much money on science.

15. Science is one of the most exciting subjects at school.

16. Science is mankind's worst enemy.

17. Science makes for a more comfortable life.

18. Science is always dull, apart from experiments.

19. There is not enough concern about science nowadays.

20. Science is making most people's jobs more boring.

21. With the aid of science, I look forward to a brighter future.

22. Scientists think they have the answers to all our problems.

23. Everybody should know something about science.

24. Science is destroying the beauties of nature.

25. Science is stimulating and fascinating.

26. Scientists make things which are a nuisance.

27. A lot more money should be spent on science.

28. In making our lives easier, science is laying up troubles for future generations.

29. More scientists are urgently needed.

30. Science is turning people into robots.

31. Science is of very little interest to me.

32. Scientists are "show-offs".

33. Modern inventions and medicine make life better.

34. Science is only important for scientists.

35. Money spent on science is well worth spending.

36. The progress of science is to blame for killing millions of people.

37. Without science we should all be living in caves.

38. Too much concentration on science is dulling people's appreciation of the arts and natural beauty.

39. Scientists are too busy discovering things to consider the harm their discoveries might do.

40. Science is very exciting.

41. Science is interfering with our liberty.

42. All scientists are mad.

43. Scientific progress solves more problems than it creates.

44. Most of the money spent in Britain on science should be spent building more houses.

45. Because of modern inventions we shall all be able to earn more money with less labour and more time for leisure.

46. Scientists are too taken up with their work.

47. We do not pay our scientists as much as they are worth.

48. The results of science are making life too much of a rush.

49. There are more good applications of science than bad ones.

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PARISH

PRE-TEST AND POST-TEST OF SCIENCE ATTITUDES

Howard Irwin Parish. A resident field experience in oceanography: Its effects on the attitude of certain college students. Unpublished Ed.D. dissertation, Columbia University, 1975. (DAI: vol. 36, p. 1412)

Instrument characteristics

Format:	Both tests are 43-item Likert scales. The post test has the same items as the pre-test, differently ordered.
Population:	College students.
View of attitude:	Attitudes are socially formed; they are orientations towards others and objects; they are selective and reflect a disposition to an activity, not just a verbalization (p.9)
Subscales:	None are explicitly mentioned, though the items suggest several.
Validity:	Decided by a panel of experts.
Reliability:	Pre-post reliability is .72.

Analysis

Cognitive items: (26)	1, 2, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 24, 25, 26, 29, 30, 31, 33, 34, 36, 38, 40, 43.
Value items: (10)	4, 18, 21, 23, 28, 32, 35, 39, 41, 42.
Attitude items: (5)	3, 6, 19, 22, 37.
Self-Report Dispositions: (2)	7, 27.
View of Science:	Implicit - Instrumentalist, item 16. Realist, item 28

Research Studies

Parish, Howard Irwin. (See above)

Students enrolled in Introductory Oceanography were divided into 3 groups: E_1 (31) had 3 days of fieldwork, E_2 (31) received an Audiovisual simulation of fieldwork; and C (25) received no fieldwork. There were no significant differences on tests of content and science processes. On attitudes, there was a significant difference between E_1 and C, but not between E_1 and E_2, nor between E_2 and C.

Commentary

An inspection of the items of this instrument reveals that they tap a number of attitudinal objects, suggesting a number of subscales. Until these are identified and validated, the instrument's usefulness is limited.

Items of the Parish Scale*

1. A scientific career offers a chance to do something really worthwhile.

2. Students' discussion of field problems would not take place without stimulation brought on by the instructor's questions.

3. Getting involved in a field research problem is more interesting than just taking a field trip.

4. It might be well to retard scientific activity for a time.

5. No one can foresee or predict what may come from scientific research in the future.

6. I'd rather read about field research problems instead of wasting time visiting places.

7. I don't know enough about scientific research to help perform an original experiment.

8. Few professions offer opportunities superior to those a scientist might encounter.

9. Science depends upon free and open communication.

10. Data gathered by many small research teams working on a problem can sometimes be combined to give an overall result.

11. Field research problems are more meaningful when they're discussed in the field rather than in the classroom.

12. You have to know or have to be socially friendly with the members of your research team in advance in order to collect valuable scientific data.

13. Conclusions drawn from a scientific experiment can usually be agreed upon by all members of the research team.

14. The fascination of research is the chance of a great discovery.

15. Secrecy is an important influence upon American science today.

16. Modern science is incapable of solving today's problems.

17. A scientist is responsible for the social implications of his work.

18. Scientific research can be done better by an individual rather than a research team.

19. I would like to see all scientific research abandoned.

20. A scientist ought to be free to do whatever experimental work he feels is important.

21. Scientific research outweighs the problem arising from this research.

22. Much of scientific work is dull routine.

23. Research in some fields should be given much more support.

24. You get to know your instructor in the field better than in the classroom.

25. Scientific research will make only minor additions to our knowledge.

26. In recent years scientific research has been dominated by the government and the military.

27. I can understand scientific problems better after I've had first-hand experience with them.

28. Students should get involved only with scientific experiments that have a definite answer which can be found during a regular laboratory session.

29. Industrial profits, not science, is responsible for the pollution problem.

30. The rewards of a scientific career would not repay the effort involved.

31. The world would have been better off without some of the recent discoveries in science.

32. Once a research team is established it is most productive for you to work with them on future experiments.

33. Overnight field experiences foster discussion of scientific problems.

34. Scientific work is usually pretty far removed from everyday reality.

35. Some kinds of experimental work should be prohibited.

36. Only a small percentage of the population could qualify to become scientists.

37. Science has an irresistible attraction for me.

38. You get to know your fellow students in the field better than in the classroom.

39. Overnight field trips take up so much valuable time that they shouldn't be used for undergraduate courses.

40. Our high standard of living is an outgrowth of scientific advances.

41. Public money spent in science teaching and research during the past few years could have been used better for other purposes.

42. It is best not to run an experiment unless there are clear goals and everyone knows how to analyze the data.

43. Scientific research is one of the best ways for developing reasoning ability.

REDFORD

ATTITUDES TOWARD SCIENCE AND SCIENCE TEACHING

Elmer G. Redford. Attitudes toward science and science teaching. In Unpublished Evaluation instruments in science education: A handbook. Edited by Victor J. Mayer, Columbus, Ohio: ERIC Information Analysis Center, 1974. ED 095 015

Instrument characteristics

Format:	42 item Likert scale.
Population:	Elementary teachers, elementary education majors, college freshmen.
View of attitude:	Not available.
Subscales:	Science and science teaching.
Validity:	"Internal consistency" reported.
Reliability:	Split-half reliabilities, science r=.88; science teaching r=.84 (N=154).

Analysis

Cognitive items: (19)	5, 7, 9, 10, 11, 14, 15, 16, 19, 26, 27, 28, 30, 31, 33, 34, 38, 39, 41.
Value items: (17)	1, 2, 4, 6, 8, 12, 13, 17, 18, 20, 21, 22, 25, 29, 36, 40, 42.
Attitude items: (6)	3, 23, 24, 32, 35, 37.
View of Science:	Implicit -- Realist, item 33.

Research Studies

Not available.

Commentary

It is difficult to determine from some items (for example 9, 12) to which subscale they belong. Additionally, there are several cognitive items in this instrument, so it may not be particularly useful for measuring attitudes.

Items of the Redford Scale

1. Elementary teachers should not be required to teach science.
2. Newspapers and magazines should include fewer articles about science.
3. Science is a subject that would be fun to teach.
4. There should be more effort expended to educate the general public in science.
5. The study of science gives man a better understanding of his fellowmen.
6. Too much money is being spent by the United States government for science programs.
7. An elementary teacher who has a negative attitude toward teaching science can still be a very effective overall teacher.
8. Our society places too much emphasis on science.
9. Procedures of inquiry, as taught in science, give a student a method of study that he can employ in many other areas.
10. A very stimulating, challenging and rewarding career is in store for the person who elects to teach science.
11. Science teachers are envied by their colleagues because they can submit their subject arguments to the test of laboratory and demonstration.
12. Too much time and money is being spent on new programs for teaching science.
13. Our schools are spending too much time on science.
14. Teaching science will lead to a teaching career filled with satisfaction.
15. Studying science courses causes a student to be more tolerant toward contrary viewpoints.
16. Fundamentally the goals of science and the attributes of good citizenship are similar.
17. Elementary education students should not be required to take a science methods course.

18. Replacing science courses with courses in other disciplines would be an improvement in a school's curriculum.

19. The only benefit received from the work of scientists is the production of technical gadgets.

20. Elementary teachers should enjoy teaching science.

21. If you are looking for an area to teach that will provide opportunities for students to express their initiative and ingenuity you should choose science.

22. To have a good understanding of the world in which we live one needs to study science.

23. As a future elementary teacher I am not looking forward to teaching science.

24. Science is a dull subject to teach.

25. Time studying science could be more profitably used studying other areas.

26. A person studying science will tend to become a dull misfit in our society.

27. Teaching science is more like a hobby or recreation to a teacher rather than another job or chore.

28. Studying science helps one make judgements more objectively than emotionally.

29. Science in elementary grades should be taught by men teachers only.

30. Instead of helping eliminate ignorance and superstition from mankind, science has tended to increase it.

31. Teaching science gives a person a means of expressing himself creatively.

32. If the opportunity developed I would encourage others to teach science.

33. A true scientist does not believe in God.

34. To be ignorant of the methods of science leaves a student unprepared for their place in society.

35. I have no desire to teach science.

36. Only the teachers of grades eight through twelve need be concerned with teaching science.

37. As a future elementary teacher I am looking forward to teaching science.

38. The aim of science is to help us understand the world and ourselves.

39. As a group, scientists are concerned with overcoming the ills of our society.

40. If teaching science were removed from the elementary grades, teaching at this level would be more pleasant.

41. Grouping elementary education students for the study of science produces a better learning situation for the students involved.

42. If you had to design a physical science course to fit the needs of future elementary teachers your approach would be very similar to the one used in your present course.

REMMERS

THE PURDUE OPINION POLLS

(Polls 45, 50 and 101 contain items measuring attitudes to science. Poll 45 is out of print.)

R.W. Heath, M.H. Maier, H.H. Remmers, and D.G. Rodgers. High school students look at science. Report of Poll No. 50 of the Purdue Opinion Panel, Purdue University, 1957.

Arline C. Erlick and William K. LeBold. Factors influencing the science career plans of high school students. Report of Poll No. 101 of the Purdue Opinion Panel, Purdue University, 1975.

Instrument characteristics

Format:	Likert-type items, with a four-point response scale.
Population:	High school students.
View of attitude:	Not stated.
Validity:	Not available.
Reliability:	Not available.

Analysis: Poll 50

(Items 21-37 and 50-63 of Poll 50's 69 items are relevant here.)

Cognitive items: (22)	All but 9 items are cognitive items.
Value items: (5)	25, 28, 59, 60, 61.
Attitude items: (3)	21, 32, 51.
Self-Report Dispositions: (1)	50.
View of Science:	Implicit - Instrumentalist, item 58. Realist, item 30.
Additional characteristics:	Ambiguous items 62, 63.

Analysis: Poll 101

(Only items 28-32 of the 38 items are relevant here.)

Cognitive items: (1) 29.

Value items: (4) 28, 30, 31, 32.

View of Science: None evident.

Research Studies

Belt, Sidney Leon. Measuring attitudes of high school pupils toward science and scientists. Unpublished Ed.D. dissertation Rutgers University, 1959. (DAI: No. 20, p. 3625)

Belt uses items from polls 45 and 50 in his research, and his instrument is discussed earlier in this collection.

Gatewood, Claude West. A study of the effect of the Oklahoma State University Travelling Science Teacher Program on the attitudes of high school students toward science and scientists. Unpublished Ed.D. dissertation. Oklahoma State University, 1962. (DAI: vol. 37 p. 7056)

The effects of the program were studied on 13 experimental schools (298 students) with 17 schools as controls (398 students). Reliabilities of .90 (to science) and .92 (to scientists) are reported. Only 3 items (of items 21-37 and 50-63 of Poll 50) showed a significant difference favoring the experimental group.

Stoker, Howard W. Jr. Aptitude and attitudes of high school youth re: Science as related to N variables. Unpublished Ph.D. dissertation, Purdue University 1957. (Publication No. 24, 408)

Data from the 1957 Purdue Opinion Poll are analyzed, using a random sample of 200 from the 2500 polled. Aptitude and attitude to science correlate (r=.35) though attitude to science as a vocation was not significantly related to aptitude.

Commentary

These polls are valuable for the large samples used to respond to attitude items. As the analysis shows, the items are largely cognitive, though.

Items of the Purdue Opinion Polls*

The response scale is: Agree
Undecided, probably agree
Undecided, probably disagree
Disagree

Poll 50:

21. Do you think that you would like to be a scientist?

22. The scientist is not able to have a normal family life.

23. Scientists are more likely to be mentally ill than people who are engaged in other types of work.

24. The scientist is more likely to be unpatriotic than other people.

25. All scientists should be employed by the government so that control can be kept over their findings.

26. Scientists are more likely than most people to listen to both sides of an argument.

27. Most scientists are not religious.

28. The scientist's attitude of questioning is all right for problems of physics and chemistry, but should not be applied to such things as religion and morals.

29. Most scientists are geniuses.

30. The scientist seeks to find out the truth with no thought of the consequences of his work.

31. Scientists are usually impractical in the way that they try to solve the problems of everyday living.

32. Most scientists are more than a little bit "odd."

33. Things like the development of the atom bomb indicate that scientists have little regard for humanity.

34. Scientists who work in colleges and universities are so removed from everyday life that they have little to contribute to practical problems.

35. Scientists are likely to be more radical about matters outside of their own field than non-scientists.

36. Scientists are more willing than non-scientists to sacrifice the welfare of others to further their own interests.

37. The willingness of the scientist to reject traditional beliefs may lead to confusion and disorder.

50. I would view with suspicion any findings reported by a scientist of certain other countries.

51. Science courses are boring.

52. Since every person is different, it is impossible to establish scientific laws of human action.

53. The goal of science is to benefit mankind.

54. Although science may be able to understand and control some things in the physical world, it can never hope to understand and control human action.

55. If it were not for science, we would still be living in ignorance and disease.

56. Scientific studies are conducted in the laboratory rather than in the actual world.

57. Scientific training leads to good citizenship.

58. Science has its place but there are many things that can never be understood by the human mind.

59. Scientific methods should be applied to human problems like segregation and poverty as well as to machines and modern conveniences.

60. Since man has a soul, it is immoral to study him by scientific methods.

61. Money should not be given for scientific research unless it has immediate practical value.

62. The widespread cruelty of man to his fellow man is largely a result of the immoral use of scientific findings.

63. Science is immoral because it rejects some of the teachings of the Bible.

Poll 101:

28. Money should not be given for scientific research unless it has practical value.

29. The by-products of past scientific efforts have been, on the whole, beneficial to man.

30. Overall, would you say that science and technology do more good than harm?

31. Some people would stop all high altitude flying to prevent possible break in the ozone layer. How do you feel about this?

32. Assume that as a taxpayer, you are asked to pay to support these programs. Which ones would you willingly pay more taxes to support?

    Conduct cancer research
    Support science education programs
    Improve the environment
    Seek alternate sources for energy
    Continue space research
    Improve techniques for food production

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SCHWIRIAN

SCIENCE SUPPORT SCALE

Patricia M. Schwirian. On measuring attitudes toward science. Science Education. 1968, 52, 172-179.

Instrument characteristics

Format:	40 item Likert scale.
Population:	University undergraduates, and high school seniors.
View of Attitudes:	Bernard Barber's position (Science and the Social Order, Collier, 1962) is used as the basis of the scale. Five cultural values are identified as conducive to the growth and development of a scientific institution in a society: rationality, utilitarianism, universalism, individualism, and belief in progress.
Subscales:	1. Rationality (items 1-8) 2. Utilitarianism (items 9-16) 3. Universalism (items 17-24) 4. Individualism (items 25-32) 5. Progress and meliorism (items 33-40)
Validity:	Item analysis performed on the original 60 items submitted to 196 subjects. Large critical ratios show that the items have good discriminatory power between low and high scores on the total scale.
Reliability:	Total reliability is .873. Subscale reliabilities (split-half) are

Rationality	.586
Utilitarianism	.639
Universalism	.639
Individualism	.668
Progress and Meliorism	.657

Analysis

Cognitive items: (10)	5, 8, 12, 14, 22, 24, 30, 32, 34, 39.

Value items: (30) All but 10 items are value items.

View of Science: Implicit - Instrumentalist, items 6, 11.
Realist, item 9.

Additional characteristics: Ambiguous items 24.

Research Studies

Barman, Charles Roy. The influence of value clarification techniques on achievement, attitudes and affective behavior in high school biology. Unpublished Ed.D. dissertation, University of Northern Colorado, 1974. (DAI: vol. 35, p. 7139)

An experimental group of 78 students received instruction in value clarification once a week for 18 weeks, while a control group of 77 students did not. The Schwirian scale was divided into two forms of twenty items each, with reliabilities of .736 and .747. There were no significant differences on any of the variables measured.

Doran, Rodney L., Guerin, Robert O., and Cavalieri, Joanne. An analysis of several instruments measuring "nature of science" objectives Science Education, 1974, 58, 321-329.

The Schwirian scale, "Test on the Social Aspects of Science", and Kimball's "Nature of Science Scale" were administered to approximately 300 high school students. There was no positive relationship between the Schwirian instrument and the others, with the exception of subscale 2 of the TSAS and subscale 3 of the Schwirian instrument.

Follette, Everett LeRoy. An appraisal of change of attitude toward science and scientists by students who have participated in an intrinsically motivated earth science class. Unpublished Ed.D. dissertation, University of Colorado, 1971. (DAI: vol. 12, p. 6823)

120 college students were divided into experimental and control groups. Change in science attitude did not correlate with other variables. There was no relationship between attitude change and membership in a belief system and between attitude change and the treatment. There was some interaction between intrinsically motivated group and attitude to science.

Miller, George Henry. Science support and science orientation of college students in Kentucky. Unpublished Ed.D. dissertation, University of Georgia, 1972. (DAI: vol. 33, p. 3426)

30 items of the Schwirian scale were used. (A validity test showed a significant difference at the .01 level between science and nonscience majors.) A total of 909 students were sampled. Students attending large state universities scored significantly higher than those at small private institutions. There were significant differences when students were compared for area of study and for semester-hours of science.

Rambally, Satnarine. The relationship between teacher's attitudes toward science, verbal interaction patterns, and student achievement in Chemical Education Materials Study. Unpublished Ed.D. dissertation, University of Northern Colorado, 1977. (DAI: vol. 38, p. 2687)

Twelve CHEMS teachers and their classes (276 students) were tested, and their classes visited twice. There was no significant relationship between teacher attitude and verbal interaction pattern. There was a significant relationship at the .05 level between teacher attitude and student achievement.

Rose, Ryda Dwarys. The relationship of attitudes, knowledge and processes to initial teaching behaviors in science. Unpublished Ed.D. dissertation, University of Pennsylvania, 1971. (DAI: vol. 32, p. 6242)

An experimental group (N=127) received a multiple methods course not received by the control group (N=13). There was no significant difference on attitude to science.

Schwirian, Patricia M. Characteristics of elementary teachers related to attitudes toward science. Journal of Research in Science Teaching. 1969, 6, 203-213.

191 elementary school teachers were surveyed. Age was associated with the greatest attitudinal difference, the younger teachers expressing the more positive attitudes. Other variables significantly affecting attitudes were highest degree held, semester hours of college science, type of undergraduate institution (more favorable attitudes being held by graduates of state schools), years of teaching experience, and whether the experience was interrupted or continuous.

Schwirian, Patricia M., and Thomson, Barbara. Changing attitudes toward science: Undergraduates in 1967 and 1971. Journal of Research in Science Teaching. 1972 9, 253-259.

398 undergraduates in 1967 are compared with 153 undergraduates in 1971. No significant differences were found.

Simpson, Ronald D., Shrum, J.W. and Rentz, R.R. The Science Support Scale: Its appropriateness with high school students. Journal of Research in Science Teaching, 1972, 9, 123-126.

24 tenth grade biology teachers were divided into 4 equal sized groups according to score on the scale, ranging from "high" (group 1) to "low" (group 4). One class of students (for a total of 618) was randomly selected for each teacher, and was administered the scale in September and the following May. F-values were not significant for the teacher group variable in four of the five subscales, nor for the total score. Scores did not increase after the course. Reliability estimates were well below those originally reported by Schwirian. Factor analysis of inter-item correlations indicated that student interpretation of item meaning did not correspond to the given subscales of the instrument.

Spears, Jacqueline D. and Hathaway, C.E. Student attitudes toward science and society. American Journal of Physics. 1975, 43, 343-348.

The scale was administered to 701 students in an introductory physical science course, and to 50 faculty members and graduate students in a physics department. The nonscience group and the physicist group differed little in their support of universalism, but differed more significantly in support of the remaining four subscales.

Symington, David J., and Fensham, Peter J. Elementary school teachers' closed-mindedness, attitudes toward science, and congruence with a new curriculum. Journal of Research in Science Teaching. 1976, 13, 441-447.

72 teachers in 24 elementary schools were studied. The only independent variable significantly affecting attitude was dogmatism. There was a high negative correlation between dogmatism and attitude to science.

Williamson, Troy Lee. Social attitudes toward science of freshman at Hinds Junior College relative to their understanding of science. Unpublished Ed.D. dissertation, Mississippi State University, 1971. (DAI: vol. 32, p. 3816).

The Schwirian scale and the test on Understanding Science were administered to 413 freshman at the beginning and end of an academic year. Attitude to science correlated significantly with understanding science and with units of high school science completed. There was a significant correlation between sex and change in social attitudes to science.

Commentary

This scale comes from a well defined conceptual base, and presents a relatively clean bill of health when analyzed. There is some discrepancy in the reliabilities, and there is concern for the independence of the subscales, as shown in the research study of Simpson et al.

Items of the Schwirian Scale *

(The items are randomly ordered before the scale is administered.)

1. It is likely that much of the scientific information we have today will be demonstrated to be inaccurate or inadequate in the future.

2. The skepticism of the scientist should be limited to his work.

3. Scientists should be free to explore all phases of man's life and the universe about him.

4. One important function of science is to teach people to be critical thinkers, not believing everything they are told.

5. The unbounded inquiry of the scientists has had a bad effect on society's moral standards.

6. When the findings or theories of science conflict with religious belief, it is better to accept the religious belief.

7. Scientific findings should not be made public if they will create social unrest.

8. Scientists go overboard on demanding evidence before drawing conclusions.

9. One important function of science is to demonstrate the wonder and orderliness of God's universe.

10. Religious leaders should be constantly on guard against the ideas and theories that scientists produce and explore.

11. Science is bound to lead our society into Godlessness.

12. The questions which are really important to man can never be solved by science.

13. The meaning of any discovery should be judged by man's moral standards rather than by his intellectual need for truth.

14. While man has become physically richer from the fruits of science, he has become spiritually poorer.

15. The material progress of science has made men care less than they should about the prospect of eternal life.

16. Men are worthy of enjoying the fruits of scientific discovery.

17. There is no place in science for sexual deviants such as homosexuals.

18. Federal scholarship programs for training scientists should be limited to citizens of the United States.

19. Science should remain a predominantly male profession.

20. Fellowships and scholarships in the sciences are better spent on men than on women.

21. If a student is very bright, he should be channeled into science because we need good scientists.

22. Those who have had a history of mental illness cannot be trusted to do important scientific work.

23. A scientist's reputation should be important in judging his findings as the techniques he uses in his research.

24. There are probably so few women scientists because women simply do not have the natural ability to be scientists.

25. The administration of colleges or universities should not discharge scientists whose political views are unpopular.

26. The primary function of a college education in science is to teach an appreciation for the findings of the past great scientists.

27. The United States government should not take on the function of directing and coordinating American science as a whole.

28. In times of national emergency a scientist's utmost concern should be for the contribution he can make to his country's needs rather than his own specific research interests.

29. It is not always appropriate for the Federal government to demand that the scientific research it sponsors serve the national policy ends.

30. Scientists could work more effectively if they were organized and guided in their work by a man who has proved himself to be an outstanding scientist.

31. Scientific work should be judged primarily by the political and social necessities of the nation and the world.

32. Scientists could work more effectively if they were organized and guided in their work by a Congressional committee which was aware of national needs.

33. Scientific inventions and discoveries have done more good than bad for mankind.

34. Modern science and inventions are responsible for much of man's personal discontent and frustration.

35. It is not appropriate for man to tamper with the order and intentions of Nature.

36. Technological advances in the future will probably be nowhere as great as they have been in the past thirty years.

37. It would be much more pleasant to live in a country in which you didn't even know about the rest of the world's problems.

38. A return to a simpler, less mechanized life would result in happier, more contented people.

39. The increased efficiency of computers does not justify their use because of all the unemployment produced when computers replace men.

40. In the long run, man's lot will be improved by scientific knowledge.

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SELMES

ATTITUDES TOWARDS SCIENCE

C. Selmes. Nuffield A-level biology: Attitudes to science. Journal of Biological Education, 1973, 7, 43-47.

Instrument characteristics

Format:	56 item Likert-type scale. (+ +, +, 0, -, --, markings are used by the subject.)
Population:	Sixth form and post graduate education students.
View of attitude:	Not available.
Subscales:	None are identified by item, but the scale is designed to measure attitudes to scientists, science in general, and science as a method of investigation.
Validity:	An original pool of 94 items was pre-tested on 249 sixth formers. A t-test compares high and low scoring groups so that items that do not differentiate are removed. Validity is found by correlating attitude scores with 0-level (certificate examination) results and with teacher's assessments of attitudes. Values of r range from .38 to .56, which are significant at the .01 level.
Reliability:	Test-retest [illegible] 83 (N=46); split-halves range from [illegible] 4 (N=73) to .87 (N=85)

Analysis

Cognitive items: (36)	1, 2, 3, 4, 8, 9, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 28, 30, 31, 32, 33, 38, 40, 42, 45, 46, 49, 50, 51, 52, 53, 55.
Value items: (6)	29, 35, 44, 48, 54, 56.
Attitude items: (10.5)	5, 6, 10, 11, 22, 27.1, 36, 37, 39, 43, 47.

Test of Possession-Disposition: (2)	7, 34.	
Self-Report Dispositions: (1.5)	27.2, 41.	
View of Science:	Explicit -	Instrumentalist items 16, 17, 21, 51, 52, 53.
		Realist items 19, 42.
	Implicit -	Instrumentalist items 4, 50, 55.
		Realist items 13, 45, 46.
Additional characteristics:	Ambiguous items 3, 18, 24, 27.	
	Difficult item 14.	

Research Studies

Selmes, C. (See above)

The scale was administered to Nuffield and non-Nuffield Biology students, 40 boys and 40 girls in each group. There was no significant difference between the mean scores of the Nuffield and non-Nuffield groups, but the difference between scores of boys and girls was significant at the .05 level.

Wilmut, J. The effect of project work on the attitudes to science held by sixth-form pupils. Educational Research. 1972-3, 15, 128-133.

A 50-item version of the scale was administered as a pre and post test to students in 30 schools: 18 taking physical science and doing project work, 6 taking physical science without project work, and 6 taking traditional physics and chemistry courses. There were no significant changes for any group between pre and post testing, neither were there significant differences among the groups on both testings. Project marks and initial attitude scores correlated significantly at the .01 level ($r=.21$, $n=172$). School mean project marks and mean initial attitude scores were significantly correlated at the .05 level ($r=.58$, $n=17$).

Commentary

Selmes' instrument has adequate reliability, and the validity of the scale appears promising. The analysis raises questions about what is being measured, though, and an inspection of the items shows that a number of subscales are imbedded in the scale, thus casting some doubt on its validity.

Items of the Selmes' Scale*

1. He who has once in his life experienced this joy of scientific creation will never forget it.
2. Scientists deal with facts not human beings.
3. Mankind doesn't stand a chance to last very long since science keeps figuring out new ways to kill more and more people.
4. In science the proof of a theory is never complete.
5. Chemistry is fascinating and exciting.
6. Science is boring.
7. Personal judgment has no place in science.
8. Scientific investigation is an art, not a science.
9. The study of science leads to a sense of wonder.
10. I would much rather listen to music than work at science.
11. Scientists are a nuisance.
12. Science is too difficult for women.
13. Science is a fixed and clearly defined body of knowledge.
14. The amount of science of which an individual scientist is IGNORANT is only slightly less than that of which the non-scientist is ignorant.
15. There are scientific people and literary people and there is mutual incomprehension.
16. We found that the theory did not fit the facts; and we were delighted; because this is how science advances.
17. We have no right to assume that any physical laws exist, or if they have existed up to now, that they will continue to exist in a similar manner in the future.

18. Men who have excessive faith in their theories or ideas are not only ill-prepared for making discoveries; they also make poor observations.

19. Scientists have proved that God does not exist.

20. Women scientists are less feminine than other women.

21. Man invents a scientific system and then discovers whether or not it accords with observed fact.

22. I studied science in order to pass my exams rather than because I liked it.

23. We know that the experience of scientific discoveries is a good and beautiful experience.

24. The formulation of a hypothesis is - let us say a guess; is inspirational in nature.

25. In physics we try to say things that no one knew before in a way that everyone can understand.

26. It is not possible to study human beings scientifically.

27. I thank God I was not made a dextrous manipulator; the most important of my discoveries have been suggested to me by my failures.

28. The important advances in science are made by a few outstanding men.

29. The basic moral rule of a scientific society is simple; mutual respect, intellectual honesty, and good will.

30. Science proceeds by the rapid alternation of imaginative and critical processes.

31. The cold dispassionate scientist is a 'mythical' creature.

32. Scientists are not like other people.

33. With accurate experiment and observation to work upon, imagination becomes the architect of physical theory.

34. Personal opinion has no place in science.

35. The study of science is far less important than any other subject.

36. Science is just learning equations.

37. Work is boring.

38. Most scientific research consists of minute concern with trivia.

39. Scientists are squares.

40. Only scientists can understand other scientists.

41. Most scientific books and articles are incomprehensible.

42. One cannot be a scientist and believe in religion at the same time.

43. I prefer talking to people to fiddling with things in the laboratory.

44. For a scientist memory is more important than intelligence.

45. Facts are the 'bricks' of scientific advance.

46. It is when experiments go wrong that we find things out.

47. I am put off science by the danger of explosions.

48. A scientist must communicate his ideas to non-scientists.

49. Psychology is not a science.

50. There is no such thing as unprejudiced observations: every act of observation we make is biased.

51. Science is the imaginative interpretation of the Universe.

52. Humans are the centre of science.

53. The criterion of a scientific theory is its fruitfulness in practice.

54. The really valuable factor in science is intuition.

55. What is observed depends on who is looking.

56. Scientists have to be more dedicated to their work than other people.

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SHALLIS AND HILLS

IMAGE OF THE SCIENTIST

Michael Shallis and Philip Hills. Young people's image of the scientist. Impact of Science on Society. 1975, 25 275-278.

Instrument characteristics

Format:	Sentence completion, semantic differential-type, and agree-disagree questions.
Population:	Readers of New Scientist and New Society.
View of attitudes:	Not stated.
Subscales:	Not given.
Validity:	Not stated.
Reliability:	Not stated.

Analysis

(Only items in question 5 are analyzed here.)

Cognitive items: (10)	A, B, C, D, E, F, G, I, J, L.
Value items: (1)	H.
Attitude items: (1)	K.
View of science:	None evident.

Research Studies

Shallis, Michael and Hills, Philip. (See above)

From the 1,559 completed returns, it is concluded that young non-scientists appear to be hostile towards science, while young scientists exhibit optimistic and even enthusiastic attitudes towards science.

Commentary

Without reliability and validity data a commentary on the usefulness of this device is impossible.

Items of the Shallis and Hills Instrument

(Additional items establish age, education and occupation)

1. Please complete the following sentence briefly before you read the questions that follow:

   When I think of a scientist, I think of . . .

2. Which word from each pair is most appropriate to your image of a scientist?

   For each pair, tick one box:

sociable	___	___	withdrawn
cautious	___	___	impulsive
remote	___	___	approachable
calm	___	___	nervous
popular	___	___	unpopular
secretive	___	___	open
many interests	___	___	few interests

3. Please rate how near your image of a scientist is to one or other of the following pairs of words.

   Tick one box in the scale between each pair:

realistic	___	___	___	___	___	unrealistic
religious	___	___	___	___	___	atheist
unconventional	___	___	___	___	___	conventional
responsible	___	___	___	___	___	irresponsible
unemotional	___	___	___	___	___	emotional

4. Please tick the boxes corresponding to those words in the list below that you think most describe your view of a scientist's work.

   (Tick as few or as many as you like)

original	___	responsible	___
objective	___	lonely	___
frightening	___	exciting	___
monotonous	___	influential	___
boring	___	important	___
involving	___	stimulating	___

5. For each of the following statements tick the appropriate box:

	Agree	Disagree
A. Scientists are interested in knowledge for its own sake and not for its application.	___	___
B. Most scientists are very much like anyone else.	___	___
C. Most scientists try to make the world a better and safer place to live in.	___	___
D. Science can solve all man's problems.	___	___
E. Most scientists wear white coats and work in laboratories.	___	___
F. Scientists tend to think of people in terms of statistics.	___	___
G. Scientists try hard to explain their work to the general public.	___	___
H. Scientists should leave moral and political question to other people.	___	___
I. Scientists are unaware of anything outside their own subject.	___	___
J. Most scientists would stop their work if they thought it was harmful.	___	___
K. Scientists are apt to be odd and peculiar people.	___	___
L. Scientists are respected by the public.	___	___

6. How near do you think the view you have expressed here agrees with the generally-held public view of scientists?

more favourable ___ the same ___ less favourable ___

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SKURNIK AND JEFFS

SCIENCE ATTITUDE QUESTIONNAIRE

Larry S. Skurnik and Patricia M. Jeffs. Science attitude questionnaire. Slough, Bucks: National Foundation for Educational Research in England and Wales. 1971.

Instrument characteristics

Format: 58 item Likert scale.

Population: High school students.

View of attitude: Not stated.

Subscales: Science interest, social implications of science, learning activities, science teachers, school.

Validity: The original collection of items were obtained from interviews with students. Two parallel forms of 70 items each were composed and tested, giving the final 58 items. Content validity "is assured." Concurrent validity was determined by correlations with aptitude and O-level examination grades.

Science interest, correlations range from .46 to .60.
Social implications, correlations range from .16 to .19.
Learning activities, correlations range from -.07 to .[illegible]8.
Science teachers, correlations range from .02 to .24.
School, correlations range from .03 to .18.

Reliability: The reliabilities for each factor are: .42, .16, .21, .35, .31 for 462 subjects.

Analysis

Cognitive items: (8) 6, 12, 14, 20, 22, 41, 50, 55.

Value items: (14) 3, 5, 9, 10, 11, 15, 17, 19, 21, 24, 25, 38, 56, 57.

Attitude items: (28)	1, 2, 4, 7, 8, 13, 16, 18, 26, 27, 29, 30, 31, 32, 33, 34, 35, 40, 42, 43, 45, 48, 49, 51, 52, 53, 54, 58.
Self-Report Dispositions: (8)	23, 28, 36, 37, 39, 44, 46, 47.
View of Science:	None explicit or implicit.

Research Studies

None have been identified.

Commentary

Clearly, very little of this scale attempts to measure attitudes to science per se. At the most, only the first two factors do this. The lack of concurrent validity and the low reliabilities of the factors suggest that the scale is not very useful.

Items of the Skurnik and Jeffs Instrument

The words in the 5-point response scale for this instrument vary. The "strongly agree -- strongly disagree" wording is used frequently. Other response scales are: much more -- much less, not at all -- very much, never -- all the time, much more -- a great deal less, and others.

Practice Items*

The following are practice items from the instrument:

1. Studying mathematics is fun.

   strongly agree   agree   not sure   disagree   strongly disagree

2. Mathematics should be taught only to boys and girls who want to learn it.

   strongly agree   agree   not sure   disagree   strongly disagree

Representative Items*

Permission to reproduce all the items of this instrument has not been granted.

Permission to reproduce three representative items has been granted.

14. Scientists are wasting public money.

25. We have good science teachers in this school.

52. I would enjoy school more if there were no science lessons.

SWAN

INVENTORY OF SCIENCE ATTITUDES, INTERESTS AND APPRECIATIONS

Malcolm D. Swan, Jr. An exploratory study of science achievement as it relates to science curricula and programs at the sixth-grade level in Montana public schools. Unpublished Ed.D. dissertation, University of Montana, 1965. (DAI: vol. 27, p. 4175)

Instrument characteristics

Format:	50 item Likert scale.
Population:	Grade six.
View of attitude:	Not stated, though mention is made of habits of thought, understanding science, and interest in science.
Subscales:	Part I of the scale (analyzed here) deals with scientific attitudes, appreciations, and interests.
Validity:	200 items were collected initially and checked against the content of textbooks used in Montana. Two field trials were conducted, giving the 50 items which have an internal consistency greater than .21.
Reliability:	Split-half, .90.

Analysis

Cognitive items: (6)	13, 15, 25, 29, 33, 45.
Value items: (9)	2, 3, 12, 16, 34, 38, 40, 44, 46.
Attitude items: (22)	4, 7, 8, 9, 10, 11, 14, 17, 18, 19, 20, 23, 24, 27, 28, 31, 32, 35, 37, 43, 47, 49.
Test of Possession-Dispositions: (5)	1, 5, 30, 39, 41.
Self-Report Dispositions: (8)	6, 21, 22, 26, 36, 42, 48, 50.

View of Science: Implicit - Instrumentalist, item 29.

- Realist, item 30.

Additional characteristics: Awkward item, 45.

Research Studies

Swan, Malcolm D., Jr. (See above)

3,080 pupils in 118 sixth grade classes were sampled. Pupils liking science scored higher on the Metropolitan Advanced Science Test than those not. Pupil interest in science related to program characteristics, experimentation, evaluation, total program, with girls more interested in science than boys.

Commentary

A review of the items of this scale shows that a very large number of disparate scrts of attitudes are being tapped, and so the validity of the scale is very questionable.

Items of the Swan Instrument*

1. When a bad man gets sick or ill, he is getting just what he deserves.

2. Most of the important things that scientists discover are more the result of lucky accidents than hard work.

3. I think that frequent washing and bathing can do more harm than good.

4. I think it is very interesting to study live animals and specimens in science.

5. We can't predict anything about nature from the results we get when we do an experiment.

6. Once I have decided that an answer is right, I will stick with it, even if the evidence indicates that I am wrong.

7. I like to read about the way scientists think the earth and planets were formed.

8. I like to study about the weather and try to predict when it will rain or snow.

9. I don't see much sense in doing extra work when the teacher doesn't give me extra credit for it.

10. I like to spend some of my spare time working on science collections and things like that.

11. It is silly to think that a man could spend many years studying about one kind of insect.

12. By the time a person has graduated from college, he has learned almost everything worth knowing.

13. The world will be a much nicer place in which to live when man learns to control all natural events.

14. I don't think it is fair that my parents should make me do my homework when TV programs that I like are on.

15. Scientists have discovered and named all the plants and animals.

16. Scientists should be free to do whatever they wish, even though a few people may be harmed, because their discoveries will help all of us.

17. I like to build things out of wood, metal, and other materials.

18. I like to study rocks and learn how they were formed.

19. I like to read magazine articles that tell me how to make and build things.

20. We have to travel a long distance to find beautiful things to look at that interest me.

21. I often forget to take my books home, or else forget my homework assignment.

22. I admire a person who will take another's side in an argument even if he knows he is in the wrong.

23. I like to experiment with baking soda, vinegar, salt and other kitchen chemicals to find out what happens when they are mixed.

24. I like to think about problems concerning how the earth and stars came about and how they were formed.

25. Science is a way of thinking and of doing to learn about things.

26. When we think about how large the universe is, I feel real small.

27. I just hate mice, bugs, and other small crawling things.

28. I think that thunderstorms are horrible and they frighten me.

29. We have few problems that scientists cannot solve.

30. We can depend on what our textbooks say, for anything that is printed has to be true.

31. I step on bugs whenever I can.

32. I like to study books and magazines to find out how motors and things work.

33. It is very difficult for scientists to find new problems to work on.

34. It is probably a waste of time for a good scientist to write out and explain the problem he is working on.

35. I like to read science newspaper and magazine articles.

36. You can usually tell if a person is mean or can't be trusted by looking at him.

37. I like to experiment with plants to find out if light or soil or other things make a difference in how fast they grow.

38. Science has done much good for man, but this is probably outweighed by the harm it has caused.

39. The communists are probably the cause of most of the airplane crashes.

40. If we have a lot more of something than we can use, there is nothing wrong in wasting some of it.

41. People with red hair usually have bad tempers.

42. I usually get a lower grade than I deserve.

43. I like to make repairs on things around home just for the fun of it.

44. Students should receive pay for the work they do in their studies.

45. When doing a very short experiment, it isn't necessary to take notes because one can remember until he is finished to write down what happened.

46. It is not good for a scientist to marry and have children because he does not have time to be with them.

47. I would like to place several eggs in an incubator and open one every day to see how a chick develops.

48. Since many people think of "13" as an unlucky number, it is not a good idea to have a birthday party at which this number of people are present.

49. I would rather go to town and look at cars and buildings than to roam about the forest.

50. My parents are often unfair and blame me unjustly for things I didn't do.

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TAMIR, ARZI, AND ZLOTO

PHYSICS ATTITUDE SCALE

Pinchas Tamir, A. Arzi, and D. Zloto. Attitudes of Israeli high school students towards physics. Science Education, 1974, 58, 75-86.

Instrument characteristics

Format: 76 item Likert scale.

Population: Grades 11 and 12.

View of attitude: Not stated.

Subscales:

1. The study of physics, 25 items (1, 2, 4, 9, 11, 18, 19, 20, 21, 24, 26, 29, 30, 33, 38, 42, 48, 56, 59, 60, 61, 63, 66, 71, 76).
2. Social and economic image of physics, 44 items (3, 5, 6, 7, 9, 13, 14, 15, 16, 17, 20, 22, 23, 25, 27, 28, 31, 32, 33, 34, 37, 39, 41, 44, 46, 47, 49, 50, 51, 52, 53, 55, 57, 58, 60, 62, 64, 65, 67, 68, 69, 70, 73, 75).
3. Role of physics in the national-political arena, 12 items (7, 10, 12, 14, 35, 36, 40, 43, 45, 54, 58, 75).
4. Masculine-feminine image of physics, 7 items (8, 32, 37, 47, 57, 68, 72).

The authors state that some items belong in more than one subscale.

Validity: A pilot study identified the sorts of areas in which items would be written. 157 students listed the factors having an effect on their choice of a major field of study in college.

Reliability: Cronbach alpha, by field of study, ranges from .75 to .87.

Analysis

Cognitive items: (56) All but 20 items are cognitive items.

Value items: (17) 1, 6, 11, 13, 21, 24, 28, 30, 32, 38, 42, 43, 44, 50, 56, 59, 76.

Attitude items: (3) 5, 29, 75.

View of science: None evident.

Additional characteristics: Ambiguous item, 73.

Research Studies

Tamir, P., Arzi, A., and Zloto, D. (See above)

157 grade 12 students were sampled. Statistically significant (positive or negative) mean attitude rating compared with the norms were found for the following subscales: 1, 17 out of 25 items; 2, 20 out of 44 items; 3, 8 out of 12 items; 4, 6 out of 7 items. Grade 12 students appear to have more realistic attitudes than grade 11 students. Statistically significant differences were found between boys and girls on 20 of the items.

Hofstein, Avi, Ben-Zvi, Ruth, Samuel, David, and Tamir, Pinchas. Attitudes of Israeli high-school students toward chemistry and physics: A comparative study. Science Education, 1977, 61, 259-268.

The Physic Attitude Scale was modified for chemistry, and both scales were administered to grade 11 and 12 physics and chemistry students. (N=300) 45 of the items on both scales correlated significantly. Girls had a more positive attitude toward the study of chemistry and toward chemists than boys. Student attitudes toward chemistry are more positive than their attitudes toward physics.

Commentary

The overlap of items in the subscales suggests that factor analysis might be a useful tool for resolving the question of the validity of this scale. The large number of cognitive items suggests that the scale may not be assessing attitudes.

Items of the Tamir, Arzi and Zloto Scale*

1. A good physics laboratory is essential to the study of physics.

2. High school physics leaves many areas uncovered.

3. Physics requires a high level of commitment and devotion.

4. Grades in physics have no effect on future career selection.

5. Physics is dangerous.

6. Physics is one of the key professions in the 20th century.

7. Training physicists costs a lot of money to the State.

8. Only able girls choose to study physics.

9. Most physics graduates turn to research.

10. Physics interferes with political activities.

11. Physics should not be a compulsory subject in high school.

12. Participation of physicists in international conferences contributes to the establishment and promotion of external relationships of the State.

13. Physics is not necessary to society.

14. We need many physicists to develop modern weapons.

15. A physicist has many opportunities to get acquainted with important people.

16. Physicists have made significant contributions to mankind.

17. A research physicist is regarded more highly than a physics teacher.

18. High school physics does not reflect the latest developments in physics.

19. Success in physics depends on mathematical ability.

20. Professional progress in physics requires cooperation among physicists.

21. A physics teacher finds his work more rewarding than a research physicist.

22. Important physicists of today will be forgotten in the future.

23. A physicist has frequent opportunities to travel abroad.

24. Team work in physics laboratories is essential.

25. Physics interferes with the family life of physicists

26. Studying physics requires special talents.

27. Physics is a prestigious profession.

28. A physicist works more hours than a secretary.

29. Physics is boring.

30. Physics is essential prerequisite to the study of other natural sciences.

31. A physicist who does not make discoveries will not have satisfaction in work.

32. Physics lessons at school are more boring for girls than for boys.

33. Unsuccessful research physicists become teachers.

34. Most physicists turn to research because it pays well.

35. The State of Israel needs many physicists.

36. The talents of a physicist helps in political promotion.

37. Boys do not like girls who study physics.

38. Lectures are the most efficient way to study physics.

39. Physicists become famous only after many years of work.

40. Most famous physicists were Jews.

41. The number of years required to obtain an academic degree in physics has a strong effect on the selection of physics as a career.

42. Physics is a worthwhile hobby for a high school student.

43. Physics make significant contributions to the State.

44. Physicists are the central personalities in social events.

45. Physicists have no influence on the external relationship of the State.

46. There are limited job vacancies for physicists.

47. Only a few girls elect physics as a field of study.

48. Physics teachers make significant contributions to the formation of attitudes toward physics.

49. A research physicist is regarded by society more highly than an engineer.

50. The status of a physics teacher is higher than that of a physicist.

51. Physicists work under hard conditions.

52. Parents have usually no effect on the attitudes of students towards physics.

53. Physicists are satisfied as they become famous.

54. A famous physicist is also a wise politician.

55. Electing a physics career depends on finding a school not far from home.

56. Too many hours in high school are devoted to physics.

57. The nature of girls drives them away from physics.

58. The State has to promote the study of physics by awarding scholarships.

59. Every high school graduate needs some knowledge of physics.

60. Most physics graduates become teachers.

61. It is impossible to study physics without actually working in the laboratory.

62. Physics is a highly profitable occupation.

63. It is impossible to succeed in physics without having a broad mathematical facility.

64. The work of a physicist interferes with his fami life.

65. Physicists become famous more easily than engine

66. Physics is considered a difficult field of study

67. Many physics graduates change their occupation.

68. Physics is a masculine subject.

69. Physicists are narrow-minded people.

70. Only few industries in Israel occupy physicists.

71. Teachers have no effect on the formation of stud attitudes toward physics.

72. Beautiful girls do not elect to study physics.

73. Only few good physicists become teachers since teaching is not a popular occupation.

74. The physicist's way of thinking is very helpful politics.

75. Physicists are interesting to talk with.

76. History of physics is an important component of physics studies.

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TILFORD

ATTITUDE TOWARD SCIENCE SCALE

Michael P. Tilford. Toward the development of an instrument to measure the attitude toward science of negro students: A research report. School Science and Mathematics. 1973, 73, 367-372.

Instrument characteristics

Format:	21 item Likert scale.
Population:	Black college students.
View of attitude:	Not stated.
Subscales:	Not identified.
Validity:	Items were gathered from the statements of black science professors.
Reliability:	For 195 students, an alpha coefficient of .7715 is reported for an original scale of 35 items. The final scale of 21 items has a reliability of .8074.

Analysis

Cognitive items: (4)	7, 8, 17, 20.
Value items: (1)	3.
Attitude items: (10)	1, 5, 10, 12, 13, 14, 15, 16, 18, 19.
Self-Report Dispositions:	2, 4, 6, 9, 11, 21.
View of science:	None evident.

Research Studies

Tilford, Michael Phillip. Factors related to the choice of science as a major among negro college students. Unpublished Ed.D. Dissertation, Oklahoma State University, 1971. (DAI: vol. 33, p. 5970)

1006 students at three predominantly black institutions in Alabama, Oklahoma, and Texas were surveyed for a large number of variables, the attitude instrument being a small part of the questionnaire. There was a significant difference in attitude between science majors and nonscience majors.

Tilford, Michael P. (See above)

When the scale is administered to 195 college students, it is found that the attitudes to science of blacks is similar to that of whites.

Commentary

A portion of this scale taps career interests, another taps enjoyment of science classes, and so on. The validity of the instrument is doubtful and it clearly has not been established.

Items of the Tilford Scale*

1. The work in science is very interesting.
2. I have the ability to do successful work in science.
3. I think I could make more money in a field other than science.
4. I have a strong aptitude for science.
5. I cannot afford the time and money it would take in preparing for a science occupation.
6. My personality is not suitable for work in science.
7. My parents would approve of my going into science.
8. I couldn't major in science because I didn't take the proper courses in high school.
9. Science is not challenging enough for me.
10. I find science courses very interesting.
11. Professors and teachers in science encouraged me to go on in this field.
12. I admire my science teachers as persons; not just as teachers.
13. Science teachers are too square for my tastes.

14. Science teachers are inspiring.

15. Science courses are dull.

16. Science work is monotonous.

17. Scientists are keenly intelligent.

18. Science teachers are stuffy.

19. I have enjoyed the science courses I've taken.

20. Scientists must do very precise work.

21. My high school science courses provided me with a good science background.

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WEINHOLD

SCIENCE ATTITUDE INVENTORY

John Donald Weinhold. An attempt to measure the scientific attitudes of elementary school teachers. Unpublished Ed.D. dissertation, Ball State University, 1970. (DAI: vol. 31, p. 1647)

Instrument characteristics

Format:	61 "Agree-Disagree" items, and 9 "Enough evidence-Not enough evidence" items.
Population:	College students in elementary education. Generally for adults.
View of attitude:	"An attitude is a stabilized mental set which expresses itself in a tendency to react to a member of a class of stimuli in the same general way." (p. 7). "A scientific attitude is an attitude which will tend to foster scientific achievement. That is, (1) any addition to the world's store of organized truth, (2) any addition to an individual's store of organized truth, (3) any use of organized truth as a basis for determining action."
Subscales:	Not identified explicitly by the author.
Validity:	The original items were examined by a panel of 3 science educators. Internal criterion measures applied to the forms B and C, administered to 791 seniors in elementary education, to yield the 70-item instrument. Average item validity index is .29.
Reliability:	Range of reliabilities, split-half, .65-.73.

Analysis

Cognitive items: (22)	1, 2, 4, 5, 8, 9, 10, 12, 13, 18, 23, 31, 33, 34, 39, 43, 48, 49, 54, 56, 58, 61.
Value items: (7)	6, 11, 19, 22, 46, 47, 52.

Tests of Possession-Intellectual Skills: (9)	62, 63, 64, 65, 66, 67, 68, 69, 70.
Tests of Possession-Dispositions: (32)	3, 7, 14, 15, 16, 17, 20, 21, 24, 25, 26, 27, 28, 29, 30, 32, 35, 36, 37, 38, 40, 41, 42, 44, 45, 50, 51, 53, 55, 57, 59, 60.
View of science:	Explicit - Instrumentalist, items 4, 40, 43.
	Realist, item 34.
	Implicit - Instrumentalist, items 8, 11, 18, 25, 33.
	Realist, items 5, 17, 51, 52.
Additional characteristics:	Ambiguous item 22.
	Awkward items 17, 19, 32, 44, 57.

Research Studies

Weinhold, John Donald. (See above)

The scale was administered to 224 college students in 5 different elementary education classes. The mean score is 33.52, and average item difficulty is .74.

Commentary

48 of the 70 items tap dispositions and intellectual skills. That is, they are measures of scientific attitudes and not attitudes to science. Given this and the fact that no attempt is made to establish the validity of the scale, it is clear that the instrument is of little value.

Items of the Weinhold Scale*

Note: No instructions for scoring are provided.

DIRECTIONS: If the statement is one with which you can agree without reservation, mark the answer sheet "A" for agree; otherwise mark the answer sheet "D" for disagree.

1. There are more problems in science unsolved than solved.

2. Scientists are usually so busy working on scientific problems that they generally are not involved in doing fun things.

3. There is some evidence that spirits have returned from the dead.

4. Science is the work of human beings.

5. Most good church members believe that science is "anti-God."

6. A scientific way of thinking would be helpful to any person in the solving of his problems.

7. Large families have closer family ties than small families.

8. The <u>more important</u> fundamental laws and facts of physical science are so firmly established that the possibility of their ever being replaced by new basic discoveries is exceedingly remote.

9. In order for a student to receive an "A" in science, he should be able to perform successful experiments to prove he has learned the relevant facts.

10. The process of science requires a systematic way of thinking.

11. Scientists should be willing to change their ideas when new evidence is found.

12. The main reason for using experiments in science is to create an interest in science.

13. The thrill of discovery is a motivating factor in scientific work.

14. Girls who wear short skirts in cold weather get heavy legs due to an increase in fat layers.

15. Italians are "hot-blooded", lusty people, for the most part.

16. It is possible to communicate with the dead.

17. Evolution is an idea of the unbeliever in God.

18. Scientists work from the basis that nature is orderly rather than disorderly.

19. The scientists, in our technological society, is a very important class of men in shaping the lives and work of men.

20. No matter how an experiment comes out, the results are always what is supposed to happen.

21. Short, fat people tend to be very jovial.

22. Learning scientific facts is useless since when they are needed they can't be remembered.

23. Useful hypothases can result from inspiration or just plain guessing.

24. The members of the Negro race generally have a better natural sense of rhythm than members of any other race.

25. The statement: "That may be all right in theory, but it will not work out in practice" is basically incorrect since a theory is "all right" only if it does work out in practice.

26. The electricity produced from the energy of a nuclear reactor is otherwise no different than the electricity produced from other sources.

27. Other planets may have life on them.

28. Since lightning is usually followed by a loud clash of thunder, one may conclude that lightning causes thunder.

29. Since the sun is a source of energy, a plant left in a dark room will not live.

30. Blonds do have more fun.

31. The work of a scientist requires creativity.

32. If, when a can with a little water in it is heated until steam comes out, is capped, taken off of the heat, and collapses, the presence of air pressure is proved.

33. Present scientific theories and hypotheses have largely evolved from old theories that have ceased to be satisfactory.

34. Science is primarily a means of finding out why things happen as they do.

35. People with red hair often have bad tempers.

36. A person's IQ (intelligence quotient) is generally a fixed quantity.

37. If a scientist carries out an experiment properly and it does not result in what he had predicted, the experiment is of doubtful value.

38. While working toward finding a solution to a problem in a science class, you notice that those around you are all approaching the solving of the problem in a process different from yours. You should continue to use your method to solve the problem.

39. In general, scientists rarely appreciate or enjoy music and the arts.

40. A scientific law can be refuted.

41. If, in making a generalization, a class draws a conclusion which is correct, the activity should be considered a success.

42. Girls with freckles have a tendency to be tomboys.

43. The laws of nature "discovered" by science are merely mathematical or mechanical descriptions of <u>how</u> nature behaves, not <u>why</u> or <u>what</u> nature "actually" is.

44. A square jay indicates a strong will.

45. The more successful a person is, the more illegible is his signature.

46. The research being carried out in the space program is of great importance to science, but the usefulness to the average man is questionable.

47. It is necessary, and proper, for scientists to try to give explanations of matters about which they are uncertain.

48. Scientists are often motivated by curiosity.

49. The main task of scientific work is to find facts.

50. Children lose their natural curiosity as they grow older as part of normal development.

51. When a scientist has established a theory, we may say that he has moved us closer to absolute truth.

52. A theory must be true before it is taught.

53. Cancer is hereditary.

54. Improved functioning of democratic forms of government may depend in a major way upon the adoption of scientific attitudes toward the solution of all problems.

55. In order to consider an experiment valid, one ought to consider the qualifications of the person performing the experiment.

56. Science is understandable only to scientists.

57. Scientists, since they all use the Scientific method, should generally agree on most everything concerning science.

58. Scientists receive much personal satisfaction from their work.

59. Lightning never strikes in the same place twice.

60. People who wear glasses read more books than people who do not wear glasses.

61. Science helps us to control our environment for our benefit.

DIRECTIONS: If you feel that the information given in the paragraph is sufficient to support the conclusion, mark the answer sheet "E" for enough: otherwise mark the answer sheet "NE" for not enough.

62. Sue's friend had a headache and red spots all over her skin. Her friend went to the doctor and was told that she had the measles. Later that day, Sue discovered that she had red spots on her arms and hands. Conclusion: Sue ought to see a doctor.

63. A slightly rusted nail is placed in a glass filled with soda pop. Almost immediately the nail appears to be eaten away by the liquid. Conclusion: Soda pop is probably harmful to one's stomach.

64. When a tornado hit Elmtown, Illinois, last year, a roaring sound was heard previous to sighting the tornado. Conclusion: If one hears a similar sound he should seek cover from the tornado.

65. A robin builds a nest in a tree. You observe the robin sitting on the nest. After several weeks you notice the robin bringing food to the baby birds. Conclusion: It is very highly probable that the baby birds are robins.

66. Group A, students, did exercises of 50 pushups, 50 situps, and ran three times around the track. Group B also did 50 pushups and 50 situps, but did not run around the track three times. Group A scored higher on their physical fitness tests. Conclusion: The higher score of Group A was due to the additional exercise.

67. Lamarck's theory of inheritance of acquired characteristics was widely accepted, but has not been demonstrated experimentally. Many experiments have been designed to test Lamarck's theory which have failed to indicate that acquired characteristics may be inherited. Conclusion: Lamarck's theory served a scientifically useful function.

68. The class discovered that magnets will attract objects made of iron or steel. A magnet will pick up Betty's hair clip. Conclusion: The clip must be made of iron or steel.

69. In a class demonstration, a lighted candle in a dish with water in the bottom is covered with a closed tube. Some bubbling is noted at the base of the tube. Vapors are visible in the tube as the candle goes out. After the candle goes out, water rises in the tube. Conclusion: Air is made up of a fraction of oxygen which is burned up by the candle before it goes out.

70. A student places two pieces of bread in separate sealed containers. The one is placed in sunlight, the other in darkness. After four days, there is mold on the piece of bread placed in sunlight, but no mold on the bread that is in the dark. Conclusion: Mold needs light to grow.

WITHEY

SCIENCE AND SCIENTISTS

Stephen B. Withey. Public opinion about science and scientists. Public Opinion Quarterly. 1959, 23, 382-388.

Instrument characteristics

Format:	12 "Agree -- Disagree" statements.
Population:	Adults.
View of attitude:	Not stated.
Subscales:	Science, items 1-6.
	Scientists, items 7-12.
Validity:	Not stated.
Reliability:	Not stated.

Analysis

Cognitive items: (6)	4, 5, 7, 8, 10, 11.
Value items: (5)	1, 2, 3, 6, 12.
Attitude items: (1)	9.
View of Science:	Implicit -- Realist, item 10.

Research Studies

Withey, Stephen B. (See above)

A positive understanding of and attitude toward science and scientists is reported.

Commentary

With so little information available about this instrument, it is inappropriate to make any commentary.

Items of the Withey Scale*

1. Science is making our lives healthier, easier, and more comfortable.

2. One of the best things about science is that it is the main reason for our rapid progress.

3. One trouble with science is that it makes our way of life change too fast.

4. Science will solve our social problems, like crime and mental illness.

5. The growth of science means that a few people could control our lives.

6. One of the bad effects of science is that it breaks down people's ideas of right and wrong.

7. Most scientists want to work on things that will make life better for the average person.

8. Scientists work harder than the average person.

9. Scientists are apt to be odd and peculiar people.

10. Scientists are not likely to be very religious people.

11. Most scientists are mainly interested in knowledge for its own sake; they don't care much about its practical value.

12. Scientists always seem to be prying into things they really ought to stay out of.

*Reproduced with permission from Public Opinion Quarterly, 23: 382-388, 1959.

APPENDIX M

SOME RECENT STUDIES RELATED TO ATTITUDES TO SCIENCE

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Cornett, L.M. A study of the relationship between the Elementary Science Study (ESS) and attitudes toward science of urban sixth grade students. Unpublished Ed.D. dissertation, University of Rochester, 1981. (DAI, 42, 3532-A)

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Dapper, J.W. Predictions of attitude towards science among undergraduate nonscience majors. Unpublished Ph.D. dissertation, University of Southern Mississippi, 1978. (DAI, 39, 5429-A)

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