# COMPARATIVE EVALUATION OF DIFFERENT METHODS FOR THE ASSESSMENT OF ATTITUDES TO SCIENCE

A thesis submitted for the degree of

Doctor of Philosophy of the

University of Keele

Tony Ralph Rickwood

September 1984

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## ABSTRACT

In the field of science education a considerable degree of confussion has existed over specifying appropriate constructs and assessment techniques to ascertain measures of a pupil's attitude towards science. In a conceptual analysis of the items from a representative sample of attitude assessment instruments ten attitude dimensions were identified. These dimensions reflected personal aspects of science attitude and interest, difficulties with science, the social implications of science and the nature and working of science and scientists. These were examined empirically on a range of attitude measurement techniques identified from the review of the literature. These techniques included the Likert, Semantic Differential and Forced Choice formats with newly developed measurement instruments, in the form of a Free Response Structured and Open Response Situation questionnaires. A teacher - pupil assessment instrument based on a repertory grid technique was also developed for comparative purposes.

The empirical study involved 1200 pupils selected from the second year of secondary education. A precise and detailed programme of analyses was prescribed to allow comparative data to be reviewed. Each questionnaire was initially analysed independently. The overall analysis of the results indicates that three perceptions are prominent to pupils of this age:

(a) Personal attitude toward science and interest in science related activities and careers,

(b) Personal characteristics of a scientist and

(c) The Social implications of science on society.

In the comparative evaluation of the different assessment methods the Likert questionnaire produced the most reliable and valid scales to assess these perceptions. The performance of the Free Response technique indicated considerable potential for further development.

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# COMPARATIVE EVALUATION OF DIFFERENT METHODS FOR THE ASSESSMENT OF ATTITUDES TO SCIENCE

## CHAPTER ONE INTRODUCTION

The introductory chapter will introduce the main areas of discussion and then follow through by describing the specific contribution the present study will contribute.

(1) In the field of attitude research there exists a degree of divergence of views and opinions over the nature of attitudes. The range of opinion that exists over the nature of attitudes has failed to produce a clear conceptual base on which the measurement of attitudes can be based. Psychological measurement should reflect clear concepts if it is to be of any real value. Both in terms of the interpretation of the results from a particular test instrument and for comparative purposes with other variables under study.

Within the field of the assessment of attitudes to science there is a similar deficiency with respect to an established conceptual base. This had lead to numerous constructs being employed in attempts to ascertain measures of attitude to science. Some of these constructs have been identified by research workers as possible components of a wider attitude dimension. The majority of instruments however have been developed with no clear conceptual structure and have relied upon the individual research worker's particular view of what constitutes attitude to science. Preliminary examination of individual items belonging to such instruments immediately points to a wide ranging perception of what has been considered as possible components of attitudes toward science. To what extent the instruments can be said to have any degree of commonality is by no means clear. The range of instruments and an overview of the constructs employed will be considered in Chapter 2.

It is important therefore to establish before proceeding any further in this field clear constructs of attitudes toward science.

The first aspect of this research study will concern itself with the identification of constructs employed in attitude to science measurement instruments. This identification will take the form of a conceptual analysis of the items which make up the measurement instruments. In this way the operational constructs which the instrument attempts to measure can be obtained. These constructs can then be carefully defined and organised into a structure whose nature reflects the range of attitude constructs employed in the assessment instruments in this particular field. This analysis will be considered in Chapter 3.

(2) Research into pupils' attitude to science, as with attitude research in general, has involved the use of a number of different measuring techniques. Investigators have generally selected the most appropriate technique available and developed a scale accordingly. The most appropriate technique usually being a form of questionnaire, of the Likert type, where new items relevant to the study are developed generally without thought to the suitability of the instrument. A number of approaches can be identified as distinctly different in attitude studies. The question as to the suitability of different techniques for the assessment of constructs related to science is one which has been rarely raised. Rather it has been assumed that any one technique is as appropriate as another for assessing the range of possible constructs. For example: little thought has been given to the development of forced choice techniques or to the detailed use of open ended questionnaires. There has also been no consideration as to the suitability, or otherwise, of these techniques across very different attitude constructs.

The second aspect of this study will examine the suitability of a range of representative measurement instruments to assess the operational constructs specified in the first part of this study. This examination will be essentially theoretical in nature and will attempt to relate clearly the use of a particular technique with the constructs to be examined. This aspect is considered in Chapter 4.

(3) The identification of operational attitudinal constructs and the selection of appropriate measurement techniques achieved in the previous stages of the study will propose test instruments that have at least a face validity. In the light of earlier comments it is essential that such an analysis is carried out for any measurement instrument. It is equally important that such instruments have also undergone empirical validation with a suitable population. A field study using a suitable school based population was undertaken. This study and the subsequent statistical analyses of the data formed the third aspect of the research study. The initial purpose of this field study will be to obtain a form of psychological validation of the prescribed attitude constructs with respect to the assessment technique employed. The construction of the new test instruments for use in the field study will be dealt with in Chapter 5.

(4) The measurement of attitudes to science has predominantly focused on the use of self report techniques. These techniques of self evaluation have relied on the premise that they are a valid report of the pupil's true opinions. They are however open to falsification either deliberately or through the pupil feeling obliged to present a favourable impression to the teacher. Rarely have the teachers themselves been employed to produce an assessment of student attitudes although they are in a favourable position to assess. An assessment by the teacher could form a useful method of comparison with pupil completed instruments and, if reliable, a very quick and efficient assessment procedure. There are problems however with teacher based assessment. The teachers assess within a specific context and a particular characteristic such as attitude to science is also likely to be related to a number of pupil characteristics

such as ability and personality which are difficult to allow for in a global assessment. Consideration would have to be given in the use of teacher based assessment to these points.

A further aspect of the research study will be to investigate the potential of a teacher based assessment instrument and to compare its function with standard self report techniques. This will specifically involve a survey of teacher assessment in the classroom context using a repetory grid technique to establish the domain of assessment, the definition of the main characteristics and the relationship between them. A suitable assessment instrument can then be constructed which will enable comparisons to be made of teacher based assessment of attitudinal characteristics and pupil based techniques. The development of this instrument is considered in Chapter 6.

It is the aim of this thesis to produce theoretical analysis and statistical evidence in direct connection with the four issues raised in the preceding text. At this stage it is however important to consider how current analytical methods will facilitate the statistical analyses in particular as this will clearly affect the organisation of the field study and subsequent analyses.

The reliability and validity of operational constructs established through the analysis of empirical data using techniques such as correlation and factor analysis is an important aspect of current educational research. It is usual to assume that the technique employed is suitable for facilitating a measure of assessment and that any weakness in reliability or validity of the prescribed constructs is due primarily to a lack of firm psychological base. There is no clear evidence to support this view and in this study it is very important not to make such an assumption. The reliability and validity of the operational constructs used should be regarded as a function of the instrument itself as well as the construct used. It is important to emphasise this point. The response to a questionnaire is dependant not only on the particular item, and its underlying construct, but also on the nature of the instrument itself. These two factors are interwoven to such an extent that it is not possible to separate them entirely. Empirical analysis of the responses will examine the assessment of identical constructs on different techniques and the appearance of similar psychological constructs on different techniques. It is then possible to examine the assessment of identical constructs for test dependence or independence and perhaps to establish the existence of common constructs and their most appropriate form of assessment.

The essential nature of this aspect of the study will be a comparative analysis of the different methods of assessing attitudinal constructs.

This approach will be reflected both in the organisation of the empirical study, Chapter 7 and in the analysis of the results in Chapter 8.

A discussion of the results from this research study and a consideration of the implications for further research are to be found in the final chapter.

# CHAPTER TWO

## REVIEW OF THE LITERATURE

Over previous years, research in the field of science education has seen a proliferation of scales developed to measure non-cognitive aspects of pupils' behaviour. In particular, attention has focused on pupils' attitudes to science. The research work undertaken here concerns itself with the classification and assessment of secondary school pupils' attitudes to science.

Research into attitudinal characteristics has formed a mainstay of social psychology for over fifty years. The intervening time between the pioneering work of Thurstone and Likert (Thurstone (1927-29) and Likert (1932)) on attitude measurement has witnessed investigations into the measurement of many attitudinal characteristics or traits. A number of these have studied pupils' attitudes to various school based subjects (Silance and Remmers (1934), Reed (1939) and Hashim (1948)). Attitudes towards science as a separate interest came under consideration in the 1950's together with the related area of interest in science (Webb (1951), Vallance(1952), McCalman (1954), Allen(1959), Kelly (1959) and Meyer and Penfold (1961) amongst others). The growth in the development of scales to assess pupils' attitudes to science in recent years has been in response to a number of factors directly connected with the teaching of science in this country. These have effectively followed developments in North America. The importance of these factors gives an indication of the need for detailed empirical research in this area and a brief review is considered here.

Two major factors should be considered:

(a) the concern over the falling enrolment numbers in science and technology courses, and

(b) the development of new curricular materials in the field of science education.

The major factor of these two is probably the second as the necessity for curriculum evaluation has had an important effect on research. Firstly, the concern over the 'swing from science'. The publication of the Dainton Report in 1968 (Dainton, 1968) drew attention to the possible future shortage of scientists and technicians and the apparent inability of the schools to provide them. The report indicated in part that poor or negative attitudes of the pupils towards science were a possible explanation for the trend in pupil choice away from the study of science. Although this is rather a superficial view, the presence of this 'attitude factor' led to increasing efforts to measure attitudes to science and to ascertain their nature (Duckworth (1972) and Gaskell (1972)). Three particular aspects of attitudes emerged from this work. The first was the perception of the difficulty of the physical sciences amongst pupils, second the emergence of a science interest and attitude dimension and third, the concern amongst pupils for the social implication of science. Similar concerns in America had already lead to the investigation of student's attitudes to science and scientists, particularly in the context of the social implications of science in society. The work of Mead and Metraux (1957) had alerted educators to the poor perceptions students had of scientists. It was indicated that the unfavourable image of science, in terms of its danger to society in the forms of say, atomic warfare and industrial pollution, were the important factors in an overall negative attitude to science (Mead and Metraux (1957)). This area became extensively researched (Belt (1959), Champlin (1970) and Steiner (1971) amongst others). This factor has been examined and refined into some detail by Ormerod in this country (Ormerod (1971 and 1976)). He demonstrates that the social implication facet of attitude measurement is empirically valid and is important in student selection of subjects.

The second area noted concerned the upsurge in curriculum development related to science subjects. The late 1950's brought an increasing concern for the nature of science teaching in both the countries of Britain and America. The educators were concerned to specify aims and objectives for science teaching and to develop these aims and objectives in new science courses. Within these aims there was an increasing reference to non-cognitive aims and their importance within any science course (Sears and Kessen (1964) and Rogers (1972)). Attitudinal goals were often specified in terms of, for example, the personal satisfaction and enjoyment a student should gain from following a particular course of study and the favourable attitude a student should possess towards science. Invariably, these aims were never specific. The importance placed upon them prompted research however and a number of studies examined the relationship between the student's attitudes to science and the effect of a new curriculum upon them (Laughton and Wilkinson (1970), Feerst (1973),and Fisher (1973) Kempa and Dubé (1975) amongst others.)

This period also saw research into the presence of certain scientific attitudes amongst studies which the new courses were attempting to encourage (Haney (1964), Diederich (1967) and Schwirian (1968)). The nature of scientific attitudes should be seen as being clearly distinct from the work concerning pupils' attitudes to science. A scientific attitude is in essence a characteristic displayed by a scientist in the pursuit of his work, for example, 'curiosity' or 'honest'. Unfortunately a number of studies have not maintained a clear distinction between the two areas and some confusion arises in what an instrument is actually measuring. (Selmes (1971) and Wilmut (1971).

Despite these factors encouraging research in the field of attitudes to science, little direct thought was given to the conception of attitudes that was being used. It has already been indicated that attitudinal aims in science teaching were often vague and that there was some confusion over the terms 'attitudes to science' and 'scientific attitudes'. The majority of researchers based their work upon a very general definition of attitude incorporating but not distinguishing a number of relevant facets. A number did pursue techniques to validate empirically their measuring instruments and so developed a series of specialised scales to measure particular aspects of attitudes (Ormerod (1976), Skurnik and Jeffs (1971) and Duckworth (1972)). To what extent the instruments had any degree of commonality was never clear.

Gardner who has criticised many aspects of research in attitude measurement in science education has said:

> "Numerous instruments are now available to measure attitudes to science. To what extent do they actually measure a common construct?"
>
> (Gardner (1975), page 31).

It appears from various attitude scales that attitude to science consists of factors associated with the appeal of science, interest in science, the difficulty of science and the perception of science and its implications for society. The fundamental question concerning the actual characteristics of 'attitude to science' has been left without serious consideration, such that the title 'attitude to science scale' could be a scale which covered any one or any combination of the different factors above. Above all this reflects serious doubt upon the direct comparisons of results from differing attitude scales. A large body of information has been accumulated on attitudes and various other characteristics such as intelligence and personality. Previously all attitude scales have been assigned the same meaning or value, could this now be justified? It is important therefore to establish before proceeding any further clear constructs of attitudes to science and to establish their operational validity.

The research into pupils' attitudes to science has involved the use of a number of different measuring techniques. Investigators generally selected the most appropriate technique available and developed a scale accordingly. It is known that different techniques have different advantages and disadvantages (Oppenheim (1966)). In the Likert technique for example (Likert(1932)), the respondent indicates his agreement or disagreement to an attitude statement on a five point scale. A direct response to a direct question. This can be contrasted to, say, a word association technique (Lowry (1966))which offers the respondent three opportunities to reply freely to a stimulus word. Which technique provides the most appropriate and reliable measure of a pupil's attitude to science? It has been argued generally but never extensively empirically researched in the area of attitudes to science. It may be that different techniques will suit different conceptions of attitude. The enjoyment of science may well be measureable on a simple scale but can the same be said of perceptions of science in society.

Measurement techniques themselves are clearly described and considered on a number of standard references (Oppenheim, (1966) and Edwards (1957)). The suitability of these techniques as assessment procedures for attitudes to science is an area lacking in detailed research. It is also important to realise that the consideration of the operational constructs of attitudes to science is inevitably bound up with the nature of the measurement technique used.

The two major areas concerning the nature of the constructs measured and the nature of the instruments used were the starting points of this review. Establishing the range of constructs apparently employed and the range of the techniques used was seen as important background to this study. In the first section of the review the range of measurement techniques which have been employed to assess attitudes in the context of educational research are considered and specified. The second section of this review considers the attempts that have been made to specify distinct attitudinal characteristics and to establish a broad overview of the domain of attitudinal assessment. In this section consideration is also given to the problems which have arisen in the construction and application of attitude test instruments.

In recent years this area of research has been fortunate in the provision of global reviews of attitude assessment (Ormerod with Duckworth, (1975)) and in critical reviews of the measurement of attitudes towards science (Gardner, (1976)). It is the intention of this review to draw particular attention to the types of attitude instrument employed and the constructs emerging from the instruments used and not to review the entire field of attitudes and related assessments. It is also the intention of the review to highlight the defects of approaches to attitudinal studies particularly in the construction and analysis of attitude scales.

## Section 1 : Techniques of Attitude Assessment

In an attempt to review the range of techniques employed in attitudinal studies an initial computer based search was instigated using the Educational Resources Information Centre in America. In response to the search words 'ATTITUDE TESTING' an initial total of 37,065 references were suggested. Fortunately when the search was further refined to include specific science attitudes within the school sector this registered only 158 specific references. Within these references and others, not yet registered, surprisingly few different techniques overall had been adopted as assessment methods. In this section consideration is given to the major techniques identified. The methods are discussed in terms of their basic approach to attitude measurement. In this review the techniques are grouped under three main headings

(a) Self Report Scales

  (i) Summative Rating

  (ii) Semantic Differential

(iii) Forced Choice Rating

(b) Differential Scales

Thurstone's Technique

(c) Projective Techniques

As with any classification of instruments there will be some overlap between categories and this grouping is more one of convenience rather than strict classification. A number of techniques which have been employed to assess student attitudes without recourse to direct attitudinal measures, such as enrolment data and observational techniques, lie outside the immediate scope of this review. These additional methods have however received some consideration in the selection of techniques for the main empirical study.

(a) Self Report Techniques

The range of techniques in this section primarily concern themselves with the pupil relating via an attitude item a direct rating or report of their particular attitude position on a presented scale.

The term summative rating is a general description which can be applied to most attitude instruments used in this field. It has been general practice in the past to add the responses to a number of attitude items to produce an overall score on a particular scale. The technique of assessment most closely associated with this approach has been the Likert technique (Likert, 1932). This technique consists of a number of attitude statements which are designed to reflect clearly positive or negative aspects of the attitude domain under consideration. These statements are then followed by a response scale which can have a varying number of categories for the pupils to indicate their particular level of agreement or disagreement. These categories can be as simple as 'yes' and 'no' or, a more popular response, strongly agree, agree, neutral, disagree and strongly disagree. This pattern of responses is usually scaled with each response being assigned a weighting. In the case of the five category response this could be 5 through to 1 or +2 through to -2. For all the statements concerning a particular attitude domain the pupil's score is then the total sum of all the scaled responses. In the development of tests from this technique, trials are usually undertaken and a selection of items made from statements whose responses show a high degree of correlation with one another. The intention of this was to produce a unidimensional scale. Full details of this technique are well reported (Oppenheim, 1966).

This particular technique has provided the mainstay of attitude research in science related domains. Over ninety Likert type instruments were identified from the initial survey. These ranged from early attempts in this field by Archer (1951), and Muthulingham (1963), who attempted simple measures of attitudes to science, to the multi scale type assessments of Skurnik and Jeffs (1971), Brown and Davis (1973) and Fraser (1977). The technique has undergone modifications . Some investigators have replaced the response section with apparently equally spaced statements reflecting the pupil's expressed view. The overall item appears very much like a multiple choice item, (Bolt(1959)and Chaplin (1970)), although it is difficult to distinguish this from a forced choice multiple completion type of item when wide ranging statements are used. Judges have also been employed to ascertain the suitability of the items before pupil responses have been considered, (Brown and Davis (1973) and Gardner (1972)). This would add a useful phase to the planning and construction of a questionnaire. Statistical analyses have undergone many advances. Initially the concept of producing a single unidimensional scale occupied the prominent position in the analytical work. Guttman,(1950) through techniques such as scalogram analysis, attempted to refine questionnaires so that they represent one clear dimension. Whilst admirable in intention, the reduction of data from a questionnaire to just one factor, despite its clear nature, is very limiting to the attitude concept. The overall effect of these procedures has been questioned in other ways. Ferguson (1952) has debated whether they do in fact produce significant improvements in attitude measurement techniques. By far the most important development has been the extensive use of both reliability and factor analyses in attitude scale construction and evaluation. These are evident in the major scale developments of recent years, (Gardner (1972), Skurnik and Jeffs (1971) and Ormerod (1976). The general importance of these techniques and their applications are considered later in this review.

In consideration of this area of the summative rating technique, a number of specific instruments such as interest inventories have been developed using this general format. Muthulingham (1963) attempted to measure four different aspects of interest in the second scale of his study. The technique has been developed to gain specific measures of interest in certain defined areas. It is not the only technique adopted in the area of interest inventories as both checklist type assessments (Skinner and Barcikowski, 1973) and forced choice type (Clarke, 1972) are in evidence in research work. It is important to note this particular range of assessments, however, as the two areas of interest in science and attitude toward science are sometimes taken together, either directly or indirectly, as one general domain. Interest inventories tend to be very subject specific and relate to specific activities whereas the attitude approach concentrates on the level of enjoyment derived from participation in science related activities. Attitudes can possess either favourable or unfavourable orientations whereas interests are only expressed as positive expressions. Gardner (1975) considers a number of instruments within his review. The review produces further classifications of interests, for example, Walberg (1967) was able to identify five dimensions of science interest relating to, academic, nature study, tinkering, cosmology and applied life. The development of such inventories using different techniques is of subsidiary value only overall as it represents an area of intense study of a particular area. The domain of science interest is recognised though as an area of valid assessment.

The Semantic Differential technique for attitude assessment developed from the research work of Osgood and his co-workers into the study of meaning. (Osgood et al, 1957). In this technique a word or phrase representing an attitude object is presented in conjunction with a pair of polarised adjectives describing an aspect of the object. These adjectives are usually part of a bi polar scale of five or seven divisions on which pupils place their respective position with regard to the attitude object. Such items as, school science interesting - dull and

science good - bad are typical.

Often a single attitude object is used with a number of bipolar scales. In this case the position on each of the scales, having been allocated a weighting, are added to present an overall score.

Initially this technique can be seen as emerging from the numerous rating scales developed to measure attitudes in the early American work (see Oppenheim (1966) for detailed examples). The development of the repertory grid technique of Kelly (Kelly 1959) which helped elucidate rating constructs and the work of Osgood noted above, have served to provide ample material for attitude based attitudes (Schibeci 1977). Factor analytic techniques have also been used extensively to refine these scales although the underlying dimensions of the scales tends to relate to the three factors identified by Osgood (Evaluation, Potency and Activity) rather than particular attitude objects. This is a problem which tends to make semantic differential scales more general in their application than, say, the Likert technique.

A further example of pupil self report questionnaire relates to the forced choice form of assessment. The ranking of various items of like or dislike is an area which is very often witnessed in our society. It is often asked of teachers to rank order their pupils. In terms of attitude assessment this area has been generally avoided partially, it seems because of the statistical difficulties involved in dealing with scores on ipsative measures. Interest inventories, noted earlier, have used this technique to ascertain clear preferences for interest areas. (Clarke, 1972). The concept has appeared in attitude instruments under the guise of a forced choice completion type item where a pupil needs to select a response from certain offered statements. (Belt (1959), Champlain (1970) and Coxhead and Whitfield (1975)). It must be noted that these research workers, particularly the first two noted, do not distinguish clearly between the type of technique they are actually using and the standard form of multiple completion. This is a useful technique and further discussion of its potential, is undertaken in a subsequent chapter.

A number of different approaches to this technique can be identified (Guildford, 1954). One approach uses a completion type technique where one item is selected from three or four to complete a phase. Another approach uses from two to four statements from which a preferred statement is chosen. A further version involves actual rank ordering the range of statements offered. Whatever the format, the construction phase involves obtaining groups of statements which all have similar acceptability to the respondent. This is usually obtained by a trial of the items where preference indices are calculated to indicate the attractiveness of a particular response. Statements should only be grouped together if they share a similar preference index. The work of Highland and Berkshire in selecting the most appropriate format for a forced choice technique is invaluable in initial considerations of this technique (Highland and Berkshire, 1951). The major conclusions from their work suggests tetrads of statements produce the most valid results providing that all the statements are of a favourable nature. In early work using scales of this nature to assess four areas of teacher performance, Remmers (1955) noted particularly that this technique overcomes the leniency tendency apparent with similar straight rating scales. Leniency in this context is the tendency for respondents to over rate items, in other words to rate highly to impress the test constructor rather than reflect strictly their own views.

(b) Differential Techniques

This type of technique was developed by Thurstone (1929). It is a questionnaire based technique in which statements reflecting the whole range of the attitude domain under consideration are presented to the respondent. The respondent selects those statements which are closest to his or her particular attitudes. Each of these statements has assigned to it a weighting. The respondent's total score on the particular attitude scale is usually taken as the sum of the weightings for those items selected. The weighting is the result of an extensive judging phase. The judges are employed to rate each item on a definite scale, which covers the whole of the attitude domain under consideration, of some seven or even eleven points. The final weighting is the mean value of all the values assigned to the particular statement by the judges. This phase not only produces an assessment of the'strength'of a particular attitude statement but also serves to have the item reviewed in terms of the proposed scale under construction. Thurstone's major concern was to produce an attitude scale which possessed equal intervals between the values on the scale. Considerable statistical analyses have been employed to further advance the possibilities of creating such a scale. The 'Q' value is one such measure (Oppenheim, 1966). In terms of the number of judges alone some conscientious workers have employed upwards of a hundred judges.

In the field of attitude research within the science education field a number of workers have used this method. Recent studies include those of McCalman (1954) Guthrie (1951), Dutton and Stephens (1963) and Newton (1975).

(c) Projective Techniques

The use of questionnaires which classify the constructs to be examined and specify the extent of the pupils response by using definite items has often been criticised. This is because such techniques use the constructors' own perceptions rather than those of the pupils they are designed for. Indirect or projective techniques have attempted to counter such criticism by allowing the pupils an open response to certain stimulus areas and classifying their responses. These responses, it is argued, uncover the hidden attitudes which are not revealed by ordinary pen-and-paper techniques. (Lowery, 1966) These techniques have their background in the field of clinical psychology where variations such as word associations, stimulus cartoons and sentence completion were developed as modes of eliciting open responses. In the field of science education the work of Lowery is the most notable. He used three forms of projective technique. Firstly word association; here one word is used as a stimulus and the pupil responding provides the first three words that occur to him or her. Secondly an apperception test; here a picture is shown and the pupil is given the opportunity to provide an interpretation. Thirdly a sentence completion test; in this form an incomplete sentence is provided for the pupil to complete. Whilst the responses to these techniques are open, Lowery nevertheless was able to scale the response in a simple form corresponding to pro-science, anti-science and neutral. He was able to show a reasonable relationship between each of the techniques but suggested that any assessment should incorporate all three methods. Further examples of the use of the sentence completion technique have been provided through the work of Perrodin (1966) and Mitias (1970). The potential of this technique is yet to be fully developed, particularly in the provision of adequate scaling methods of the responses elicited.

An important development in the area of this technique has been the work of Spada and Lucht (1977). They have developed a further method to assess pupil attitudes within the science field through a projective type technique called a situation test. In this test, items are presented as short stories in which the pupils discuss questions relating to the attitudes under consideration. The pupils react to these items by continuing the stories in their own words towards a conclusion reflecting their own personal attitude. The attitudes under investigation in their study related to the provision of nuclear power plants. They have developed a number of statistical treatments of the responses which are initially scored in terms of the response content. The initial results have proved very encouraging.

In this country the use of the situational technique has been explored in the work of Hadden (1975). Here, however, the aspect of free response has been replaced by a form of structured response which presents clear categories of possible response to the situation under consideration. It is possible that the use of such a scheme could incorporate the most important aspects required by all attitude testing, that is, a clear conception of what is being asked together with a clear assessment of the response of the pupil. The potential of this technique requires further development.

In this section a wide range of attitude assessment techniques have been reviewed and considered. Whilst the use of any technique could be argued, the comparative nature of these techniques has received little real consideration. The selection of one technique over another for a particular assessment can only be made on the basis of comparative testing of the techniques.

The early work of Proshansky (1943) reported the comparison of Likert and Thurstone scales. He noted that the two scales correlated well. Whether this finding has led to the construction of large numbers of the Likert questionnaire, this questionnaire being somewhat less time consuming in its construction than the Thurstone, is perhaps debatable. In a more recent study, Schibeci (1982) has provided a particularly relevant review of science based Likert and Semantic Differential questionnaires. Using instruments developed by Fraser (1978) as a representative of a multi-scale Likert instrument and a semantic differential instrument, also multi scale, developed by the author (Schibeci 1978), a comparison of the pupils performance on both instruments was undertaken. Although the correlations between the various scales on both techniques are significantly related to one another, like named scales do not have the highest correlations with one another. The author does not see the techniques as interchangeable. He recommends that general attitudes are readily assessed with the semantic differential instrument but that more specific attitudes should be assessed using the Likert questionnaire. In consideration of this conclusion, it should be noted that at the time of the comparison the individual instruments were not fully validated in terms, for example, of factor analytic methods.

Without the detailed comparison of validated instruments representing the various approaches, it is very difficult to recommend suitable instruments for the measurement of attitudes to science. In view of the lack of this information at present, it is perhaps advisable to adopt a number of different techniques rather than one in particular. This approach is reflected in some recent studies (Reid 1978). It is the intention of this research study to provide suitable analyses relating to this question to enable a more objective choice to be made.

## Section 2 The Assessment of Attitudes to Science

In the field of attitude assessment within the context of science, numerous instruments have been developed. As indicated in the introduction to this chapter many of these have employed constructs which reflect a wide range of conceptions of 'attitude'. In this section a number of these conceptions that can be identified explicitly from the research will receive consideration. Initially, however, some of the more important research issue. which have led to problems in assessing what an instrument actually measures are given consideration.

In a critical review of attitude measurement Gardner (Gardner, 1975b) has classified the defects in attitude technique construction into two clear areas. Firstly he identifies the absence of any discernible theoretical construct and secondly, the confusion of constructs or variables which occur on attitude measurement techniques. The appearance of these defects on recent attitude studies is described with clear examples which reflect the poor conception of measurement present in a number of studies. Essentially the review indicates that in the act of producing an attitude measure, the initial construct conception must be clear and that within an instrument, the reduction of what are apparently quite distinct constructs, to a single score cannot be regarded as acceptable without clear reason and relevant analyses. Unfortunately these structures are all too often ignored or violated in the work reviewed during the course of this research study.

The subsequent utilization of attitude questionnaires after the initial construction has also been the cause for critical concern. Without suitable reference to modern methods of assessing reliability and validity, what evidence is there that even the most carefully constructed questionnaire is performing as originally intended? A further area of criticism is thus the absence of empirical measures of internal consistency and operational validity. Once a questionnaire has been used, measures providing an indication of these should be obtained.

In terms of the area of internal consistency, measures of reliability have been available for a number of years. These measures reflect how consistent the items on the scale are with one another. This is achieved through examination of the correlation between the scores on an item to each other item on the questionnaire and also the total score for a set of items to the score on individual items. These have been adapted into reliability scale values such as Cronbach's alpha coefficient (McKennell, 1970). General rules concerning the magnitude of such values are scarce but as a rule of thumb, values of 0.80 would be desirable. (Edwards and Kenney, 1967). The consistency of a scale reflects, to an extent, the consistency of the construct it is based upon but also, the number of items on the scale.

The concept of operational validity of a construct is a wide ranging idea. In current terms the factor analytic approach to analysing questionnaire responses is by far the most appropriate in providing evidence of the existence of distinct scales of attitude assessment. The history of attitude test construction has seen many statistical methods proposed to identify or refine clear operational scales. Guttman, as noted earlier, developed techniques such as scalogram analyses to ensure unidimensionality The work of Egenck and Crown (1949) began the move towards using factor analytic techniques with computer based analysis for the purpose of identifying or verifying the existence of attitudinal constructs. The use of the technique is now exceedingly important to research workers in the measurement field. It must be noted that the technique has its failings. It is often easy to accept statistical information produced from such analyses as representing the only method of assigning items to scales. The interpretation of the results from factor analysis require careful consideration, particularly as to the sense of the scales identified using this technique.

In the light of these comments it is interesting to review the concepts of attitude that have been employed in recent studies and to what extent these studies can help in defining the operational constructs needed for future work. Initially the work of Gardner and Ormerod with Duckworth, identifies the various scales that have been used in this field. This was supplemented by further work as indicated. The early materials such as McCalman (1954) represent, in the majority of items on the scale, a clear idea of attitude towards science connected with enjoyment, being interesting and a favourite school subject. Muthulingham (1963) also employs a similar concept but also begins to consider within his attitude domain areas such as science and society, with items reflecting the danger of science to mankind and concepts of difficulty. The areas of criticism discussed ealier become apparent even in a brief consideration. The later work becomes even more complicated in it s concept of what measures 'attitude to science'. Selmes (1971) includes items on his 'Attitude Scale' which reflect the previous dimensions above and also the nature of scientific work and the characteristics of a scientist. Clearly a range of concepts are present and in these instruments, undoubtably, are implicit rather than explicit.

However, certain questionnaires seem to provide a more substantial analysis of the concept of attitude to science.

The Science Attitude Questionnaire developed by S  rnik and Jeffs (1971) represented a major attempt to produce a valid and reliable assessment instrument. They identified five scales:

(1) science interests
(2) science in society
(3) learning activities
(4) science teachers and
(5) school.

These scales were assessed on a Likert type technique but with variable options on the response format according to the item presented. The scales were identified from the factor analysis of the complete bank of items. The analysis was used as the prime method of allocating items to the scales noted above. This resulted initially in the scales possessing fairly high values of reliability. The scales themselves, however, on examination are not conceptually pure in that they contain a wide range of items which really can be seem to reflect different attitude domains. For example the scale concerned with science interest has items which not only reflect personal interest in science but also parental concern, as in item 12:

"My mother wants me to become a scientist"

and perception of personal achievement, as in item 23:

"I do badly in science."

Whilst it is important to praise the well intentional use of statistical procedures in the construction of questionnaires, consideration must be given to the face validity of the items before scales are finalised.

An attitude to science scale was developed by Brown and Davies in response to specific objectives arising from the Scottish Education Department Curriculum Paper 7 (Brown and Davies, 1973). Five scales were developed, relating to:

1. an awareness of the inter-relationship of the different disciplines of science;
2. awareness of the relationship of science to other aspects of the curriculum.
3. awareness of the contribution of science to the economic and social life of the community.
4. interest and enjoyment in science.
5. an objectivity in observation and in assessing observations.

The breadth of these scales in terms of attitude concept is wide ranging and incorporates concepts relating to scientific attitudes within scale five. The objectives were assessed by means of a Likert technique using statements which had been scrutinised by a panel of judges. The scales were administered to pupils but no factor analytic procedures were adopted to aid with the construction of the five scales. In a later study (Brown, 1976) an analysis was undertaken to consider the performance of scales on a factor analysis. Using a restricted analysis accounting for just over a third of the total variance the first, second and fourth item groups were confirmed, the fifth partly and the third group of items were mixed with the positive item and negative items separating and relating to the fifth objective. The scale relating to the interest and enjoyment of science was comprised of items relating to the enjoyment of science, characteristics of a scientist and scientific occupations. Again the scale name is a global term for a collection of items reflecting a particular perception of what interest and enjoyment in science means.

The attitude scales developed by Duckworth (1972) relied on the initial use of repertory grid technique. The technique identified appropriate constructs in relation to attitudes to school subjects and three areas were identified:

(i) interest, or lack of interest in the subject

(ii) difficulty, or easiness, in relation to other subjects and

(iii) 'worth-whileness' of the subject in terms of its perceived social benefit.

Further testing with a school population using bipolar type items relating to these areas was analysed statistically using factor and cluster analyses. The three groups noted above were substantiated together with a fourth group of items which reflected a 'freedom to express one's own ideas'. This 'freedom' factor was identified along with others in the final list of possible attitude dimensions. The number of items reflecting these dimensions are particularly low, three scales of five items and one of three items. The values of test-retest reliability were correspondingly low; interest, five items and difficulty, five items mean value of 0.68; freedom, five items and social benefit, three items mean value of 0.49. In terms of the interest domain the items refer specifically to interest and enjoyment. One item reflects the apparent ability of a subject to 'satisfy my curiosity about life'. It is difficult to envisage such a scale as being only related to an interest factor.

An extensive study of pupils' attitude towards science has been undertaken by Ormerod (1976). Initially he identified two distinct dimensions relating to science as a school subject and the social implications of science. Further work using additional items has provided the identification of four additional scales relating to the original social implications dimension as well as the initial attitude to science as a school subject. These scales reflect:

(1) the aesthetic nature of science, the effects of science upon our world,

(2) the practical value of science to society,

(3) the importance of spending money on science, and

(4) the characteristics of a scientist in relation to their personal attributes.

These scales have been carefully analysed for reliability and validity and they present homogeneous scales reflecting a clear construct. The subject attitude scale includes mainly perceptions of enjoyment, but also an item relating to the desirability of a scientific career. Overall the scales developed and refined in this research represent the most conceptually clear construct scales at present developed. Their construction and subsequent validation has also much to be commended.

In terms of the classification of attitudes to science, a number of research studies have provided important perceptions as to the extent of the attitudinal domains likely to be incorporated in a global attitude assessment instrument. Etzioni (1973) provides a particularly useful classification upon which a subsequent questionnaire was based. The interpretation of attitudes considered a number of scales:

1) The purpose of science, a consideration of theoretical versus utilitarian approaches

2) The nature of scientific theory, a consideration of the laws and theories of science in terms of their immutable nature or flexible approximation.

3) The method of science, essentially a consideration of the practical versus the theoretical approach.

4) The impact of science on society, science and the effect it has on society.

5) The implications of science for mankind, the overall results of scientific endeavour are beneficial or harmful

6) The scientist as a person, the perceived image of a scientist as favourable or unfavourable.

Detailed classifications of this type are valuable. A similar list of attitudes has been prepared by Moore & Sutman in the construction of their Scientific Attitude Inventory (1970). It represents a wide ranging concept of attitude and incorporates distinctly cognitive based scales. They provide however an initial framework on which to consider the range of constructs that have been used in other questionnaires. The problem that is becoming increasingly apparent in this review is not only the variety of constructs being used, sometimes under somewhat different scale names, but to what extent they can be classified to enable further work to proceed.

On a preliminary investigation the range of concepts used in the consideration of attitudes to science is very widespread. Even when there are distinct titles for the concepts present, an analysis of the scale items reveals some interesting items whose content appears quite inappropriate for the construct which they are said to reflect.

The problem of providing a range of operational constructs from reviewing material cannot be deemed as particularly definite or very thorough in its approach. Munby has considered an analysis by statement type, or content in trying to establish what the items upon a questionnaire actually measure as opposed to what the research worker has put forward as the concepts of measurement (Munby 1980). It seems that such a method will provide the only clear way of identifying specific operational constructs behind attitude questionnaires. Thus this form of analysis, by statement type, forms the major part of the review of actual attitude materials used in previous work. The next chapter addresses itself to this particular problem in detail.

In this chapter consideration has been given to the development of the area of the assessment of attitudes to science. This has been examined from a brief historical perspective and then, in a concentrated review of the wide range of attitude test instruments that have been employed to assess an equally wide or diverse range of attitudinal constructs.

The review of the literature was undertaken at an early stage in the study. Subsequent searches have revealed no further research studies which have adopted completely new approaches towards the measurement of attitudes to science.

# CHAPTER THREE

## ANALYSIS OF THE MEASUREMENT INSTRUMENTS

Research workers have used a wide variety of theoretical and empirical constructs in the examination of attitudinal characteristics of pupils. This, it has been observed, could lead to considerable confusion over comparative studies between research studies, apparently in the same field and to establishing what characteristic an instrument measures.

Attitudes have been compared with cakes, made up of a number of ingredients. Research workers tend to produce their own version of the cake each time an assessment of attitudes is made. The problem is to find if there is a basic set of ingredients. This can be achieved by a detailed examination of all the ingredients that have been used, followed by an attempt to specify what the constituents are.

### The analysis of attitude to science measurement instruments

The analysis begins by classifying the previous attempts at measurement into distinct categories, based upon available information on each questionnaire or test.

Each questionnaire presents a number of items, questions or statements to which the person completing the questionnaire is invited to respond. A strong indication of what a questionnaire is attempting to assess can be ascertained from the test's constituent items. Taken at face value these items will present an indication of the underlying construct being examined. For example, an item such as:

'I like science at school'

indicates that the researcher is questioning the affective response of the individual towards science as a school subject.
Whereas an item such as:

'Science is a difficult subject'

will question the individual's perception of the intellectual difficulty of school science. A consideration of the nature of all the items on a particular questionnaire will thus indicate what the questionnaire at face value is attempting to assess in terms of individual attitudinal constructs. Further analysis for other questionnaires will produce lists of attitudinal constructs which have some points of comparison and also some differences in the attitudinal constructs used. In pursuing this type of iterative analysis over a range of questions a considerable number of attitudinal constructs can be identified. These can then, in turn, be organised to form an overall scheme which details the major dimensions of attitudinal characteristics which have been assessed on measurement instruments. In considering broad areas of attitudinal investigation, a number of research workers have produced some guides to their own classification. (Krathwohl et al, 1964 and Klopfer, 1971). These guides, however valuable, have concentrated in producing a taxonomy of affective behaviour indicating the strengths of an individuals value system. Ultimately a classification of constructs as undertaken here, would wish to present assessment criteria throughout a range of a value system such as proposed by the authors noted above. This is certainly an objective for future reference. The later work of Munby (Munby, 1980), however, would have been particularly valuable as he had already built up a conception of the range of items, analysed by item content, contained within a sample of attitude questionnaires. This work was not available at the time of this present analysis. In some areas, evidence is available from the use of certain validation techniques such as factor analysis. This information is valuable for this task but cannot necessarily be taken as providing a firm starting point. Scales produced using factor analysis do not necessarily always produce a scale where all items are pure, in the sense of the construct they represent. However scales produced by researchers such as Ormerod (1976) and Skurnik and Jeffs (1976) provide a basis for the next stage of the analysis.

The process of forming these constructs into an overall classification is an iterative one. The items on each questionnaire were taken one by one and assigned a possible construct. The constructs in turn were examined and ordered and grouped together where a common thread seemed to exist:

For example:

Science lessons in school are interesting, and

Practical work in science is fun.

These items represent two different underlying constructs: one relates to school science lessons and the other to practical work. Nevertheless they can be regarded as themes on a common thread, that of an affective response to science teaching within school. Throughout the analysis attempts were made to locate major dimensions of the attitudinal items and to express them in terms of general statement with related themes around this statement.

The final listing of major attitudinal attributes is one of personal interpretation. It is comprehensive in that it reflects the major dimensions studied but there are items which have eluded interpretation and constructs which appear very infrequently. For example, the item 'school science is anti-religion' bears interpretation but remains outside the mainstream of items.

The process of classifying the items and defining the areas of the dimensions present required several interpretations. Each time the breadth of the dimensions represented increased and a greater number of the items on each of the questionnaires examined was incorporated into the classified dimensions. The dimensions and the classification were of necessity reviewed after each additional questionnaire. At a stage when ten major dimensions had been identified, with a degree of clarity, the analysis was concluded. This decision was reached in the light of the overall intentions of this research study. The dimensions identified here were to form the basis of assessment instruments for comparative purposes at a later stage. In terms of the number of separate dimensions already identified the nature of the assessment instruments considered would result in large and probably impractical test instruments. It is important to bear in mind that this conceptual analysis is considered as a initial research problem undertaken to provide important information for the practical construction and comparison of instruments. Nevertheless the analysis up to this point represents a picture of the major measurement dimensions emerging from the conceptual study. The range of dimensions identified at this stage represent the widest conception of 'attitude' used in the research field to date.

A listing of the attitude dimensions identified and classified is to be found in table 3.1. These dimensions represent the major areas represented on attitudinal measures, they are not ordered in terms of priority. Full examples of these dimensions are considered in the construction of the new instruments.

Table 3.1. **ATTITUDE DIMENSIONS**

These attitude dimensions are the major dimensions to emerge from the construct analysis of a large number of attitude related test materials. They present a conception of science and scientists which is seen to be appropriate for pupils of the early secondary age level.

(1) Commitment to & Enjoyment of Science

Description

The affective reaction of the pupil toward science. An expression of the pupils' enjoyment and enthusiasm for the subject.

Themes

A) School science in the curriculum

i) the pupils' view of school science in the curriculum

ii) the pupils' view of school science compared with other subjects.

B) School Science learning activities

i) the pupils' view of school science practical learning activities

C) Science in general

i) the pupils' view of science in general

(2) Scientific Occupations

Description

The pupils' desire and enthusiasm to take up a science related occupation on leaving full time education.

Themes

A) The desire to take up a science related occupation

i) an unspecified occupation

ii) a specified occupation

iii) an unspecified occupation in comparison with others.

B) The difficulties associated with pursuing scientific careers and the desire to overcome them.

(3) Scientific Interests and Pastimes

Description

The pupils' interest in science as indicated by their participation in scientific hobbies and pastimes and school science activities not within the formal curriculum.

Themes

A) General interest and participation in active pastimes.

B) General interest and participation in passive pastimes.

(4) Characteristics of the Scientist

Description

Selected important characteristics perceived by the pupil as relating to the personal and professional qualities of a working scientist.

Themes

A) Personal and social characteristics - intellectual, behavioural, social and physical.

B) Professional characteristics - creativity, methodical, perseverance, honesty, objectivity and co-operativeness.

(5) Difficulty with Science as a School Subject

Description

The difficulties perceived by the pupil in association with the science curriculum in school.

Themes

A) Intellectual difficulties

i) conceptual

ii) mathematical

iii) linguistic

B) Manipulative and observational difficulties in practical work.

C) The personal time commitment involved in studying science.

(6) Science and Society

Description

Science can interact with society in a beneficial and harmful way. In general science is essentially a force for good within society and thus it justifies scientific expenditure and government and public support.

Themes

A) A general view of science and society

B) The benefits and illeffects of science on society.

C) The extent of scientific expenditure.

(7) Science and the Individual

Description

Science can have both beneficial and harmful effects on the life of the individual. It is essential of benefit to the individual. It is important in this day and age that every individual knows and understands and is aware of science in society.

Themes

A) The benefits and illeffects of science on the individual

B) The individual's involvement in science.

(8) Scientific Theories and Laws

Description

Scientific theories and laws are flexible statements which incorporate and explain,as well as possible,the known facts available and can be used to predict further information about the natural and physical world.

Themes

A) Flexible statements about science which reflects the changing state of knowledge.

B) The incorporation into scientific theories and laws of all available knowledge.

C) The predictive capabilities of scientific theories and laws.

(9) The Scientific Method

Description

The scientific method is essentially concerned with taking careful and detailed observations from nature or from an experimental situation and using these observations as a basis for a scientific explanation of the natural and physical world. In doing this there is a need for self criticism and an acknowledgement of the work of others and their criticisms regardless of their professional standing.

Themes

A) Observation the basis for the scientific method

B) A scientist should critically consider all findings

C) A scientist should acknowledge the work and the criticism of others regardless of their professional standing.

(10) The Aims of Science

Description

The major aim of science is seen as falling into a dichotomy between an idea generating, theoretical approach in a search for knowledge and a technological activity primarily for the service of man.

Themes

A) Science is seen as a technological activity primarily in the service of man.

B) Science is seen as an idea generating activity primarily intended as a knowledge seeker and classifier.

The dimensions represent a very broad view, expressed within questionnaires, of the concept of attitude. Initially the analysis gives rise to the question as to whether these dimensions can be regarded as completely attitudinal in nature. Whilst it is perfectly acceptable to regard the first dimension, 'Commitment and Enjoyment of Science', as attitudinal, the ninth dimension, 'The Scientific Method', is undoubtably based on a cognitive domain rather than attitudinal. This qu stion is an important one. At this stage it is crucial to the concept of the study to reflect the full range of 'attitudinal' concepts within the test instruments wherever possible. It is only by attempting to proceed in this manner that evidence may be provided to recommend a serious review of what is used as the attitude concept in measurement techniques. The instruments used to arrive at this description of attitude dimensions are detailed in table 3.2. The instruments and their relation to the dimension appear in the comparison matrix table 3.3. Whilst the analysis presented in this table forms a useful critical appraisal of the instruments under review it is not the intention of this section to proceed to a further detailed analysis of each instrument. Essentially it has been important to establish the nature of the dimensions for future test development. However, a number of general points must be made in the light of the criticisms levelled at attitudinal measurement instruments.

Firstly, the conceptual purity of a number of these instruments gives great cause for concern. This is especially important where as in a number of cases, (for example, twenty two, see table 3.3. instruments eight, twenty four), the results from scores on these instruments are added together to measure 'attitude to science'. Not only is the conception of the total score almost meaningless but for different instruments this score could be totally different. Any comparative studies carried out by looking at results from these instruments measuring a common 'attitude to science' are almost worthless.

Secondly, even if the overall concept of attitude does incorporate such wide ranging dimensions as, enjoyment of science and the social implications of science (e.g. instrument ten, and twenty two, table 3.3), can adding together so few items even attempt to produce a reliable scale? In only a few questionnaires (e.g. instrument twenty two, table 3.3.) has detailed consideration been given to attitude concept and scale reliability.

Thirdly, the analysis is revealing if consideration is given to the distinction between what can be classified as attitudinal dimensions. Consider those areas which contain items asking for a personal or affective response as attitudinal and cognitive dimensions as those areas which contain items where responses are based on factual knowledge. One can draw up an initial division of the dimensions such that the attitude area may be represented by

1) Commitment and Enjoyment of Science

2) Scientific Occupation

and 3) Scientific Interests and Pastimes

whereas 6) Science and Society

7) Science and the Individual

8) The Scientific Theories and Laws

9) The Scientific Method

and 10) The Aims of Science

could be regarded as cognitive. This division will receive further consideration later. For an initial review of the questionnaires analysed, this means that a considerable proportion of attitude questionnaires contain a considerable number of cognitive items (for example see instrument one on table 3.3). Whilst this may be feasible if the division is in fact recognised for subscales within the questionnaire, in the majority of cases no such division occurs and the scores are taken as cumulative for all items. Not only does this question again the true sense of the instrument but it also provides an interesting comment on the issue relating attitudes to achievement. If a proportion of items on an attitude questionnaire are based on cognitive areas, would not this increase the correlation between attitude and ability or achievement, perhaps unfairly?

This analysis has served to highlight a number of the issues which have directly led to the preparation of this current research study. The dimensions identified will now be translated into appropriate measurement instruments. In the analysis of these instruments further comment will be advanced on the suitability of these dimensions in providing actual representations of the pupil's attitudinal domain.

Table 3.2. ATTITUDE AND INTEREST TEST MATERIAL

TEST MATERIAL USED

1 ALLEN, H.R.

Attitude to Science (1959)

2 ARCHER

Attitudes to Biology (1951)

3 BELT, S.B.

Science and Scientists (1959)

4 BROWN, S.B. and DAVIES T.N.

Attitudes to Science (1973)

5 CHAMDLIN, R.F.

B.A.T.S.S. (1970)

6 COXHEAD, P. and WHITFIELD, R.

S.U.M. (1975)

7 DUCKWORTH, D.

Attitudes to School Subjects (1974)

8 DUTTON, W.H. and STEPHENS, L.

Attitude toward Science (1963)

9 EBSWORTH, D.G.

Attitude to Science (1968)

10 FEERST, F.

Attitude Inventory (1973)

11 FISHER, T.H.

Science Opinionaire (1973)

12 GUTHRIE, H.C.

Attitude Test (1959)

13 HADDEN, R.A.

Affective Objective Tests (1975)

14 KEMPA, R.F. and ETZIONI, S.M.

S.A.Q. (1973)

15 LAUGHTON, W.H. and WILKINSON

S.O.P. (1975)

16 McGALMAN, H.

Attitude Test (1954)

17 MOORE, R.W. and SUTMAN, F.X.

S.A.I. (1970)

18 MEYER, G.

A Test of Interests (1969)

19 MOTZ, La L

S.A.S.S. (1970)

20 MUTHULINGHAM, S.

Talking about Science I (1963)

21 NEWTON, D.P.

Attitudes to School Science (1975)

22 ORMEROD, M.B.

Science Attitude Scale (1976)

23 REED, C.G.

Attitude towards ..... (1939)

24 SELMES, C.

Attitudes to Science (1971)

25 SKURNIK, L.S. and JEFFS, P.M.

Science Attitude Questionnaire (1971)

26 TAMIR, P. et al.

Attitudes to School Physics (1974)

27 TISHER, R.P. and POWER, C.N.

Attitudes to Science and Science Lessons (1975)

Key to Table 3.3.

Test Instruments

TEST Numbers refer to table 3.2.

TYPE L Likert

FC Forced Choice

SD Semantic Differential

TH Thurstone

ST Situation Type

Numbers presented in the matrix refer to the number of items.

Attitude Dimensions are classified as table 3.1.

1 A represents the first construct, theme A.

Notes

For the categories noted below certain differences are present.

2, both aspects of Scientific Occupations are considered together

5, the difficulties expressed with practical work as a theme was added following a final questionnaire review.

6, the general theme for the science and society was added to present an overall item category. The divisions B (1) and (11) represent benefits and illeffects respectively.

7, the divisions A (1) and (11) represents benefits and illeffects respectively.

U unclassified items, under the present classification.

AGE S - secondary

J - junior

T - tertiary

Table 3.3. Comparison of Attitude Dimensions and Attitude Test Instruments

ATTITUDE TEST INSTRUMENTS

| | | L | L | L FC | L | FC | FC | FD | TH | TH L | L | L | TH | L SD ST | L | L | TH | L | L | L | L | TH | L | TH | L | L | L | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEST | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| TYPE | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | A | | 35 | | | | | | 5 | | 2 | 1 | | | | 3 | | | | | 4 | | 1 | | 1 | 2 | | 1 |
| | B | | 35 | | 2 | | | | | | | 5 | 6 | | | 10 | 23 | | 20 | | 4 | | 5 | 17 | 5 | 6 | 4 | 8 |
| | C | 2 | | | 3 | | | | | | 1 | | | | | | | 1 | | | 1 | 6 | 5 | | | | | |
| 2 | | 1 | | | 3 | | | 4 | | | 1 | | 1 | | | 1 | 2 | 6 | | | | 2 | 1 | | | 3 | | |
| 3 | A | | | | 1 | | | | 3 | | | | | | | 1 | | | 14 | | 1 | 1 | | | | 2 | 1 | 1 |
| | B | | | | | | | | | | 1 | 1 | | | | 2 | | | 39 | | 1 | | 1 | | | 2 | 1 | |
| 4 | A | 25 | | 30 | 4 | 13 | 1 | | | 5 | 1 | | 1 | 1 | 10 | 1 | | 3 | | 5 | 1 | 6 | 4 | | 13 | 6 | 17 | |
| | B | 5 | | 4 | | | 1 | 1 | | 1 | | | | | | | | | 13 | | | | | | | | | |
| 5 | A i) | 1 | | | 1 | | | | 1 | | 4 | 1 | 1 | | | 1 | 1 | 4 | | 1 | 2 | 2 | | | 1 | | 1 | |
| | ii) | | | | | | | | | | | | | | | 1 | | | | | 1 | 2 | | | 1 | | 2 | |
| | iii) | | | | | | | 6 | | | | 1 | | | | 1 | | | | | | | | | | 1 | | |
| | C | | | | | | | | | | | 1 | | | | | | | | | | 1 | | | | 1 | | |
| 6 | B i) | 4 | | 2 | 2 | 1 | 2 | | 1 | 6 | 4 | | | 2 | 5 | | | 1 | | 3 | 4 | 2 | 4 | | | 3 | 4 | |
| | ii) | 7 | | 3 | | | | | | | 1 | | | | 3 | | | 1 | | | 2 | 2 | 6 | | 1 | 4 | 1 | |

Table 3.3.

| | | L | L | L FC | L | FC | FC | SD | TH | TH L | L | L | TH | L SD ST | L | L | TH | L | L | L | L | TH | L | TH | L | L | L | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEST | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| TYPE | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | C a | 3 | | 1 | | 5 | 1 | 1 | | | | | | | 1 | | | | | 1 | | 1 | 9 | | | 3 | 2 | |
| | b | 5 | | 1 | 6 | | 1 | | | | | | | | 2 | | | 5 | | 2 | | | 2 | | | 1 | 1 | |
| 7 | A i) | | | | | 4 | | | | | 2 | | 1 | | | | | | | | 2 | | 3 | 1 | | | | |
| | ii) | 1 | | | 1 | 1 | | | 1 | 2 | | | | | 4 | 1 | | | | | 1 | | 4 | | | | | |
| | B | 1 | | | 1 | | | 2 | 1 | | | | | | 1 | 1 | | | | | | | | | | | | |
| 8 | A | | | 1 | 1 | | 3 | | | 1 | | 3 | | | 3 | 1 | | 8 | | 4 | | | | | 3 | | | |
| | B | 1 | | 1 | 5 | | | | | 1 | | 1 | | | 3 | | | 3 | | 2 | | | | | | | | |
| | C | | | 2 | | | | | | 1 | | | 1 | | 4 | | | 5 | | 2 | | | | | | | | |
| 9 | A | | | 1 | | | 5 | | | | | | | 4 | 5 | | | 9 | 2 | 7 | | | | | 7 | | | |
| | B | | | | 1 | | 1 | | | | | | | 8 | 1 | | | | | 1 | | | | | 1 | | | |
| | C | | | 1 | 5 | | 2 | | | 1 | | | | 1 | 4 | | | 4 | | 4 | | | | | 1 | | 2 | |
| 10 | A | 6 | | 1 | | 3 | | | 1 | 1 | | | | | 6 | | | 7 | | | | | | | 1 | | | |
| | B | 2 | | 1 | | | | | | | | | | | 3 | | | 2 | | 2 | | | | | | | | |
| | U | 29 | | 14 | 24 | 5 | 3 | 5 | 5 | 2 | 1 | 5 | 8 | 1 | 2 | - | 4 | 1 | 60 | 32 | 6 | 7 | | 2 | 21 | 24 | 38 | 26 |

# CHAPTER FOUR

## SELECTION OF THE MEASUREMENT TECHNIQUES

In the review stage of this present study the variety of different measurement techniques were grouped under a number of general headings to facilitate further consideration. These major groups are noted below:

(a) Self Report Scales

1. Summated R ting Scales

(a) Likert Type

(b) Equal Appearing Intervals
(Multiple Choice Technique)

(c) Interest Inventories

2. Semantic Differential Scales

(a) Osgood et al type

(b) Activities Inventories

3. Forced Choice Rating

(b) Differential Scales

Thurstone type

(c) Projective Techniques

1. Word Association

2. Sentence Completion

3. Situation Tests

In ad ition to these other forms of assessment have been used in attitudinal work these include: preference ranking, enrolment data and observational methods. The teacher has also been used as an external assessor of pupils. The role of the teacher as an assessor is considered in a subsequent chapter. The question as to the suitability of these different techniques for the assessment of constructs related to science is one which has been rarely raised. That is, why one technique should be directly preferred to another to assess attitudes. The review earlier has indicated that the Likert technique is the most favoured instrument for attitude assessment. The question must now be raised as to whether this particular technique should have preference alone in the selection of techniques to assess the attitude domains specified in the previous chapter. It may be that no theoretical grounds can be advanced in terms of the technique to indicate that it is not a suitable form of assessment. In this case the general importance of the technique is assessed and further comment on its suitability will be left to the empirical stage. Essentially there are four concerns that are considered in the selection of suitable techniques for this study.

1) The major categories of testing techniques identified should be represented.
2) The range of techniques, ranging from structured answers to open ended questions, should be represented.
3) Where possible the techniques selected should be capable of assessing, at least theoretically, the full range of the attitude dimensions identified.
4) Consideration should be given to techniques which display potential as assessment instruments even though they may have provided only a few examples of use to date.

The techniques described will now be considered in the light of these points.

Self Report Scales

1. Summated Rating Scales

The techniques in this section have seen wide use in educational research. On the basis of the assessment of the major dimensions only interest inventories seem to have been used too specifically to cover the range of dimensions intended. The ratings on these inventories have been used to assess interest either in a general form or of a particular field of interest. This technique may be suitable for the interest domain but not the others. The other techniques have no major disadvantages that can be for seen. The Likert technique is taken as being representative of this area for the purpose of the present study. In view of the wide use of this techniques it is important that it is included for comparative purposes. An initial check reveals that all the identified dimensions can be assessed using this instrument.

2. Semantic Differential Scales

This technique has been adopted easily to assess a pupil's reaction to attitude objects such as science or science lessons. As a technique it offers a distinct measurement approach which is founded upon a considerable theoretical framework (Osgood et al, 1957). It provides a viable addition to the study programme.

The activities inventories, like interest inventories, are more specific scales which can assess the attractiveness of certain activities. These activities could well be science related in terms of the science interest dimension identified, but again this technique is specific to one dimension only.

In the examination of the attitude dimensions and the general measurement technique, a problem arose in the provision of suitable assessment items for the dimensions concerning scientific theories and laws, the scientific method and the aims of science. The standard format of presenting a word or phrase, representing an attitude object, followed by a pair of opposite stimulus adjectives was considered for each of these dimensions. Examples of these items are now considered.

Scientific Theories and Laws

| | |
|---|---|
| scientific theories and laws | flexible - rigid |
| scientific theories and laws cannot be broken | disagree - agree |

The scientific method

Ideas in science are based on observation agree - disagree

Famous scientists are always right agree - disagree

The aims of science

Science aims to seek knowledge agree - disagree

Science aims to be practical agree - disagree

The major objection to these items is that they fail to correspond with the essence of a semantic differential item in that they should present an attitude object followed by a bipolar scale. These items are essentially statements followed by an agree - disagree scale, almost identical in fact to Likert items. If they are compared with items considered as suitable for this technique such as

School science lessons interesting - boring

the difference becomes noticeable.

Further attempts were considered in terms of examining a range of bipolar scales, as in the 'flexible - rigid' pair in the first example here. Again the attempts did not meet with the operational concept of the technique.

Whilst this imposes limitation on this technique it is still sufficiently important as a measurement instrument to be included in the study.

3. Forced Choice Techniques

The forced choice technique has not often been used in studies of attitudes to science, and not within the wide bounds of our attitude dimensions. However, as an assessment technique there are a number of advantages and disadvantages which would be worthy of discussion in the light of the possibility that this technique could well be included within the empirical study.

Many attitude techniques have a tendency to encourage pupils to respond positively to the items they present. This positive response by pupils is in essence an attempt by the respondent to create a favourable impression with the tester, to produce a 'halo' of good responses to please the tester rather than indicating their true feelings, which if negative, the student may well see as presenting a bad impression of **himself** to the tester. This effect, when present, will obviously invalidate any serious assessment of a pupil's attitudes and render attempts to validate empirical constructs meaningless. In addition to this point, conventional testing methods have been criticised for not producing sufficient distinction between constructs employed on an assessment instrument. Given that a pupil responds truthfully it is still possible for a pupil to give equal preference or scores to two different items offered. Discrimination is also reduced because interests of different size may be used by respondants in their answers.

Forced choice testing has laid claim to offer the advantage of producing scores in which the distinction between constructs is maximised, basically because the items relating to the constructs have to be rank ordered by the respondants. This should occur because the pupil is making a conscious decision on the relative merits of the statements involved with respect to his/her perceptions.

Points in favour:

(1) reduction of the halo effect

(2) increased concentration of the items presented

(3) increased discrimination between the constructs

There are a number of disadvantages. The constructs for use in a forced choice instrument must be pre-determined so that when items **are** constructed the components of these items reflect each of these constructs. Consequently, the forced choice technique cannot be applied as a means of checking or validating empirical constructs. The scores which are derived from forced choice instruments are generally ipsative, so the total scores have the characteristic of adding up to a constant. This imposes strict limitations on the range of statistical treatments that can be performed on the scores. Even correlational analysis should not be performed as the scores are dependent upon one another. Finally the forced choice instrument does not give information about the intensity of the respondent's feelings for different constructs. The instrument cannot provide information concerning the relative intensity of feeling on individual constructs.

Previous research into the use of the various forms of forced choice instrument has favoured the use of four constructs being examined within one item, forming a tetrad. The statements forming the items should all have favourable or positive aspects (Highland and Berkshire, 1951). In assembling items for a tetrad particular care has to be taken over the statements such that no significant bias is introduced into the items by including statements which may have an intrinsically greater attraction to the population under consideration. A degree of pre-testing of items is necessary to ensure that no statements have high preference indices.

Within this study in particular a number of additional difficulties present themselves. There are ten attitude dimensions which require investigation. When putting items together it will be necessary to reflect each of these dimensions and also to arrange the comparison of these dimensions on a logical basis. Considerable care needs to be exercised over the construction of items such that the constructs in any one item have a sound basis for comparative judgement. All items therefore within a tetrad must be acceptable as true and/or correct. This basically calls for 'factual' type statements of which the most preferred or most appropriate one is selected. Items which would normally invite a respondent to judge their appropriateness or applicability to himself are thus not as suitable for inclusion in a forced choice instrument.

Note: It is possible to achieve this by making all statements appear rather 'neutral' or non-controversial by the use of expressions such as 'can' or 'could be' or 'is usually...'. Nevertheless it is difficult to produce items which overall are not 'matters of opinion'.

It has been noted that the tetrad is the most suitable form of forced-choice instrument. Any attempt to examine ten constructs in this way would be

(1) quite unwieldy, as twenty items, of four statements each are required to compare/contrast ten constructs each with the other only once(i.e. 80 statements)

(2) require the assumption that the ten constructs have a degree of validity not yet established.

A logical division of the constructs into four main divisions would allow the development of an empirically viable instrument. An examination of the constructs suggests that the following divisions of the major dimensions bears face validity:

(1) Personal attitude toward science

(2) The characteristics of scientists

(3) The social effects of science

(4) The nature of science.

(These are amplified at a later stage)

With consideration given to the advantages and disadvantages of a forced choice instrument it is apparent that this instrument can offer distinct advantages in testing and that a number of the disadvantages can, to some extent, be overcome. However, the differences between a forced choice instrument, with modifications as indicated in the above dimensions, and the other instruments in the study poses a further difficulty in the assessment of the actual usefulness of this technique compared with the others. To overcome this problem it is intended to construct an almost identical instrument which embodies the characteristics of traditional assessment techniques. Therefore as a condition of developing a forced choice instrument, a parallel instrument using the same format and items but allowing a free choice, is necessary. This combination of instruments allows certain important points to be commented on in the light of the study.

(a) The examination of whether the choice of constructs by means of the forced-choice instrument corresponds to that achieved by the free-choice instrument.

(b) A consideration as to whether there are different mean levels identifiable by a comparison of forced-choice and free-choice scores.

(c) To explore further the problems of interpreting and handling forced-choice derived scores, which are ipsative, compared with the free-choice scores which are normative. This is an issue which will require the development of additional statistical procedures, to facilitate comparison.

(d) Overall to assess the potential usefulness of the forced-choice technique as a general instrument by which attitudes can be measured.

Thus, from this discussion, two questionnaires related to forced choice and a free response format were developed for the study.

(b) <u>Differential Scales</u>

<u>Thurstone's Differential Technique</u>

At present no instrument of this type has been included in the test programme. Two points support its absence.

(1) A number of studies have already examined the issue of the comparability of Thurstone's and Likert's technique for attitude measurement (Seiler and Hough, 1977). To bring these results down to a single sentence is unfair but essentially the results indicate the Likert has a greater reliability of the two tests, for the particular constructs employed. It could be inferred that this will be the case here.

2) The construction of a Thurstone type instrument in our particular case involves the provision of items which display various degrees of feeling or perception of the particular construct involved. This is so the pupil may endorse the degree of feeling for his/her self. Consider this for part of the dimension 'Commitment and Enjoyment of Science', the following statements could be provided:

(a) Science lessons are boring

(b) I usually find science lessons boring

(c) I find science lessons neither enjoyable nor boring

(d) I sometimes enjoy school science lessons

(e) I always enjoy school science lessons

Similar sets of statements would be provided for each aspect of each dimension in keeping with designing instruments on defined constructs or dimensions. Judges will then be asked to rate these statements along a continum from say 0-9 for the particular construct 'Commitment and Enjoyment in Science'. In essence due to the presentation of the statements in the above example the judges would be forced by commonsense, it seems, to assign their ratings from 0-9 from (a) through (e). There may of course be some discrepancy over where statements are actually assigned, for example, is statement (b) to be rated '2' or '3'? However the ordering will remain the same. Essentially what is being suggested is that the Thurstone technique is essentially producing a scaled version of the Likert test with all the alternatives being made explicit in written form instead of occurring in the Strongly Agree-Strongly Disagree format next to a single statement. This occurs, it seems, because of our particular constraints on the production of a Thurstone-type test. Previous examples of the application of Thurstone's method to the measurement of attitudes to science have only used one construct, predominantly, 'attitudes to science', in no more explicit form than this. A host of related statements are then judged without reference to the differing aspects of science attitudes, relying on the judges' own perceptions of what statements express positive or negative attitudes. For example, in a scale constructed by Dutton and Stephens, the following statements are scored in one dimension (mean item value in brackets).

(a) Science is boring (0.3)

(b) Science seems to be 'over my head' (2.7)

(c) Elementary school science should be taught to groups of children with approximately the same I.Q. (5.8)

(d) Science is very important in this scientific age in which we live (10.3)

The production of a scale such as this is of little value in the context of our study. In producing a scale within our constraints, are we producing a significantly different operational scale for comparison?

In contrast it should be noted:

1) No examination of Thurstone and Likert type technique has been undertaken in the context of research into attitudes to science and not within specific dimensions.

2) No examinations seem to have been made comparing the Thurstone technique and other techniques used in the study.

3) It has been argued, on theoretical grounds, that Likert and Thurstone techniques are fundamentally different and hence comparisons or substitutions of one technique over another cannot be made (Fishbein, 1967).

On balance the technique was not employed due to the difficulty likely to be encountered in the construction.

(c) Projective techniques

In the consideration of the techniques available for attitude assessment it would be difficult to exclude these techniques as they offer a considerably different mode of working to all other techniques. To reflect the breadth of attitudinal assessment alone, a technique of this type was considered for addition to the study programme. In terms of a technique such as word association it is comparatively easy to provide stimulus words for responses representing all of the dimensions. Items such as 'school science', 'practical work' and 'scientists' could well provoke responses in relation to the dimensions already identified. However the technique itself serves the purpose of generating rather than validating constructs and if incorporated within this study its use must reflect this point. In accepting this, the use of this technique may, however, provide valuable information on the suitability of the theoretical constructs rather than providing us with measures of reliability and validity. If from a projective item such as indicated above, a number of open responses emerge; these can be classified in the same manner as the items were from the original questionnaires. Such a classification of pupils' responses would invariably be a long, iterative process but it would eventually lead to a pupils' based set of dimensions of response. The importance of this would be that a direct comparison could be made between the direct areas of response, seen as important to the pupil and the theoretical framework devised by the research analysis. Thus such a comparison would provide a form of check or validation of the original dimensions.

The ideas outlined above need consideration when selecting a suitable example of this technique as a representative. To enable the pupil to respond to items which specifically reflected the initial dimensions a form of situations test seemed the most appropriate instrument. Whilst this technique is an open response, it does allow a clear picture of the area to be drawn, hopefully to stimulate an associated response. This should allow a degree of direct comparison for a particular dimension. Thus if an item is constructed to portray pupils enjoying science lessons, in accordance with the first dimension, then the open response may well encourage a comment on the situation in an affective manner together, perhaps, with some qualification. The qualification may or may not reflect the themes identified in the theoretical analysis. Comparisons can thus be made across the range of dimensions proposed if suitable situations are presented to stimulate responses in these areas. This proposal develops the idea of the projective technique into providing an important comparative instrument. The work involved in creating a suitable reference scheme may well provide the basis for a future attitudinal measure.

In the review of techniques a particular type of situation test had been used but with a clearly defined structured response to ascertain both opinion and interpretation of certain situations (Hadden, 1975). To investigate further the suitability of this technique, situations were created to represent the dimensions identified, as above, but with a detailed structured response scheme to facilitate direct assessment of the pupil's response. It is thought that this technique, referred to as 'Science Situation Test - Structured Response', may well provide an additional technique for attitudinal measure. It should provide a clear statement of views, via the situation and thus allow the pupil to make a clear association with the item so encouraging a response reflecting clearly their attitudinal position.

Arising from this discussion of the suitability of the addition of a projective measure within the study, two techniques have been proposed for further investigation. Firstly an open ended situation type questionnaire and, secondly, a structured response situation type questionnaire. Both these techniques are adaptable to provide relevant items for each of the dimensions identified.

In addition to these techniques of assessment three other forms of attitude related measurement techniques received consideration and are noted here.

<u>Preference Ranking</u> - This has been used as a comparative technique to assess students' preferences for one subject over another (e.g. Ormerod, 1975). The technique appears to assess an overall like or dislike for

specific subjects although the precise nature of the student's judgement is uncertain. This technique, whilst providing useful additional information, has limited use in the context of assessing particular attitudes in relation to science and science learning.

Enrolment Data - Used as a technique to assess a global like interest in certain courses through the student's selection of the course. This assumption has attracted much criticism, predominantly because the assumption ignores or fails to take into account, factors such as economic conditions external to the school, parental and teacher pressures and the complexities of a school option system. Irrespective of this the technique, like preference ranking, offers useful additional information but has a limited use in the context of assessing particular attitudes in relation to science and science learning.

Observation Methods - Methods such as classroom observation are not set aside, at this stage, on critical grounds but because the prime concern is with psychometric forms of assessment and their comparability. Such methods may well form a useful further research project, particularly if they can be developed within the context of teacher rating which is considered in a subsequent chapter.

This chapter has seen a discussion of the suitability of attitude measurement techniques and a selection of an appropriate range of instruments to be incorporated in the present study. The instruments selected for development are as follows, classified according to response format:

1. Fixed Response Questionnaires
   - i) Likert Questionnaire
   - ii) Semantic Differential Questionnaire
   - iii) Forced Choice - Free Response Questionnaires
   - iv) Situation Type - Structured Response Questionnaire

2. Free Response Questionnaires

Open Response Situations Type

The development and construction of these techniques is considered in the next chapter.

# CHAPTER FIVE

## DEVELOPMENT AND CONSTRUCTION OF THE ATTITUDE ASSESSMENT INSTRUMENTS

In the previous two chapters a range of attitude dimensions and a range of suitable measurement techniques have been specified. This was to enable the development and construction of a set of attitude assessment instruments to form the basis for the comparitive analyses central to this study. In this chapter the construction of these techniques is reported.

The process of constructing assessment instruments in this area has been the subject of detailed criticism (Gardner, 1975). The areas of this criticism have been noted, in the initial review, and every attempt has been made to produce conceptually clear scales based upon well written items appropriate to the population under consideration. A number of standard texts such as Edwards (1957), Kerlinger (1973) and Oppenheim (1966) have been consulted to define techniques and to provide guidelines for the construction of items. It is also important to note here that considerable care was undertaken to provide clear instructions to the pupils (and also the teachers) as to the exact requirements of a particular questionnaire. Providing adequate instructions for the use of a questionnaire is an obvious area of concern but one frequently ignored by research workers. In terms of the pupils who complete the questionnaire it is important, for example, that they appreciate that these instruments do not represent tests or that their answers will be openly available to teachers within their school. The constructional aspects of each of the techniques is now considered in the following order.

Section 1 : Fixed Response Questionnaires

i) Likert

ii) Semantic Differential

iii) Forced Choice and Free Response

iv) Situation Type - Structured Response

Section 2 : Free Response Questionnaire

Open Response Situation Type

## Section 1 Fixed Response Questionnaires

### 1) Likert Technique

In the construction of the Likert questionnaire, in addition to the points noted in the introduction, a number of additional points are of particular note.

a) Particular attention was paid to the level of language and sentence structure used. The provisional items were submitted to a panel of six teachers for comments concerning both the language and suitability of the items for assessing the proposed dimensions. The items were subsequently revised in the light of comments. A minimum of twelve items was constructed for each construct to ensure, even with two or three poor items eliminated, a reliable scale could be constructed. In each case the twelve items selected were made as representative of the construct as possible.

b) The items formed one questionnaire of 120 items with the items from each of the separate constructs randomly distributed. The pupil responded to the items on a five point, agree to disagree, scale.

c) Attention was paid to the presentation of the questionnaire. It was initially thought that a total of 120 items would place considerable demand on the concentration of the pupils completing the questionnaire. A small scale pre-test indicated that this posed little, if any, difficulty. Comments on the suitability of the questions in terms of language were favourable at this stage.

The items presented in this questionnaire are noted in table 5.1.1. The complete questionnaire is contained in the appendix.

Table 5.1.1. LIKERT QUESTIONNAIRE ITEMS

The numbers following the statement indicate the questionnaire item number.

1) Commitment and Enjoyment of Science

| | | |
|---|---|---|
| 1.1) | I am always glad when school science lessons are over | 024 |
| 1.2) | I enjoy school science lessons | 086 |
| 1.3) | Science is my favourite subject at school | 067 |
| 1.4) | I would rather do any other subject than science at school | 057 |
| 1.5) | Science lessons in which we do experiments are boring | 116 |
| 1.6) | I look forward to doing science experiments in science lessons | 034 |
| 1.7) | I would rather read a book than do experiments in the science lessons | 102 |
| 1.8) | I would not be happy just being taught science without the practical work | 082 |
| 1.9) | In general I do not like science | 059 |
| 1.10) | Science is fascinating | 027 |
| 1.11) | I think science is interesting | 010 |
| 1.12) | Science is not worth bothering about | 106 |

2) Scientific Occupations

| | | |
|---|---|---|
| 2.1) | I should like to become a scientist when I leave school | 117 |
| 2.2) | Being a scientist is the last job that I would like | 094 |
| 2.3) | A scientific job is the job for me when I leave school | 040 |
| 2.4) | I would not like to become an engineer when I leave school | 108 |
| 2.5) | I would not like to become a science teacher | 073 |
| 2.6) | I would like to work in a science laboratory | 061 |
| 2.7) | I would rather be a scientist than a newspaper reporter | 064 |
| 2.8) | Working in an office would be better for me than working in a laboratory | 070 |
| 2.9) | I would rather join the policeforce than become a scientist | 104 |
| 2.10) | There is too much hard work involved in becoming a scientist | 079 |

Table 5.1.1. contd

| | | |
|---|---|---|
| 2.11) | I would have to stay at school too long to become a scientist | 050 |
| 2.12) | There is too much practical work in the job of a scientist to interest me | 044 |
| 3. | Scientific Interests and Pastimes | |
| 3.1) | I would help form a science hobbies club after school | 017 |
| 3.2) | I enjoy science as a hobby at home | 007 |
| 3.3) | If I was helping in the school play I would like to help with wiring the lighting | 053 |
| 3.4) | I would like to build my own radio | 090 |
| 3.5) | I should like to experiment with breeding fish to see how different kinds are produced | 036 |
| 3.6) | If someone gave me some money I would like to buy a chemistry set to do all sorts of experiments at home | 074 |
| 3.7) | I am interested about learning science at home | 054 |
| 3.8) | I would join a school science club | 112 |
| 3.9) | Science programmes on T.V. like 'Tomorrow's World' are great to watch | 103 |
| 3.10) | I like listening to science talks on the radio | 110 |
| 3.11) | I take books on science subjects out of the library | 096 |
| 3.12) | It would be fun to visit a science museum | 092 |
| 4. | Characteristics of the Scientist | |
| 4.1) | One has to be very intelligent to be a scientist | 052 |
| 4.2) | Scientists are scatterbrained | 060 |
| 4.3) | Scientists are dedicated to their work | 012 |
| 4.4) | Scientists are really boring people | 046 |
| 4.5) | When at home scientists lead a happy family life | 028 |
| 4.6) | When with other people scientists tend to be shy and withdrawn | 091 |
| 4.7) | Scientists often use their imagination to think up new ideas | 006 |
| 4.8) | A scientist works in a well planned orderly way | 021 |

Table 5.1.1. contd.

| | | |
|---|---|---|
| 4.9) | When trying to answer a difficult problem a scientist will keep on trying until it is solved | 078 |
| 4.10) | Scientist tell the truth about their work | 105 |
| 4.11) | A scientist will consider all the different ways of explaining a discovery before choosing the best | 087 |
| 4.12) | Scientists often work together and share their information | 014 |
| 5. | Difficulties with Science | |
| 5.1) | I do not find it hard to understand the ideas we are taught in science lessons | 020 |
| 5.2) | One needs to learn science 'off by heart' as it is difficult to understand | 099 |
| 5.3) | It is all the maths in science lessons that makes them so hard | 118 |
| 5.4) | One has to be good at maths to do well at science in school | 081 |
| 5.5) | Science lessons contain too many special words that I find hard to understand | 101 |
| 5.6) | If I could only see what all the special words and names meant in science it would be easy to do | 077 |
| 5.7) | I am no good at science because I cannot set science experiments up right | 083 |
| 5.8) | Practical work in science lessons is easy to do | 109 |
| 5.9) | I find it hard to see what the results from our practical work means | 013 |
| 5.10) | The results of the practical work in science really help you to understand science | 038 |
| 5.11) | There is just too much science to learn in school time | 031 |
| 5.12) | Too much work is crammed into too little time in science lessons at school | 005 |

Table 5.1.1. contd

| | | |
|---|---|---|
| 6. | Science and Society | |
| 6.1) | Science creates more problems than it solves in society | 058 |
| 6.2) | Science does more harm than good in society | 043 |
| 6.3) | The world is a better place to live in with science | 001 |
| 6.4) | Science helps mankind | 071 |
| 6.5) | Science has provided many labour saving devices for industry | 066 |
| 6.6) | Science has given us the ability to talk and see people all over the world | 042 |
| 6.7) | Science provides energy for our needs | 045 |
| 6.8) | Science produces too many dangerous weapons which could destroy mankind | 080 |
| 6.9) | The government should aid science by giving more scientists jobs and building more labs. | 008 |
| 6.10) | The money spent on science could be better spent elsewhere | 119 |
| 6.11) | Money spent on scientific projects is wasted | 039 |
| 6.12) | Scientists should be paid as much as 'pop stars'. | 084 |
| 7. | Science and the Individual | |
| 7.1) | I can travel all over the place easily thanks to science | 069 |
| 7.2) | Science has provided many helpful devices at home to make our lives easier | 056 |
| 7.3) | Thanks to science our houses are very comfortable compared with years ago | 114 |
| 7.4) | Science has provided medicines to keep us healthy | 075 |
| 7.5) | The clean and peaceful countryside has been spoiled for us by science | 100 |
| 7.6) | Science has provided us with plenty of food to eat | 120 |
| 7.7) | There is too much noise in our everyday lives because of science | 026 |
| 7.8) | Leisure toys such as the T.V. and radio have been provided for us by science | 011 |

Table 5.1.1. contd

| | | |
|---|---|---|
| 7.9) | We should all be involved in science in this day and age | 029 |
| 7.10) | Everybody needs to learn and understand science today | 063 |
| 7.11) | Science should be left to the scientists it does not concern me. | 085 |
| 7.12) | We all need to learn science to survive in this day and age | 113 |
| 8. | Scientific Theories and Laws | |
| 8.1) | Even though a scientific law has been stated this does not mean it may never need changing | 051 |
| 8.2) | Scientific theories and laws are true beyond any doubt | 097 |
| 8.3) | Laws and theories in science can be changed if new facts emerge | 003 |
| 8.4) | Scientific theories and laws are fixed for all time | 032 |
| 8.5) | New theories and laws in science are based on the old ones | 089 |
| 8.6) | A scientific theory or law can just be set up without bothering about what went before | 115 |
| 8.7) | When putting forward new theories scientists throw the old ones away. | 009 |
| 8.8) | The theories and laws of science today are stepping stones for the future | 076 |
| 8.9) | A useful thing about theories and laws in science is that they help tell us what might happen next | 035 |
| 8.10) | Scientific theories and laws only tell us what we know already | 095 |
| 8.11) | Scientific theories and laws help us predict the future | 002 |
| 8.12) | Scientific theories and laws do not tell us anything new | 068 |
| 9. | The Scientific Method | |
| 9.1) | Scientific ideas are based on observation | 025 |
| 9.2) | The scientific method is based on careful observation | 098 |
| 9.3) | A scientist obtains most of his information through reading and not experimenting | 015 |
| 9.4) | A scientist just guesses at the reasons behind why things happen in the world | 004 |

Table 5.1.1. contd.

| | | |
|---|---|---|
| 9.5) | A scientist should report exactly what he sees even if it does not seem right to him at the time | 033 |
| 9.6) | Scientists should check and recheck all the results of their experiments | 023 |
| 9.7) | When scientists carry out experiments they only need to consider one set of results | 016 |
| 9.8) | As a scientist, I know my experiments will always give me the right answers | 037 |
| 9.9) | Scientists should not criticise each other's work | 111 |
| 9.10) | If a famous scientist and an unknown scientist disagree we accept the opinion of the famous scientist | 107 |
| 9.11) | Even if a theory has been put forward by a great scientist it may be proved wrong by an unknown scientist. | 048 |
| 9.12) | A scientist is willing for others to try out his theories | 062 |
| 10. | The Aims of Science | |
| 10.1) | The importance of science is not in its ideas but what it can be used for. | 019 |
| 10.2) | The main aim of science today is to develop new products for man | 093 |
| 10.3) | Finding a use for a newly discovered substance is more important than finding out what it is made of | 049 |
| 10.4) | Science is valuable because it helps solve practical problems | 065 |
| 10.5) | Science aims to serve mankind | 018 |
| 10.6) | Science discoveries that do not have a practical use are a waste of time | 055 |
| 10.7) | Explaining the way of nature is more important than finding out how to use nature | 072 |
| 10.8) | Scientific discoveries are worthwhile even if they have no practical use at all | 030 |

Table 5.1.1. contd.

| | | |
|---|---|---|
| 10.9) | It is not the main aim of science to seek knowledge | 022 |
| 10.10) | Science is just for dreaming up new ideas | 088 |
| 10.11) | Ideas are the important products of science | 041 |
| 10.12) | Science is about explaining and describing how things happen in the world | 047 |

ii) <u>Semantic Differential Technique</u>

The following points were noted in the construction stage.

(a) Reference textbooks present guidelines for the construction of Semantic Differential items (Osgood et al,1957) and these were carefully adhered to. Particular notice was taken of the provision of pairs of adjectives with a continuous scale between them.

(b) It was found, through trial and construction of items, that the following dimensions

8) Scientific Theories and Laws

9) The Scientific Method

10) The Aims of Science

were difficult to construct meaningful items. These were omitted as noted in the previous chapter. The questionnaire constructed therefore assessed only the first seven dimensions.

(c) Each construct was represented by twelve items, giving a total of 84 items which were randomly ordered. A seven-point response scale was selected.

The items as presented on the questionnaire are noted in table 5.1.2. The complete questionnaire is contained in the appendix.

Table 5.1.2. SEMANTIC DIFFERENTIAL ITEMS

1) Commitment and Enjoyment of Science

| | | | |
|---|---|---|---|
| 1.1) | science lessons | enjoyable - not enjoyable | 14 |
| 1.2) | science lessons | unpleasant - pleasant | 39 |
| 1.3) | science lessons | interesting - boring | 23 |
| 1.4) | science lessons | stimulating - monotonous | 78 |
| 1.5) | practical work in science | not enjoyable - enjoyable | 60 |
| 1.6) | practical work in science | dull - exciting | 21 |
| 1.7) | practical work in science | interesting - boring | 49 |
| 1.8) | practical work in science | tedious - stimulating | 35 |
| 1.9) | science in our world | pleasant - unpleasant | 80 |
| 1.10) | science in our world | interesting - boring | 16 |
| 1.11) | science in our world | dull - exciting | 06 |
| 1.12) | science in our world | stimulating - monotonous | 53 |

2) Scientific Occupations

| | | | |
|---|---|---|---|
| 2.1) | a job as a scientist | boring - interesting | 61 |
| 2.2) | a job as a scientist | exciting - dull | 44 |
| 2.3) | a scientific career | interesting - boring | 67 |
| 2.4) | a scientific career | monotonous - stimulating | 54 |
| 2.5) | scientific work | enjoyable - not enjoyable | 27 |
| 2.6) | scientific work | boring - exciting | 82 |
| 2.7) | scientific work | hard - easy | 84 |
| 2.8) | becoming a scientist | difficult - straightforward | 25 |
| 2.9) | becoming a scientist | complex - simple | 51 |
| 2.10) | working in a science laboratory | tedious - stimulating | 32 |
| 2.11) | working as an engineer | interesting - boring | 72 |
| 2.12) | becoming a scientist | easy - hard | 69 |

Table 5.1.2. contd

| | | | |
|---|---|---|---|
| **3.** | **Scientific Interests and Pastimes** | | |
| 3.1) | taking up a scientific hobby | stimulating - dull | 11 |
| 3.2) | building a radio | boring - interesting | 04 |
| 3.3) | working with a chemistry set | not enjoyable - enjoyable | 75 |
| 3.4) | watching programmes on science on television | exciting - dull | 41 |
| 3.5) | a visit to a science museum | pleasant - unpleasant | 20 |
| 3.6) | running a science club | tedious - exciting | 28 |
| 3.7) | taking scientific books out of the library | interesting - boring | 76 |
| 3.8) | studying the weather | stimulating - monotonous | 57 |
| 3.9) | collecting and studying plants | dull - exciting | 50 |
| 3.10) | reading a science fiction book | entertaining - dull | 56 |
| 3.11) | collecting fossils and rocks | boring - interesting | 45 |
| 3.12) | studying the stars and planets | enjoyable - not enjoyable | 43 |
| **4.** | **Characteristics of the Scientist** | | |
| 4.1) | scientists | clever - dull | 74 |
| 4.2) | scientists | scatterbrained - thoughtful | 81 |
| 4.3) | scientists | boring - interesting | 08 |
| 4.4) | scientists | sociable - unsociable | 71 |
| 4.5) | scientists | unimaginative - imaginative | 17 |
| 4.6) | scientists | honest - dishonest | 42 |
| 4.7) | scientists in their work | easily diverted - persevering | 03 |
| 4.8) | scientists in their work | organised - disorganised | 13 |
| 4.9) | scientists in their work | unco-operative - co-operative | 31 |
| 4.10) | scientists in their work | indifferent - dedicated | 52 |
| 4.11) | scientists in their work | open-minded - narrow-minded | 40 |
| 4.12) | a scientist's family life | unhappy - happy | 10 |

Table 5.1.2. contd

5. Difficulties with Science

| | | | |
|---|---|---|---|
| 5.1) | scientific ideas | easy - hard | 12 |
| 5.2) | scientific ideas | complex - simple | 46 |
| 5.3) | science lessons involving maths | difficult - easy | 62 |
| 5.4) | science lessons involving maths | simple - hard | 34 |
| 5.5) | scientific terms and names | easy - hard | 48 |
| 5.6) | scientific terms and names | difficult - simple | 30 |
| 5.7) | the amount of work in science lessons | too much - too little | 36 |
| 5.8) | the pace of work in science lessons | rushed - slow | 55 |
| 5.9) | practical work in science | confused - clear | 09 |
| 5.10) | practical work in science | difficult to perform - easy to perform | 65 |
| 5.11) | practical work in science | straightforward - difficult | 19 |
| 5.12) | practical work in science | helps my understanding of science - does not help my understanding of science | 02 |

6. Science and Society

| | | | |
|---|---|---|---|
| 6.1) | science in our society | good - bad | 79 |
| 6.2) | science in our society | harmful - helpful | 70 |
| 6.3) | science in our society | useful - useless | 01 |
| 6.4) | science in our society | unimportant - important | 26 |
| 6.5) | science in our society | worthless - valuable | 22 |
| 6.6) | science in our society | threatening - comforting | 68 |
| 6.7) | science in our society | productive - wasteful | 73 |
| 6.8) | science in our society | safe - dangerous | 33 |
| 6.9) | science in our society | destructive - constructive | 05 |
| 6.10) | science in our society | chaotic - orderly | 63 |
| 6.11) | money spent on science | excessive - too little | 66 |
| 6.12) | money spent on science | well spent - wasted | 37 |

Table 5.1.2. contd

7. Science and the Individual

| | | | |
|---|---|---|---|
| 7.1) | science in relation to me | helpful - harmful | 24 |
| 7.2) | science in relation to me | useless - useful | 77 |
| 7.3) | science in relation to me | unimportant - important | 59 |
| 7.4) | science in relation to me | worthless - valuable | 29 |
| 7.5) | science in relation to me | comforting - threatening | 47 |
| 7.6) | science in relation to me | productive - wasteful | 64 |
| 7.7) | science in relation to me | dangerous - safe | 15 |
| 7.8) | science in relation to my health | helpful - harmful | 08 |
| 7.9) | learning about science | unimportant - important | 18 |
| 7.10) | learning about science | useful - useless | 83 |
| 7.11) | science in my home | useless - useful | 38 |
| 7.12) | learning about science | wise - foolish | 58 |

Note: the numbers following each statement refers to the questionnaire item number.

iii)

Forced Choice and Free Response

Following the discussion in the previous chapter the attitude constructs emerging from the attitude test analysis were classified into four major categories.

(1) Personal attitude toward science

- interest, commitment and enjoyment of school science
- scientific hobbies and pastimes
- difficulties of learning science
- personal view of the importance of learning science

(2) Scientists

- characteristics of the scientist as perceived by the pupils, intellectual and social attributes
- work habits of the scientist
- the educational requirements to become a scientist

(3) Social effects of science

- the benefits of science to society
- the illeffects of science within society
- science as a problem solving/problem creating force
- scientific expenditure

(4) Nature of science

- the scientific method
- scientific theories

Two instruments were constructed based upon this categorisation, a forced choice and a free response questionnaire. Each contained twenty-four tetrads, 24 items representing each category. Items were assigned randomly to present a different order within the tetrad on the final versions. In terms of the items all statements were non-controversial, and wherever possible any value judgements were removed.

The format of the forced choice questionnaire was such that the statements in each tetrad were rank ordered according to the level of importance attached to the statements by the pupil. All statements were to be accepted as true.

The format of the free response questionnaire was such that each statement within a tetrad could be assigned up to four votes according to the pupil's level of agreement with the statement. The votes could be used as often as the pupil desired.

The items corresponding to the four major categories are presented in table 5.1.3. together with their final allocation on the questionnaire. Each questionnaire contained the same body of items but a different set of instructions as to how to rate the individual tetrads or items. A complete version of each questionnaire together with an answer grid is contained in the appendix.

Table 5.1.3. Forced Choice - Free Response Questionnaire Items

The number before each item correspond to the items tetrad allocation.

The letter in brackets is the position within that tetrad.

Personal Attitude towards Science (PERSON)

1P (a) Science lessons contain many specialised words which can be difficult to understand

2P (b) One cannot learn much school science in school time.

3P (c) Building a radio can be an interesting thing to do.

4P (d) Science programmes on the T.V. are usually interesting to watch.

5P (a) One can learn much about science from library books.

6P (b) It could be enjoyable to own a chemistry set to do home experiments.

7P (c) Collecting fossils and rocks can be an interesting hobby.

8P (d) The experimental work in science lessons is usually interesting.

9P (a) Science is amongst the most popular subjects at school.

10P (b) Compared to other school subjects, science is generally one of the most interesting.

11P (c) School science is usually interesting.

12P (d) Some of the ideas we are taught in science lessons are difficult to understand.

13P (a) One usually needs to learn science 'off by heart' as it is difficult to understand.

14P (b) It can be important for everyone to learn about science today.

15P (c) The school science lessons are usually worth looking forward to.

16P (d) The science lessons are amongst the most enjoyable in the school.

17P (a) In general everyone needs to learn and understand science today.

18P (b) A science hobbies club could provide a good after school activity.

19P (c) Experiments in science lessons are generally difficult to set up.

20P (d) It is usual to find practical work in science difficult to do.

21P (a) It is the maths in science lessons that usually makes them so hard.

Table 5.1.3. contd

22P (b) Doing experimental work in science is usually enjoyable.

23P (c) In general science is an important subject to learn in this day and age.

24P (d) Science can be an enjoyable hobby at home.

SCIENTISTS (HUMAN)

1H (b) Generally scientists are not shy and lonely individuals.

2H (a) Scientists usually find their work stimulating and challenging.

3H (d) Scientists, like others, are concerned about the welfare of people.

4H (c) Scientists do not 'show-off' any more than other people.

5H (b) Scientists are no less friendly and sociable than are other people.

6H (a) Scientists are usually serious people, dedicated to their work.

7H (d) Scientists live a normal life at home just like anyone else.

8H (c) In their view of life scientists are generally broad minded.

9H (b) Generally scientists are dedicated to their work.

10H (a) In their approach to work scientists are usually thoughtful and precise.

11H (d) To become a scientist one has to stay at school and college a long time.

12H (c) Scientists are no more absent minded than are other people.

13H (b) Just like other people scientists can be interesting to talk and listen to.

14H (a) The scientist is usually thoughtful about his actions.

15H (d) All scientists, it seems, have to do well at school and college

16H (c) Scientists are generally intelligent people.

17H (b) A scientist usually works out all possible ways to answer a problem before choosing the best.

18H (a) To become a scientist a lot of hard work at school and college is required.

19H (d) A scientist tends to work in a well planned way.

20H (c) A scientist usually keeps an open mind when looking at a new problem.

21H (b) Scientists may often work together and share their findings.

22H (a) Scientists are just as creative as other people.

23H (d) Scientists are just as honest as other people.

24H (c) Generally scientists do not give up a problem easily.

Social Effects of Science (EFFECT)

1E (c) Money spent on scientific projects is usually money well spent.

2E (d) Science itself cannot be blamed for pollution.

3E (a) Our life is effected by the inventions of science.

4E (b) The government should aid science by financing research and building labs.

5E (c) The work of science in our society is usually worth rewarding.

6E (d) Because of the inventions of science, homes are now more comfortable than they used to be.

7E (a) Science itself cannot be blamed for changing the countryside.

8E (b) Leisure toys such as the T.V. and radio have been provided for us by science.

9E (c) Some of the problems of society have been eased by the inventions of science.

10E (d) The inventions of science themselves cannot be blamed for societies problems.

11E (a) One can help solve some of the problems in our society by using the works of science.

12E (b) The problems of our society cannot just be put down to the presence of science.

13E (c) Our lives have been made easier at home because of the inventions of science.

14E (d) The inventions of science have provided many labour saving devices for industry.

15E (a) The cause of the worlds troubles cannot just be put down to the work of science.

16E (b) Although weapons are produced by science, it is not the aim of science to use weapons to destroy man

17E (c) The presence of science in our society is generally beneficial.

18E (d) Science can allow us to talk and see people all over the world.

19E (a) The inventions of science can be used to help mankind.

20E (b) The wasting of our natural resources cannot just be put down to the work of science.

21E (c) The medicines which keep us healthy have been provided by science.

22E (d) In general the benefits of science to society are greater than any illeffects.

23E (a) It is not just the fault of science that there is noise in our everyday lives.

24E (b) Energy for our needs can be provided by science.

Nature of Science (NATURE)

1N (d) Scientific theories and laws usually have to be changed as time goes by.

2N (c) A scientific theory is only as good as are the observations on which it is based.

3N (b) Even if a famous scientist claims a theory is true, this does not mean that everyone will accept it.

4N (a) Laws and theories in science are changed if and when new facts emerge.

5N (d) Scientific ideas must always be based on careful observation.

6N (c) Theories and experiments suggested by one scientist are always checked by others before being accepted.

7N (b) Most of the information a scientist obtains on the world is through experimentation.

8N (a) It is always possible for an unknown scientist to prove the theories of a famous scientist wrong.

9N (d) When events happen in the world science tries carefully to reason out why.

10N (c) When a scientific law is stated it may need to be changed in the future.

11N (b) The basis of the scientific method is always careful observation.

12N (a) New theories and laws put forward in science include the old theories and laws.

13N (d) New scientific theories and laws are based on the old versions of the theories and laws.

14N (c) Scientific theories and laws do not tell us just what we know already.

15N (b) Theories and laws in science today are forming stepping stones for the future.

16N (a) We can use scientific theories and laws to predict future events.

17N (d) Scientific theories and laws may change with time.

18N (c) The checking and rechecking of the results from experiments is important in the scientific method.

19N (b) The meaning of the results from experiments are always considered carefully in science.

20N (a) When carrying out experiments in science a large number of results are always taken.

21N (d) Scientific theories and laws help us to predict the future.

22N (c) As our knowledge of science grows our scientific theories and laws may change.

23N (b) Everyone working in the field of science allows their work to be criticised by others.

24N (a) A useful thing about scientific theories and laws is that they may tell us what might happen next.

iv) Situation Type - Structured Response

In the construction of this questionnaire attempts were initially made to present relevant situations to the pupils. In a small-scale trial, using a straightforward interview technique, a situation was read to a pupil and a discussion followed as to the level of understanding of the particular item. This proved to be a useful exercise in terms of not only relevance but also the style and language appropriate to the pupil was revealed.

The structured questionnaire contained eighteen items in an attempt to cover the full range of themes identified within the attitude dimensions. Each situation is followed by a five-point structured answer and the pupils select the most appropriate answer to coincide with their particular view on the matter. In table 5.1.4. the items are presented, classified according to the dimension and general theme. Unlike the other questionnaires within the study, there exists a degree of imbalance between the numbers of items representing each construct. This obviously reflects the diversity of the main themes considered. It is certainly possible to remedy this point but the questionnaire would become exceedingly long. At this stage the questionnaire was used in this format with the thought that separate, extended questionnaires could be a possible future development depending on the performance of this initial version.

A complete copy is included in the appendix for future reference.

Table 5.1.4. Situation Type Structured Response Items

Commitment and Enjoyment of Science

(1) Roger and Paul were on their way to their next lesson.

"It's science next", said Paul. "I always enjoy science lessons."

Roger replied: "That's allright for you, but I am always glad when science lessons are over. I don't enjoy them at all."

Question: If you were walking alongside Roger and Paul, and they turned and asked you what you thought about science lessons, would you

(a) Strongly agree with Paul about science lesson?

(b) Mildly agree with Paul about science lessons?

(c) Strongly agree with Roger about science lessons?

(d) Mildly agree with Roger about science lessons?

(e) Neither agree or disagree with Roger or Paul?

(2) Going home on the school bus one day, Alan and Mike were discussing what school subjects they would do if they could pick for themselves. Alan said that science was his favourite subject and that he would choose to do science first of all his subjects.

Mike replied that he could not stand science and that there were lots of other subjects in school that he would put before science.

Question: If you could choose your school subjects, would you

(a) Be just like Alan and pick science as your favourite?

(b) Put science near the top of a list of your favourite subjects?

(c) Be just like Mike and pick another subject as your favourite?

(d) Put science near the bottom of a list of your favourite subjects?

(e) Not be bothered as all subjects are the same to you?

(3) Joy and Tracey had just sat down at their bench in the laboratory, when they heard the teacher say: "In this lesson we are going to do some practical work."

Joy immediately turned to Tracey and said: "Great! I always like practical work; let's get started!"

Tracey replied: "Well, I don't like doing practical work and I shall be glad when it's over."

Question: If you had been with Joy and Tracey, what would have been your view?

(a) I agree with Joy. I always like doing practical work in science lessons.

(b) I enjoy practical work in science lessons most of the time.

(c) I agree with Tracey. I don't like doing practical work in science lessons.

(d) I rarely enjoy doing practical work in science lessons.

(e) I never have really thought about whether or not I like practical work in science lessons.

(4) Brian had just arrived home from school one day when he overheard his brother, Mark, and his sister, Judith, talking.

Mark was saying how he was very interested in science and always enjoyed watching television programmes and reading newspaper reports on science.

Judith replied that she had no interest in science at all and always avoided anything to do with science on the television or in newspapers. When they saw that Brian was listening they asked him what his view was.

Question: If you were Brian what would your view be?

(a) Like Mark. I am very interested in science.

(b) I am interested in science now and then.

(c) Like Judith, I am not interested in science at all.

(d) I am very rarely interested in science.

(e) I am undecided about whether I am interested in science or not.

Scientific Occupations

(5) Bill was reading a book called "How to become a scientist".

John came up to him and said: "What are you reading that for?" You are not thinking of becoming a scientist when you leave school are you?"

Bill replied: "I certainly am. There are plenty of jobs which involve science that really interest me."

John responded by saying that he would never think of becoming a scientist, he was not interested at all.

Question: If you were discussing taking a scientist job on leaving school, with Bill and John, what would your view be?

(a) Like Bill. I would be very interested in taking a scientific job.

(b) I would be mildly interested in taking a scientific job.

(c) Like John. I would not be interested at all in taking a scientific job.

(d) I am not really interested in taking a scientific job.

(e) I am undecided about whether or not I would be interested in taking a scientific job.

(6) David was trying to make up his mind about what he would do when he left school. He was interested in science and so he asked his teacher about training to be a scientist. His teacher had told him that he would have to stay at school and work for a lot of exams before he could become a scientist.

Question: If you wanted to become a scientist, like David, how would what the teacher said affect you?

(a) It would not make any difference at all to my interest in becoming a scientist.

(b) I would probably still be interested in becoming a scientist.

(c) I would definitely give up any interest I had in becoming a scientist.

(d) I would probably not be interested in becoming a scientist.

(e) I am uncertain as to whether it would affect my interest or not.

Scientific Interests and Pastimes

(7) One afternoon Andrew was at home trying out an experiment with his science kit that he had been given as a Christmas present.

Ralph, his friend, called to see him and, seeing what Andrew was doing, said: "I cannot understand why you are so interested in playing around with that science stuff. I can think of lots of things I would rather do in my spare time than take up science as a hobby."

Question: How do you feel about science as a hobby ?

(a) Just like Andrew. I am very interested in scientific hobbies.

(b) I am sometimes interested in carrying out scientific hobbies.

(c) Just like Ralph. I am not interested at all in scientific hobbies.

(d) I am not usually interested in carrying out scientific hobbies.

(e) I am undecided or neutral about carrying out scientific hobbies.

(8) Gillian and Mary were looking at books in their school library. Gillian had picked out some books on science to read at home and she showed them to Mary and said: "These look really interesting. I will enjoy reading these at home."

Mary replied: "They would be the last thing that I would read in my spare time. I've taken out much more interesting books that have nothing to do with science."

Question: When selecting books from the school library, would you

(a) Always look for a book on science?

(b) Usually look for a book on science?

(c) Never look for a book on science?

(d) Occasionally look for a book on science?

(e) Not be bothered about what books you took out?

Characteristics of the Scientist

Peter and Steven were both looking through their daily paper to see what was on television that evening.

Peter said: "This show looks interesting. They are interviewing a famous scientist."

Steven said: "I don't think that will be very good. All scientists are dull people who don't lead very interesting lives."

Peter replied: "Well, I think it will be good. Scientists are not dull at all and usually have very interesting things to say about their lives."

Question: What is your view about scientists?

(a) I agree strongly with Peter.

(b) I agree mildly with Peter.

(c) I agree strongly with Steven.

(d) I agree mildly with Steven.

(e) I neither agree or disagree with Peter or Steven.

(10) Anne and Margaret were sitting watching a film on television. Part of the film was about a scientist who spent his time working

Anne said: "That's just like a scientist! Scientists are always by themselves and doing nothing but work all the time!"

Margaret replied: "No, that is just the film!" Scientists often spend time with other people; they might work like that sometimes but only if something important needs to be done."

Question: If you were watching the film with Anne and Margaret and they asked you what you thought about scientists and their work, would you

(a) Agree strongly with Anne?

(b) Agree mildly with Anne?

(c) Agree strongly with Margaret?

(d) Agree mildly with Margaret?

(e) Neither agree or disagree with Anne or Margaret?

Difficulties with Science

(11) Tim and Phil were coming out of their science lesson.

Tim said to Phil: "All this maths that we do in science lessons really puzzles me. I think that I could understand what was going on if we didn't have to keep doing maths as well."

Phil replied: "I find that it's all the long words that bother me. I just do not understand them."

Question: How do you feel about these problems in your science lesson?

(a) I agree with both Tim and Phil.

(b) I agree with Tim but disagree with Phil.

(c) I agree with Phil but disagree with Tim.

(d) I disagree with both Tim and Phil.

(e) I neither agree nor disagree with Tim or Phil.

(12) Janet and Michelle are talking about the problems they had with their science lessons.

Janet said: "My problem is that I cannot understand the ideas behind what we are taught in science. They just don't make any sense to me." Michelle said: "My problem is with the practical work in science. I just cannot set experiments up and get sensible results."

Question: How do you feel about these problems in your science lessons?

(a) I agree with both Janet and Michelle.

(b) I agree with Janet but disagree with Michelle.

(c) I agree with Michelle but disagree with Janet.

(d) I disagree with both Janet and Michelle.

(e) I neither agree nor disagree with Janet or Michelle.

(13) Dawn was talking to Mary about science lessons in their school.

Dawn said: "I find that there is always too much to do in our science lessons and so I have to do a lot of work in my spare time to keep up and to understand what is going on."

Question: If you were Mary and Dawn was talking about science lessons in your school, would you.

(a) Agree with Dawn, that there is always too much to do in your science lessons?

(b) Agree that there is sometimes too much to do in your science lessons?

(c) Disagree with Dawn, and say that there is always too little to do in your science lessons?

(d) Disagree and say that there is sometimes too little to do in your science lessons?

(e) Neither agree nor disagree with Dawn?

Science and Society

(14) Jane and Mike were watching the news on the television when it was announced that a large sum of money had been given to a new science project.

Jane said: "Ithink it is wrong to give science so much money. All science does is cause trouble and make a mess in our world."

Mike had a different view and said: "Well I think that science should have as much money as it needs. Science helps us to solve all our problems today."

Question: If you were watching the television with Jane and Mike, would you

(a) Agree strongly with Jane?

(b) Agree mildly with Jane?

(c) Agree strongly with Mike?

(d) Agree mildly with Mike?

(e) Neither agree nor disagree with Jane or Mike?

Science and the Individual

(15) One afternoon Jenny and Sheila were listening to records in Jenny's house.

Jenny said "You know if it were not for science we would not be able to listen to these records.

Sheila, looking puzzled, asked: "What do you mean?"

Jenny replied: "Well scientists discovered all the things that go together to make a record and a record player, you see. Science does a lot for us."

Sheila then said: "You could be right there but science has also spoilt the peace and beauty of some of our countryside, through all the discoveries science has made in helping industry."

Question: How do you feel about science and your everyday life?

(a) I agree with Jenny and Sheila.

(b) I agree with Jenny but disagree with Sheila.

(c) I agree with Sheila but disagree with Jenny.

(d) I disagree with both Jenny and Sheila.

(e) I neither agree nor disagree with Jenny or Sheila.

Scientific Theories and Laws

(16) John and Ian were sitting at their bench in the science laboratory, when they heard the teacher say: "Today we are going to look at some famous theories and laws in science."

John whispered to Ian: "What does he mean by theories and laws in science?"

Ian replied: "I think they are a way of making a summary of what we know in science and helping us say what might happen next. They change as time goes on as more things are discovered."

John then said: "Oh! I thought they were certain true facts in science that never changed."

Question: If John and Ian asked you to decide which of their views was closest to your own, would you

(a) Agree strongly with John?

(b) Agree mildly with John?

(c) Agree strongly with Ian?

(d) Agree mildly with Ian?

(e) Neither agree nor disagree with John or Ian?

The Scientific Method

(17) At the end of a science experiment, the teacher had collected all the observations made by the class on the board. He then asked everyone to examine these observations carefully and to explain what had happened in the experiment.

Gary said to Nigel: "This is the way science works. First you observe what goes on and then you try to make sense of it."

Nigel replied: "I thought that science worked by scientists just thinking about the world and then deciding what was right."

Question: If Gary and Nigel asked you how you thought science worked, what would you say?

(a) I would be intotal agreement with Gary.

(b) I would mildly agree with Gary.

(c) I would be in total agreement with Nigel.

(d) I would mildly agree with Nigel.

(e) I would neither agree nor disagree with Gary or Nigel.

The Aims of Science

(18) Carol was writing down in her book a list of different types of materials which the teacher had written up on the blackboard.

Susan, her friend said: "I'm fed up of doing this. Why can't we do something useful? After all that is what science is about, namely, being useful to people."

Carol replied: "Well I think that science is really for collecting together facts about the world and putting them down in order."

Question: What do you think science is about? Would you

(a) Agree with both Carol and Susan?

(b) Agree with Carol but disagree with Susan?

(c) Agree with Susan but disagree with Carol?

(d) Disagree with both Carol and Susan?

(e) Neither agree nor disagree with Carol or Susan?

## Section 2 Free Response Questionnaire

### Open Response Situation Type

Following in the construction of the structured response technique a number of the items were immediately available as 'open' items for this questionnaire. The items were modified to cover the range of dimensions but using one item per dimension. The items representing each dimension are noted in table 5.2.1.

In the completion of this type of questionnaire it is important to stress in the instructions that the response is important and not considerations such as spelling and punctuation or even filling the available space.

A complete version of the questionnaire is included within the appendix.

Table 5.2.1. Open Response Situation Type Items

Commitment and Enjoyment of Science

(1) Roger and Paul were on their way to their next lesson.

"It's science next", said Paul. "I always enjoy science lessons."

Roger replied:"That's alright for you, but I am always glad when science lessons are over. I don't enjoy them at all."

Question: Suppose that Roger and Paul asked what you thought about science lessons. Write down below what you would say to them.

Scientific Occupations

(2) Bill was reading a book called 'How to become a scientist'.

John came up to him and said: "What are you reading that for? You are not thinking of becoming a scientist when you leave school are you?"

Bill replied: "I certainly am. There are plenty of jobs which involve science that really interest me."

John responded by saying that he would never think of becoming a scientist because it would take too much hard work.

Question: What do you think about becoming a scientist after leaving school? Write your answer in the space below.

Scientific Interests and Pastimes

(3) One afternoon Andrew was at home trying out an experiment with his science kit that he had been given as a Christmas present. David, his friend, called to see him and, seeing what Andrew was doing, said: "I cannot understand why you are so interested in playing around with that science stuff. I can think of lots of things I would rather do in my spare time than take up science as a hobby."

Question: How do you feel about science as a hobby?

Characteristics of the Scientist

(4) Anne and Margaret were sitting watching a film on television. Part of the film was about a scientist who spent his time working alone on experiments in his laboratory.

Anne said: "That's just like a scientist! Scientists are always by themselves and doing nothing but work all the time."

Margaret replied: "No, that is just the film! Scientists often spend time with other people; they might work like that sometimes but only if something important needs to be done."

Question: What are your thoughts about scientists and their work?

Difficulties with Science

(5) Tim and Phil were coming out of their science lesson.

Tim said to Phil: "All this maths that we do in science lessons really puzzles me. I think that I could understand what was going on if we didn't have to keep doing maths as well."

Phil replied: "I find that it's all the long words that bother me. I just do not understand them."

Question: What problems do you have with school science?

Science and Society

(6) Jane and Mike were watching the news on the television when it was announced that a large sum of money had been given to a new science project.

Jane said to Mike: "I think that it is wrong to give science so much money. All science does is cause trouble and make a mess in our world."

Mike had a different view and said: "Well I think that science should have as much money as it needs. Science helps us to solve all our problems today."

Question: What do you think about science in our world?

Science and the Individual

(7) One afternoon Jenny and Sheila were listening to records in Jenny's house.

Jenny said: "You know if it were not for science we would not be able to listen to these records."

Sheila, looking puzzled, asked: "What do you mean?"

Jenny replied: "Well scientists discovered all the things that go together to make a record and a record player, you see. Science does a lot for us."

Sheila then said: "You could be right there but science has also spoilt the peace and beauty of some of our countryside, through all the discoveries science has made in helping industry."

Question: What do you think about science and yourself?

Scientific Theories and Laws

(8) John and Ian were sitting at their bench in the science laboratory when they heard the teacher say: "Today we are going to look at some famous theories and laws in science."

John whispered to Ian: "What does he mean by theories and laws in science?"

Ian replied: "Ithink they are a way of making a summary of what we know in science and helping us say what might happen in the future. They change as time goes on as more things are discovered."

John then said: "Oh! I thought they were certain true facts in science that never changed."

Question: Suppose John asked you what you thought about theories and laws in science. Write down below what you would say to him.

The Scientific Method

(9) Gary and Nigel had just finished doing an experiment in their science lesson. Their teacher then told everyone to carefully examine the results from their observations and then to use their results and everyone else's to explain as a class, what had happened in the experiment.

Gary said to Nigel: "This is the way that science works. First of all you observe what goes on and then you try and make sense of it." Nigel replied: "I thought that the way science worked was by scientists just thinking about the world and deciding what they thought was right.

Question: How do you think that science works?

The Aims of Science

(10) Carol was writing down in her book a list of different types of materials which the teacher had written up on the blackboard. Susan, her friend, said: "I'm fed up of doing this. Why can't we do something useful? After all that is what science is about, namely, being useful to people."
Carol replied: "I do not think that is true. I think that science is really for collecting together facts about the world."

Question: What do you think that science is about?

In this chapter the design and construction of the attitude based questionnaires have been considered. The questionnaires represent the range of measurement instruments used in attitude research and are based upon clearly defined, operational constructs.

# CHAPTER SIX

## THE TEACHER-PUPIL RATING INSTRUMENT

The assessment of pupils by teachers is a process which is a key part of education. In the field of attitudinal assessment teachers have, however, rarely been asked to provide evaluations of their pupil's attitudinal characteristics. This is perhaps unusual as firstly, they are in a favourable position to assess pupils and secondly, as noted in the review, attitudinal variables have formed important aims in relation to curriculum developments of late. Generally the assessment of pupil's attitudinal characteristics have relied upon the questionnaire techniques which have been considered in the previous three chapters. As this research study is primarily concerned with the evaluation of different methods for the assessment of attitudes to science, the incorporation of a teacher based assessment was seen as important as a separate measurement technique. It was also seen as a potentially useful technique for further research work in this and other related areas of pupil assessment.

In terms of related areas, teacher based assessments form the basics not only of the ongoing evaluation a teacher makes of the student's progress but also increasingly of continuous assessments made for external examinations. Although specifications for assessments are often provided, no account of the pupil variables which may influence this assessment have been considered. The nature of a teacher's assessment of a pupil would, intuitively, seem to be a complex weighing of relevant factors reduced usually to a single numerical estimate. The factors or assessment criteria a teacher uses in reaching an assessment of whether a pupil is 'good' or 'poor' have never been made explicit. If it became possible to reveal these assessment criteria in some detail it may well provide a means of examining these criteria and their inter-relation with respect to the assessment of pupils. Thus one could build a picture of teachers evaluation criteria and see to what extent the assessment of one criterion was inter-related with another. Above all it could well prove possible to identify key assessment criteria around which many other criteria are associated. Then, importantly, how these key criteria relate to pupil completed assessment instruments. Particularly, in this study, for attitudinal based instruments.

In the following sections the general view of teacher pupil assessment criteria is considered first, followed by a detailed consideration of the constructions and field testing of a teacher pupil rating instrument.

## Section 1 The Characteristics of Teacher Assessment

The criteria by which teachers assess their pupils could simply be stated and some measure of recognition for terms such as 'achievement', 'effort', and 'classroom behaviour' gained. However, this is unsatisfactory for two major reasons. Firstly, can we be sure that such criteria are the important axes of assessment? Secondly, when teachers assess under such criteria, can we be sure that despite assessing under a common name, such as achievement, that all teachers are assessing the same construct? Uncertainty here would place all comparisons with teacher based assessment in serious doubt. An analysis of teacher-pupil assessment was therefore required, such that

(a) the breadth of teacher-pupil assessment could be recorded, and

(b) what teachers were assessing could be clarified for future use.

To facilitate these aims, an analysis of teacher-pupil assessment was undertaken. To establish teacher-assessment constructs a repertory grid technique was employed. This is a standardised procedure for investigating individual perceptions developed by G.A.Kelly (Kelly, 1955). Essentially the procedure assumes that each person perceives the events and people in his or her life through a repertoire of bi-polar constructs. Nash has used this technique successfully in revealing some of the constructs employed by primary and secondary school teachers in their perceptions of their pupils (Nash, 1973). In this case our interest lies in how a teacher perceives the class of children in front of him, and importantly, what specific personal constructs the teacher employs in assessing those children.

The technique is explained in detail in a number of standard texts (Kelly, 1955). Essentially the form used here involves the teacher considering a series of cards. Each card has the name of an individual pupil printed upon it and the set of cards represents a complete class that the teacher is responsible for in a teaching situation. The teacher is then asked to view the complete set of cards before him and to begin to differentiate between pupils on a criterion he or she would use. A teacher may well say these pupils are 'hardworking', all the cards representing these students would be grouped together and identified in the teacher's own words as hardworking. The teacher would then be required to identify the remaining pupils in terms of an opposing characteristic of his choice, for example 'lazy'. In this way a number of bi-polar characteristics would be elicited, each with two key words, clearly defined by the teacher. The procedure would then be repeated using a further characteristic. This continues until the teacher feels that the constructs elicited present as complete a picture of the particular group as possible. A complete list or 'map' of the teacher's constructs is then arrived at.

Construct 'maps' were to be established for a sample of teachers. Consideration was given to the various factors that could effect the construct maps teachers would produce. It is almost certain that the age and ability of the students under consideration would govern the constructs considered. Differences may well be apparent according to age and/or experience of the teacher concerned. The sex of the teacher and to some extent the teaching approach could also be considered (Taylor, 1976). To minimise effects of this nature, a sample of teachers was drawn up which was related particularly to the study in hand. The construct maps were established for second year secondary pupils in mixed ability science classes. A balance according to sex and experience of the teacher was also achieved.

Each teacher completed a series of cards for their particular class to encourage recognition of the students. Once the task was explained no help was given or in fact required. A careful note was taken of all constructs used in terms of

(a) the bi-polar words used and

(b) a brief description of the construct given by the teacher.

For the sample of teachers used (ten in all), some 58 constructs were elicited. The standard technique would then be to proceed to take each teacher and further examine the relationship for an individual with his or her own constructs. This is achieved by asking them to rate each student in the group on each construct on a five or seven point semantic differential type scale. However, the essential part of this exercise was to obtain information concerning the nature of teacher assessment within the classroom. Having achieved this it was decided to use these characteristics to form the basis of a composite instrument so that certain representative characteristics could be examined for all teachers. A general pattern of relationships could then be established between these characteristics and a more useful assessment tool developed.

Considerable care was exercised over the choice of characteristics to be used further. The following points were of concern.

(a) Frequency of occurrence.

The characteristics which occurred more often in the construct map were obviously of importance. Four groups of characteristics were used by all teachers in the pilot study in some form.

(1) ability of the pupil for example, 'bright', 'able';

(2) the personal application of the pupil to work, for example, 'hardworking';

(3) classroom behaviour for example 'disruptive';

(4) the presentation of the pupil's work.

(b) Range of characteristics.

Although an extensive technique for eliciting constructs was used it is unsatisfactory to select those specified according to frequency alone. This is because;

(i) teachers may not be overtly aware of important characteristics they have missed, and

(ii) the major questions we are asking require an examination of the relationships between characteristics but particularly the place of attitudinal characteristics in relation to them. The constructs of 'attitude to science' or 'interest in science' was used rarely but this may be because of misunderstanding of the construct or the incorporation of this construct under a more every-day guise.

By extending the range of characteristics covered beyond a simple frequency criterion a more informative result, in the light of this study certainly, ensued. Considerable effort was applied in conversation with teachers to clearly express a construct in a precise and unambiguous way. In selecting representative constructs, constructs were required which could be recognised by teachers as being part of the legitimate domain of assessment of pupils. As they originated from teachers, this should be so but certain teachers in the repertory grid stage extended their perception of the assessment task to include very wide ranging characteristics such as 'level of parental concern' and the personal honesty of the pupil. Whilst important for some teachers a restriction was placed on these for the purpose of the study. It is important to realise that this reductionism, although undesirable in theory, will produce a more relevant instrument in practice. The range of characteristics selected for further use are described in table 6.1.1. The scales used in the rating instruments are also noted here together with later abbreviations.

Table 6. 1. 1. Selected Characteristics of Teacher-Pupil Assessment

The abbreviated name follows the description in brackets.

1. General Ability - The general ability of the pupil to cope intellectually with the academic rigour and demands of the school curriculum in general. (GENABIL) Scale, high - low

2. Ability in Science - The ability of the pupil to cope intellectually with the academic rigour and demands of the science subject(s) studied. (SCIABIL) Scale, high - low.

3. Literacy- The ability of the pupil to comprehend written and oral communications and skill in the use of language. (LITER) Scale, high-low.

4. Numerical Ability - The competence of the pupil in performing mathematical manipulations and calculations with acceptable speed and accuracy. (NUMABIL) Scale, high - low.

5. Manipulative Skills - The competence of the pupil in the careful and dexterous handling and use of equipment in the orderly execution of practical tasks. (MANSKIL) Scale, dextrous - hamhanded, careful - careless.

6. Observational Ability - The ability of the pupil to observe scientific phenomena in a reliable manner and to take accurate measurements and readings. (OBSABIL) Scale, high - low.

7. Personal Application - The application of the pupil to his/her academic work in the science subject(s) within the classroom. (PERSAPPL) Scale, tries hard - makes little effort.

8. Academic Performance - The achievement of the pupil in the science subject(s) studied compared with his/her academic potential in the subject(s) (ACADPERF) Scale, works to full potential - underachieves

9. Trend in Achievement - The trend in achievement of the pupil in terms of whether the pupil's achievement has improved or deteriorated over the last two terms. (ACMTREND) Scale, performance improving - performance deteriorating.

10. Written Classwork - The neatness and legibility of the pupil's written work in class. (CLASSWRK) Scale, neat - untidy, readable - illegible.

11. Homework Punctuality - The punctual completion and submission by the pupil of homework assignments. (HWKPUNCT) Scale, always punctual - always late.

12. Quality of Homework - The pupil's homework in terms of the quality and organisation of its content. (HWKQUAL) Scale, high - low

13. Effort in Homework - The 'effort' made by the pupil in the preparation of his/her homework is evidenced, for example, by the care and thoroughness taken over it. (HWEFF) Scale, tries hard - makes little effort

14. Classroom Behaviour - The overt behaviour of the pupil in the classroom in terms of his/her influence on the normal flow of the lesson. (CLASBEH) Scale, co-operative - unco-operative disruptive.

15. Personality - The personality of the pupil in the classroom in terms of whether he/she is lively and outgoing, as opposed to shy and withdrawn. (PERSON) Scale,- outgoing - shy; lively - withdrawn

16. Maturity - The level of maturity displayed by the pupil in the classroom in terms of whether the pupil's behaviour is mature and sensible, as opposed to immature and childish for his/her age. (MATURE) Scale, mature - immature, sensible - childish.

17. Interest in Science - The pupil's interest in the science subject(s) studied as reflected by his/her eager involvement in all activities within the classroom. (SCIINT) Scale, keen - disinterested, active - passive.

18. Motivation toward School - The pupil's intrinsic drive towards learning and school work in general. (SCHMOT) Scale, eager - indifferent, ambitious - unconcerned.

19. Motivation toward Science - The pupil's intrinsic drive towards science work and science learning activities. (SCI MOT) Scale, eager - indifferent, ambitious - unconcerned.

20. Attitude toward School - The like or dislike and degree of commitment the pupil has toward school. (SCHATT) Scale, likes and is committed to school - dislikes and is committed against school.

21. Attitude toward Science - The like or dislike and degree of commitment the pupil has toward the science subject(s) studied. (SCIATT) Scale, likes and is committed to science- dislikes and is committed against science.

## Section 2 The Teacher-Pupil Rating Schedule

In order that the relationship between the pupil characteristics could be investigated, two instruments were devised for the teachers to complete. In each case, teachers were asked to rate the pupils in their class for each of the characteristics selected. The characteristics were described and the rating performed on a bi-polar scale of seven divisions. The development of two instruments arose due to the difficulty in resolving a question concerning the most appropriate method for rating a class. Two methods were considered:

(i) The pupils were considered individually and rated on all of the characteristics (Format A).

(ii) The pupils were considered as a group and rated on one characteristic at a time (Format B).

Each method has its merits. Taking one pupil at a time would focus the attention of the teacher on that particular pupil and would encourage a profile-like assessment of the pupil on all the characteristics. Considering the pupils as a group with one characteristic at a time would focus the attention of the teacher clearly on the characteristic to be rated and encourage comparative judgements across the whole group. Both formats were used and a teacher questionnaire was developed to gain comments on the suitability of the characteristics and the time for completion of the ratings. Copies of these instruments are to be found in the appendix. The ratings, for both formats, were completed by the original group of teachers and a further ten teachers, making twenty in all. The total number of pupils rated on these schedules was 572 (50.4% male, 48.6% female).

Each scale on each characteristic was assigned a rating of value one to seven according to polarity. The responses of the teachers were then marked, recorded and entered onto a computer file. The relationships between the characteristics were examined using a factor analytic procedure consisting of a principal component analysis followed by a varimax rotation.

The two formats were analysed independently. A number of results emerged from this analysis.Initially the two formats produced similar patterns of relationships between the characteristics and so further comments will therefore be related to both formats. These relationships are in the form of correlation coefficients and factor analysis patterns.

The factor analysis to Kaiser's criterion produces three clear factors which account for nearly eighty percent of the total variance. The three factors contain characteristics which tend to reflect the following orientations.

Factor One:- The pupil's performance in science,

Factor Two:- The pupil's academic abilities,

Factor Three:- The pupil's personality.

(see table 6.2.1.)

The major characteristics on the first factor relate to the actual performance of the pupil on work in the classroom. This includes, in terms of major loadings, personal application, academic performance, achievement trend, the homework assessments, and maturity. The characteristics relating to motivation and attitude are shared across all three factors and interest across the first and third factor. The school based motivation and attitude characteristics have their major loading here. The assessment of the pupil's classwork is shared with the second factor.

The major characteristics on the second factor relate to academic abilities. General ability, ability in science, literacy, numerical ability, manipulative skill and observational ability are the characteristics with clear major loadings on this factor. The homework assessments also have minor loading on this factor as do the motivation and attitude characteristics.

The major characteristics on the third factor relates to the assessment of the pupil's personality. Although the science based assessments of interest, motivation and attitude have their major loadings, here, as well, only the personality characteristic shows no associations on the other factors.

Table 6.2.1. Pupil Rating Schedule Characteristics

(Varimax Analysis to Kaisers Criterion)

Total Variance 79.4%

| CHARACTERISTIC | FACTOR 1 | FACTOR 2 | FACTOR 3 |
|---|---|---|---|
| GENABIL | | 86 | 31 |
| SCIABIL | | 82 | 36 |
| LITER | | 86 | |
| NUMABIL | | 86 | |
| MANSKIL | 50 | 64 | |
| OBSABIL | 43 | 66 | 34 |
| PERSAPPL | 86 | | |
| ACADPERF | 83 | | |
| ACHTREND | 58 | | 33 |
| CLASSWRK | 52 | 55 | |
| HWKPUNCT | 80 | 30 | |
| HWKQUAL | 64 | 58 | |
| HWKEFF | 86 | 31 | |
| CLASSBEH | 82 | | |
| PERSON | | | 53 |
| MATURE | 59 | 37 | |
| SCIINT | 57 | | 66 |
| SCHMOT | 62 | 49 | 48 |
| SCIMOT | 58 | 40 | 64 |
| SCHATT | 61 | 48 | 45 |
| SCIATT | 57 | 37 | 65 |

The decimal point has been omitted from these loadings.

The abbreviations are noted in full on table 6.1.1.

It is interesting to speculate on this analysis. Overall it would seem that the teachers perceive three general areas in their assessment of the pupil, the pupil's academic ability or natural ability; the pupil's actual performance in the subject and their personality. 'Ability', 'Effort' and the pupil's behaviour in terms of being 'lively' or 'dull' seem to be familiar areas of teacher comment. The affective characteristics, interest, attitude and motivation seem to relate to all three areas. This would indicate either that no clear perception of these characteristics exists or that affective characteristics are indeed reflected, in all aspects of the teachers perception, that is of performance, ability and personality.

An examination of the correlation matrix reveals that the majority of the characteristics are significantly correlated to one another (one percent significance or greater) with the sole exception of personality and achievement trend, homework punctuality and effort and classroom behaviour. The factor analysis indicates that there are three areas that comprise the basis of teacher assessment. The individual characteristics may reflect one area more than another when the teacher rates them but overall the rating of one characteristics must be related to another either intentionally or through a form of co-judgement. It must be noted that this may well be the case as the limits of accurate perception of teachers with large mixed ability classes may well be restricted. A certain degree of associated judgement from one characteristic to another is inevitable.

The separation between classroom behaviour and personality is <u>not</u> a finding which may have been expected. The relationship between an extrovert pupil and his or her level of disruptiveness would, on first thought, be expected. The teachers in this study are overall making the fair judgement that a lively pupil is not necessarily disruptive or cooperative in the classroom.

On the basis of the full analysis, a number of characteristics were selected to form a further instrument to be used in conjunction with the main empirical study. A number of points were considered from responses to the teacher questionnaire as well.

(1) The teachers much preferred the rating schedule format B in terms of time and ease of use. That is the rating of all pupils on one characteristic at a time.

(2) Homework characteristics were thought to have the least relevance to an assessment schedule for this particular population of pupils.

(3) Difficulties were expressed by some teachers in the independent assessment of closely related characteristics such as 'General Ability and 'Ability in Science' and 'Science Attitude' and 'Science Interest' to note two. Some teachers thought that general school based characteristics such as 'School Motivation'and 'School Attitude' were difficult to assess as well as to separate.

In the light of these comments and the previous analysis six characteristics were chosen to form part of a further Pupil Rating Schedule of the B format:

(1) Ability in Science

(2) Personal Application

(3) Personality

(4) Science Attitude

(5) Science Interest

(6) Classroom Behaviour

The first three characteristics represent the three main areas identified. Two further points should be added. Both Science Interest and Science Attitude were selected because, although they are regarded as identical in the view of the teachers, preliminary evidence indicates that they are different in terms of pupil response. To include both is important, as part of the original intention of developing a teacher assessment instrument was to examine the relationship between teacher ratings of pupils and the pupil's expression of interest and attitude within science. It may be that one of the pupil domains is related to the teacher assessments more than the other.

The inclusion of the characteristic 'Classroom Behaviour' is to facilitate further evidence on its relationship with the other characteristics, particularly personality, within a larger study.

In this chapter a range of teacher assessment characteristics have been identified and specified as operational assessment scales. In a pilot analysis of the relationship between these characteristics although they are, for the majority, clearly interelated, there appear to be three underlying areas which comprise teacher assessments. These areas group together

(1) the pupil's academic ability or capability

(2) the pupil's performance or actual achievement and

(3) the pupil's personality.

An instrument reflecting these key areas together with the particular areas of science attitude and interest an assessment of classroom behaviour have been prepared and included in the main comparative study.

# CHAPTER SEVEN

## THE EMPIRICAL STUDY

The previous chapters have specified particular assessment techniques which are used to assess attitudinal constructs. This chapter deals specifically with the organisation of the field study and the marking procedures adopted. The first section concerns itself with prescribing the requirements to facilitate the comparison of the techniques developed in the earlier chapters and with a suitable prescription of sample size and composition. The second section concerns itself with the organisation of the field study and the resulting details of the field materials tested. The final section concerns itself with the marking procedures and the organisation of the data file for computer based analyses.

### Section 1 The study format and population

In the previous chapters a number of assessment instruments have been developed and constructed with the central aim of providing a comparitive analysis of attitudinal constructs on different methods of assessment. The instruments noted below, with future abbreviations, were required for direct comparison with one another.

| Questionnaire | Abbreviation |
|---|---|
| Likert | L |
| Semantic Differential | S.D. |
| Forced Choice - Free Response | FC - FR |
| Situation Type - Structured Response | ST (1) |

In addition to these the Pupil Rating Schedule (P.R.S.) was incorporated to provide comparative data on teacher and pupil assessment. The open response situation type questionnaire (ST(2) ) was also developed to provide additional comment on the construct domains of the pupils.

To facilitate the necessary comparisons of the questionnaires and schedules certain requirements were identified,

(1) Each questionnaire technique and the rating schedule must be able to have direct comparison with each other. To perform satisfactory statistical analysis a group of at least 100 pupils would be required for each comparison as a general rule.

(2) Each questionnaire must be examined statistically for internal reliability and validity. To perform satisfactory statistical analysis on a questionnaire an additional number, beyond the number required for the comparative study, may be required.

The provision of a pupil population to meet such requirements is possible in a number of ways; for example, a complete comparison of the questionnaire and measures could be carried out using 100 pupils, from one school, for five test sessions. However, the school concerned would obviously impose some limitation on the time their pupils would be available for. It must also be noted that considerably more pupils are required for the internal analysis of certain questionnaires. With these points in mind a matrix form of testing was proposed.

This form of testing involves the dividing of the number of comparisons required into smaller units such that a certain number of questionnaires are completed within one school and further sets are undertaken in other schools. For example one school would complete the Likert, Semantic Differential and Situation Type questionnaires where as another would complete the Likert, Free Response and Forced Choice questionnaires. Initially, it was thought that a school could offer perhaps 100 students who could complete three separate questionnaires. To ensure the completion of the full programme a matrix was drawn up to monitor the questionnaires. Attention was then given to the sample population. The sample population that was selected was drawn from the second year of secondary schools. A number of points were considered in arriving at this selection. Initially a population was required that had experienced science teaching to enable relevant expressions concerning the pupil's attitude toward science to be current. The general policy of many schools in the area of the study was to begin teaching separate science subjects at the beginning of the third year occasionally with options which removed one or more of the aspects of a general science course. That is a selection from physics, chemistry and biology. Previous research workers have made attempts to specify attitudes towards particular branches of science (Archer, 1951, Gardner 1972) and thus it was thought that to select the study population from pupils beyond the second year may cause problems with the particular interpretation of science the pupils held. Generally up until the third year of secondary education all pupils will have experienced the full breadth of science courses either through a combined science scheme or lessons reflecting each of the main subject areas. The basis for the pupils' own assessments would be approximately the same throughout the sample if then they were drawn from the second year.

Further to this point, consideration was also given to the composition of the sample in terms of male and female pupils. Again beyond the second year the balance of male to female pupils studying science subjects tends to move in favour of the male group. In the schools in the area this tends to be the case despite biology attracting a reasonable subscription from female pupils. Up to the second year the balance is approximately equal between the sexes.

Finally consideration was given to the attitude domains that pupils of this sample population were likely to possess as part of their perceptions. In the construction of attitude based questionnaires in the past, a wide range of domains or construct areas have been used regardless of the age of the pupil. This emerged from the analysis of the instruments considered in Chapter three. It also became apparent that a number of these domains could be considered as requiring a large cognitive component of attitude for their assessment to be realistically undertaken. In relation to this and the suggested sample population it may well be that attempts to assess such areas as scientific theories and laws or the scientific method are unlikely to succeed on these grounds. Two points were noted however relating to this, firstly an essential part of the study is to incorporate the full range of dimensions used by workers in this field to ascertain their suitability and secondly, the extent to which current science teaching practice would provide cognitive examples in these areas for older pupils is by no means certain. In other words, selecting the sample from an older population would not guarantee an improvement in the assessment of these areas. On balance the sample population was specified in terms of second year secondary pupils.

## Section 2 The organisation of the field study

A preliminary programme was drawn up to facilitate the completion of a full comparison matrix and to ensure that sufficient numbers of pupils completed each questionnaire. Some twenty-five schools in the Staffordshire area were contacted to help in the study. When their own timetable limitations and the number of pupils available were taken into consideration many modifications were necessary to ensure the complete programme. Eventually nine schools were involved in the main programme and nearly 1200 pupils completed various questionnaires and measures. All these pupils were drawn from the second year of secondary schools and the full range of ability was used. The information concerning, the number of schools and of pupils participating is summarised together with the numbers of tests completed in table 7.2.1. The final comparison matrix which resulted is presented in the following table 7.2.2.

Table 7.2.1. Empirical Study Questionnaire Data

| SCHOOL | L | S.D. | F.C.FR | S.T.(1) | S.T.(2) | P.R.S. |
|---|---|---|---|---|---|---|
| | | Numbers completing each instrument | | | | |
| 1 | 235 | 53 | 175 | 214 | 203 | 249 |
| 2 | | 210 | | 226 | | 255 |
| 3 | 27 | 27 | | | | |
| 4 | 75 | 75 | 75 | 75 | | |
| 5 | 97 | 135 | | | | 122 |
| Sub Total | 434 | 500 | 250 | 515 | 203 | 626 |
| Additional | 249 | 171 | | | | |
| TOTAL | 683 | 671 | 250 | 515 | 203 | 626 |
| Pupil Data | | | | | | |
| Percentage | | | | | | |
| Male | 49.6 | 50.4 | 51.6 | 50.4 | 52.0 | 48.7 |
| Female | 50.4 | 49.6 | 48.4 | 49.6 | 48.0 | 51.3 |

Table 7.2.2. Comparison Matrix for Attitudinal Measures

| | L | S.D. | F.C.F.R. | S.T.(1) | P.R.S. |
|---|---|---|---|---|---|
| L | | 252 | 250 | 289 | 346 |
| S.D. | | | 128 | 285 | 377 |
| F.C.F.R. | | | | 250 | 175 |
| S.T.(1) | | | | | 250 |
| P.R.S. | | | | | |

Key: L - Likert S.D. - Semantic Differential

F.C.F.R. - Forced Choice and Free Response

S.T.(1) - Situation Type - Structured Response

S.T.(2) - Situation Type - Open Response

P.R.S. - Pupil Rating Schedule

## Section 3 Marking Procedures and the Data File

The information obtained from the questionnaire and tests was coded, marked and entered onto a computer file for statistical analysis.

The coding of the information has two aspects - reference coding and questionnaire coding. Reference coding requires that a number is assigned to each individual such that the basic information on that individual is noted. In this case each pupil was assigned a number within a school and the pupil's sex was registered. This number appears on all the pupil's questionnaire responses so that cross reference at a later date is possible.

Questionnaire coding requires that the responses the pupils make to the various tests and measures are assigned a numerical code to enable statistical analyses to be performed. In this research programme the tests fall into two types of instrument:

(a) fixed response

(b) open response

Each category is now considered.

(a) fixed response

The following tests are considered in this category.

(1) Likert

(2) Semantic Differential

(3) Situations Type - Structured Response

(4) Forced Choice and Free Response

(5) Pupil Rating Schedule

Each of these has a definite response pattern which can be coded as follows:

Likert: the five responses from completely agree to completely disagree (AA, A, N, D, DD) are assigned a code one to five depending on the polarity of the item. The polarity of the item refers to whether the item supports or opposes the construct it is testing, for example, the item responses completely agree to completely disagree for the item 'I like school science' would be scored 5 down to 1 on the construct 'Commitment and Enjoyment of Science'. A total of 120 items are coded.

<u>Semantic Differential</u> - the sevel responses between the two poles are assigned values one to seven according to polarity of the item. A total of 84 items are coded.

<u>Science Situations - Structured Response</u> - the five responses (a), (b), (c), (d), (e), are generally assigned a value one to five according to the nature of the item. On a careful examination two of the items on this questionnaire were found to have an answering scheme which provided two pieces of information instead of one.

These were the items which related to difficulties experienced with science, (Items 11, 12). The structured response related the following pattern:

(a) I agree with A and B

(b) I agree with A but not B

(c) I disagree with A but agree with B

(d) I disagree with A and B

(e) I neither agree nor disagree with A or B

A and B as individuals expressed difficulty with certain subjects areas.

To enable a scoring procedure to be adopted which would reflect the level of difficulty experienced overall a modified scoring system was devised as follows.

| | Score on A | Score on B | Total |
|---|---|---|---|
| (a) agree A and B | 3 | 2 | 5 |
| (b) agree A disagree B | 3 | 0 | 3 |
| (c) disagree A agree B | 1 | 2 | 3 |
| (d) disagree A and B | 1 | 0 | 1 |
| (e) neither A or B | 2 | 12 | 3 |

This enabled two separate sub scores to be recorded and an overall difficulty score arrived at by adding them together. A total of 20 scores were thus coded of which 18 represented the main items.

Forced Choice and Free Responses - the responses to items on both of these questionnaires are coded by the pupils on a one four scale and so each item is coded appropriately. A total of 96 items were coded per initial questionnaire and 32 items coded per subsequent questionnaire.

Pupil Rating Schedule - there are six characteristics which are used to assess pupils. Each pupil is assessed on a seven point bi-polar scale for each characteristic. The responses are assigned a code of one-to-seven according to the polarity of the item. Each pupil has a rating on each of the six characteristics below coded.

(1) Attitude toward Science

(2) Interest in Science

(3) Personal Application

(4) Ability in Science

(5) Classroom Behaviour

(6) Personality

Open Response - Situation Type

This questionnaire generates pupil constructs as compared with the assessment of pre-determined constructs in the first category. The coding is therefore somewhat difficult. However, a scheme of coding can be drawn up by a detailed consideration of the pupil's responses. Initially a restricted sample of the questionnaires was examined and each response to every item noted. The nature of response made by the pupils is then clarified such that a number of important aspects of the pupil's response are classified as possible constructs. Thus in a response to an item it is possible to look for certain key points or phrases whose presence would be registered as an indication of a particular construct. The initial list of pupil constructs was well defined and practical in its application for this to work. An example of this treatment is the pupil's response to an open-ended item concerning science within their school. If the pupil had written "I enjoy science at school and find the practical work very interesting" this indicated a favourable attitude on two constructs concerning the affective response toward science and interest in practical work. The categories having been identified, their presence or absence can be recorded for all pupils within the sample and a comparison made of the attitude profile produced using the open-ended technique with the initial construct prescription.

The data produced on open-ended measures is extremely broad in its content. It is therefore envisaged that the data will be considered only from the viewpoint of information relating to the constructs already identified and those emerging from the statistical analysis of the structured questionnaire used in this study. After a classification of the pupil's response, a frequency analysis relating the percentage of the responses using the various categories was undertaken. The full results from this procedure are presented in the analysis section which follows this chapter.

This chapter has dealt with the basic organisation of the empirical study carried out in this research project. It has detailed the numbers and types of questionnaires completed and clearly indicate the appropriate marking procedures undertaken to produce the extensive data file. The analysis of the questionnaires, both individually and compar tively, is considered in the next chapter.

# CHAPTER EIGHT

## ANALYSIS

### Section 1

#### Review of the strate gy for the programme of analyses

The first major problem that was encountered in the review of attitude to science measures was the lack of a clear conceptual base. This problem has been considered in an earlier chapter through a conceptual analysis of attitude test instruments. In this earlier chapter the operational constructs present in the instruments were carefully elicited and defined in terms of a list of attitude-to-science dimensions. A further important area of the research study was to look for empirical validation of these constructs within a range of measurement techniques whilst considering the comparability and suitability of these techniques to assess attitudinal constructs. These two areas are considered in the following discussion which highlights their close interelationship. A strate gy for analysis is then proposed to allow comment to be made on these important research issues.

A range of measurement instruments have been employed to obtain empirical data on the various attitude dimensions. Although some justifications have been put forward in favour of the use of particular techniques, two general assumptions have been made in this area of research without the existence of clear experimental evidence.

(1) All techniques are capable of measuring reliably all of the attitude constructs identified.

(2) All techniques assess the same attitude constructs in similar ways and that there is little difference in the reliability of one technique with respect to another in assessing the same construct.

These assumptions are often fostered by text-books in which authors provide a list of possible techniques for attitude measurement. Whilst they note the advantages and disadvantages of particular techniques and describe the mechanics of their operation, little or no consideration is given to the assumptions noted above. Given, for example, a particular construct would the various techniques produce a common assessment?

It is important to realise that the nature of a measurement technique may well affect the assessment of an attitude construct. Gardner, in his survey of attitudes to science, notes in his recommendations "Numerous instruments are now available to measure attitudes to science. To what extent do they actually measure a common construct? Some comparative studies would be useful."
(Gardner, 1975)

Consideration is now given to the relationship between the two assumptions and the present research study.

Points relating to the first assumption

In the case of the first assumption consideration has been given, when the techniques were developed in terms of measuring instruments, to establish, that in theory there were no difficulties in the use of particular techniques assessing the prescribed attitude constructs. At this stage it was found, for example, the semantic differential instrument could not be used to assess constructs relating to the nature of science. It is however in the field situation, faced with empirical evidence that judgements should be made concerning the suitability of techniques to assess prescribed constructs. The question is however fraught with difficulties which may not be possible to disentangle completely. To begin with, although the conceptual analysis has established attitude constructs with face validity, it must be asked: to what extent are the input constructs validated from the empirical data? Essentially, do the input constructs have psychological meaning? Whether they do or do not appear as constructs identified in the analysis of the data from a particular questionnaire, could be because

(i) they do/do not have psychological meaning,

(ii) that the instrument itself is/is not able to measure the construct.

A number of analyses could help in gaining an indication in this area. Initially each instrument should undergo an item analysis such that items on the instrument can be evaluated and 'poor' items can be eliminated or set aside. These items will then not cloud any pattern emerging from subsequent analyses.

The remaining items will be examined as scales in the form of their original construct allocation in terms of their reliability and validity as assessment scales. From further analysis of the items, through factor analysis for example, new or 'derived scales' may well emerge. These in turn will undergo a reliability analysis.

For each individual technique it will be possible to comment on its suitability to assess the input constructs and the nature of any derived constructs the technique produces and their corresponding reliabilities. It will be possible at this stage to comment on the generalisibility of constructs from technique to technique and their comparative reliabilities.

This analysis will include two main stages therefore:

STAGE 1 Item Analysis

STAGE 2 Scale Analysis

(a) Analysis of the Input Constructs

(b) Analysis of the Derived Constructs.

These are now considered in some detail to prescribe the exact statistical procedures.

## STAGE I ITEM ANALYSIS

All items are to be reviewed as they occur within the initial input constructs. Each item will undergo a threefold examination generally.

(i) The characteristics of the item response in terms of its mean, standard deviation and response distribution.

All items with unusual response characteristics will be identified. There are two aspects of response distribution which are of particular note in assessing the usefulness of an item.

(a) Skew

An item which possess excessive skew records the majority of the responses to the item at one end of the response categories. This would indicate an item which would descriminate badly, if at all, between respondents.

A nominal value of +/- 1.5 indicates 75% of responses in one category.

(b) Kurtosis

In line with point (a) this value indicates a tendency for reposes to be very much in one category with no normal spread.

(ii) The item-item correlation within the input constructs.

Each item will be considered in terms of its correlation with all the other items within the construct scale. This procedure is used to identify unusually weak items.

(iii) The items correlation with all other items on the questionnaire.

Items identified under points (i) and (ii) above will be examined further to establish whether other relationships exist within the data, maybe outside the input construct, which would warrant their inclusion in further derived scale analyses.

**Note:** In prescribing excessive values of kurtosis and skew it should be realised that this procedure is appropriate due to the relative nature of the study undertaken here. Items with excessive kurtosis and skew may in fact find particular use in other studies and it is not implied, therefore, that such items would always be judged to be "poor" in all circumstances.

The data package used for these analyses is the S.P.S.S. (Statistical Package for Social Sciences) using the FREQUENCIES and RELIABILITY programmes.

STAGE 2 SCALE ANALYSES

(a) Scale Analysis of the Input Constructs.

All the items on the questionnaires were developed with a specific set of constructs in mind. The initial allocation of items to a particular construct is thus an important one and the main purpose of the scale analysis in this section is to examine the validity of these constructs for a particular questionnaire.

Two main modes of investigation will be considered.

(i) Reliability Analysis

The reliability of the input construct scales will be examined through a calculation of Cronbach's Alpha value. This analysis will consider the complete input scales made in the light of item analyses. Comments can be made on their qualities as scales of measurement. The programme utilised for this analysis is the RELIABILITY programme noted earlier.

(ii) Factor Analysis

The items on each questionnaire will be subjected to a factor analysis which will examine the items within their initial construct groupings. In the light of the item analyses certain items may well be omitted at this stage so as not to 'cloud' the analysis.

The analysis carried out will be a principal component analysis with orthogonal rotation. At this stage orthogonal rotation is used as it is the independence of factors that is looked for. The rotation will be to the varimax criterion. This tends to produce one major factor, as the first factor, providing the best interpretation of the data with other factors following of lesser importance. An additional rotation may also be attempted, to the equimax criterion. This tends to 'equalise' the importance of the factors and, it is thought, may present a better model for the data under consideration, where a number of factors may be of equal importance rather than just one. These analyses use the FACTOR programme on S.P.S.S. In all analyses a loading of 10.3 will be taken as indicating a significant loading.

In addition to these modes of investigation, items on certain questionnaires will be entered into a cluster analysis. Using a cluster analysis of the hierarchical type, such as McQuitty's Similarity Analysis, underlying patterns in the data can be identified as groups of items assigned to a particular cluster based on similarities in response pattern. The major groups of clusters identified will be examined in terms of the items they contain and how they reflect the initial constructs.

This analysis is performed using the CLUSTAN 1B suite of programmes. Due to the type of analysis attempted, where cases are represented as individual items, only a maximum number of 200 cases can be considered. As this is very small when compared to the number of items or variables this information is regarded as supplementary to the other analyses rather than a major tool for validation purposes.

(b) Scale Analysis of the Derived Constructs.

In the light of the evidence presented by the item analysis and the scale analyses of the input constructs, comment can be made concerning the performance of a questionnaire in the assessment of the original input constructs. The underlying 'psychological' association of the items will undoubtably give rise to constructs of a different or modified nature which may require the re-allocation of items within the questionnaire to different scales of measurement. Thus each questionnaire will be examined to ascertain the nature of these 'derived' scales and their subsequent reliability.

Again two modes of investigation are considered.

(i) Factor Analysis

Using the information gained from the initial analysis carried out above (a (ii) ) scales will be identified which group items in terms of similarity of response only. In other words, the factors appearing from the analysis will be used as completely separate scales and items allocated according to loading on the factors. These scales can then be interpreted freely.

(ii) Reliability Analysis

Taking the factor scales determined above as a starting point the scales will be further refined by applying the reliability procedure outlined earlier.

A set of clearly defined scales of known reliability will be produced.

Points relating to the second assumption

In the case of the second assumption, the central question raised here is, to what extent are the instruments measuring common constructs? In other words, what degree of commonality is there between constructs assessed on one technique with another?

This question can be tackled in a number of analyses. Firstly accepting the input attitude constructs possess face validity, do the measurements of these constructs on different techniques show any relationship? Secondly, through the analysis of individual measurement instruments from the empirical study we have established constructs which have both face and psychological validity for a particular questionnaire. Again do these constructs, those with a similar nature, possess any degree of commonality? Through the following analyses it is hoped to establish whether the identified constructs are test dependant or otherwise.

To establish the basis for these analyses consideration is now given to the detailed format that they will take.

From the analyses of the individual questionnaires there are three sets of data available for comparative analyses.

(i) Raw scales data

This data reflects the initial scale design based on the predetermined constructs.

(ii) Refined scale data

This data reflects the initial scales from the predetermined constructs but refined through item analysis and reliability measures.

(iii) Modified scales data

This data reflects the scales derived from the initial pool of items by means of factor analyses which has given rise to derived scales subsequently modified by reliability analyses.

In the comparative analyses the refined data appearing in data sets (ii) and (iii) will be considered.

In considering these scales there are for each technique clearly defined construct scales. In general the first scale on one technique is equivalent to the first scale on a further technique in terms of the underlying construct. These in turn would be equivalent to the first scale on a further technique. Each technique has a number of scales and there are a certain number of techniques. Consider a theoretical matrix of scales and techniques as detailed below:

| SCALE | TECHNIQUE | | |
|---|---|---|---|
| | Technique 1 | Technique 2 | Technique n |
| Scale 1 | S1(T1) | S1(T2) | S1(Tn) |
| Scale 2 | S2(T1) | S2(T2) | S2(Tn) |
| Scale n | Sn(T1) | Sn(T2) | Sn(Tn) |

In a comparative analysis the relationship between the scales on the different techniques requires examination. Two extreme possibilities can be hypothesised.

(a) The pupil's responses are predominantly dependant on the content of the items.

In this case a strong relationship will exist between the scales bearing a similar name or construct nature. Thus there will be a degree of commonality between constructs assessed on different instruments irrespective of the format of presentation. This will be referred to as horizontal grouping. This demonstrates test independence.

(b) The pupil's responses are significantly influenced by the format of the items. In this case a strong relationship will be displayed by the scales on one technique with one another. Thus, irrespective of the similar nature of the items, a response is made which is more dependant on the format of presentation. This will be referred to as vertical grouping. This demonstrates test dependence.

The nature of the relationship between the scales can be examined by correlation and factor analyses.

In considering the modified scales data a similar argument can be pursued except that there is a necessity to establish initially whether the scales derived by the factor analyses are in fact compatible in terms of their underlying content.

The above pattern of analysis is suitable for consideration for the Likert and the Semantic Differential techniques without modification. However for the other techniques some modifications are necessary to accommodate their particular format.

In the construction of the Forced Choice - Free Response questionnaire a constraint was placed on the organisation of the items through the use of tetrad groups. This resulted in a reorganisation of the initial constructs into four distinct categories.

PERSONAL reflecting pupil's personal attitude towards science.

HUMAN reflecting the perceived characteristics of a scientist.

EFFECT reflecting the benefits and illeffects of science on our society

NATURE reflecting the nature of science with respect to the scientific method and scientific theories.

In order to provide comparative information with the other techniques it is necessary to consider the reorganisation of the original construct scales to reflect these four categories. The following arrangement produces the closest match using the construct scales intact. The other possibility would have considered reassigning the items within the separate questionnaire to one of four categories. In fact very few items would have been allocated differently.

PERSONAL

Commitment and Enjoyment of Science

Scientific Occupations

Scientific Interests and Pastimes

Difficulty with Science as a School Subject

HUMAN

Characteristics of the Scientist

EFFECT

Science and Society

Science and the Individual

NATURE

Scientific Theories and Laws

The Scientific Method

It should be noted that The Aims of Science construct is not included as it is not directly related and that the semantic differential instrument will have three and not four groupings.

The construction of the Science Situations questionnaire reflected the input constructs and their various facets. However the number of items was necessarily limited and correlational analyses are only to be undertaken with caution. In the case of comparative analyses with the above groupings the items distribute themselves as follows:-

PERSONAL - 11 items HUMAN - 2 items EFFECT - 2 items NATURE-2 items

This will allow some confidence in the use of the Personal scale but not in the others.

Further background information will be provided concerning the reliability of the new tetrad scales within the comparative study.

Orthogonal versus Oblique Rotation

In the analyses of the instruments it has been customary to perform orthogonal rotations. Such a rotation 'forces' factors into a position of independence and as weak a relation as possible. A procedure using oblique rotation acknowledges the possibility of a relationship between the data orthogonality is then but a special case. It has been argued that unless there is an apriori reason for assuming independance of factors an oblique rotation is to be preferred.

"The oblique rotation method is more flexible because the factor axes need not be orthogonal (uncorrelated) and is more realistic because the theoretically important underlying dimensions are not assumed to be unrelated to each other.

The ultimate goal of any rotation is to obtain some theoretical meaningful factors, and, if possible, the simplest factor structure."

(Nie et. al., 1975)

The implications for this particular study of this issue are as follows. In certain cases the use of oblique rotation may well be pertinent and provide useful information. In the case where constructs are sought from a random number of items, the usual demand is for factors or scales to be identified where one factor can be treated as being different (in meaning) from another. This would be the case when the item responses to individual questionnaires are analyses and a derived construct structure is sought. An orthogonal rotation would be appropriate here. In the case where the initial input constructs are examined these constructs are accepted for use on the basis of their face validity but with consideration, through scale analyses, to the scales reliability. As there is no reason to assume that these constructs are independent from one another an oblique rotational analysis becomes appropriate. This will reveal the degree of interelationship between the scales and may also help identify sub structure present within the scales.

A similar case exists in the consideration of the analyses of the derived construct scales. Where these have been identified and reliable scales formed, an analysis of the scales themselves using an oblique rotation may again be appropriate.

It can be recommended therefore that in analyses involving distinct construct scales an oblique rotation should be performed. This will be in addition to the traditional varimax analysis.

The Teacher - Pupil Rating Instrument

One of the initial areas identified in the outline of the research study considered the lack of use of teachers as assessors of pupil characteristics. In the light of this a specific test instrument has been developed to assess a small range of representative pupil characteristics. Attitudinal assessment has formed an important part of this assessment so as to facilitate comparison at this stage between pupil self report techniques and teachers assessment. Having established clear attitudinal constructs with respect to the pupil, comparison can now be made between the pupil's own assessment and that of their teachers. This will enable clear comment to be made on the suitability of the assessment method.

This analysis will take the form of a correlation analysis followed by factor analysis of the main teacher assessed characteristics and the major pupil self report techniques. Using both orthogonal and oblique rotations the patterns of similarity in the two modes of assessment can be commented on.

All the oblique rotations performed adopt the delta criterion which results in a fairly oblique solution, (Nie et.al. 1975).

## Section 2 Analysis of the Fixed Response Questionnaires

### (a) The Likert Questionnaire

### Stage I - Item Analysis

(i) Item - Total Correlation Data

The items on the questionnaire were selected for further examination if their item - total correlation was below $\pm$ 0.12. The 1% significance level for correlations for a sample of 500 being $\pm$ 0.115.

A total of 21 items was identified. (see Likert Data Sheet, Table 8.2.1)

(ii) Item Characteristics

Two main points became apparent as indicators of unusual items.

(a) Excessive Skew.

An item possessed excessive skew if its value exceeded $\pm$ 1.5. This means that of all the responses to the item over 75% occurred in one category at the end of the response scale. This would indicate an item which would discriminate badly, if at all, between respondents.

(b) Excessive Kurtosis

An item was judged to posses excessive kurtosis if its value exceeded 2.0. This value was based upon the overall data from the questionnaire. In line with point (a) this value indicated a tendency for responses to be very much in one category with no normal spread.

Although these measures reflected the mean and standard deviation of the items, these were also checked for exceptional deviations.

A total of 8 items were identified. (see Likert Data Sheet, Table 8.2.1.)

It should be noted at this point that there is no overlap between the items identified in these two procedures. It is suggested that items in group (i) represent items that are in general poorly understood in group (ii) represent items which are well understood and produce a consistent response across the whole population. An examination of the complete correlation matrix is now undertaken before further comment is made.

(iii) Item - Item Correlation Data

Each of the items noted above were further examined for significant correlations with all other items on the questionnaire, (see Likert Data Sheet, Table 8.2.1.)

In the first group of items, which were unrelated to the input constructs they were assigned to, the items 18, 88, 47 and 65 have a number of associations with other items. This would suggest they may well form items on other scales in further analyses and they should be retained. The remaining items, 17 in all, could face elimination on the grounds that they would 'cloud' any further analyses. An examination of these items in detail reveals, in some cases, why they are weak items. For example item 108. "I would not like to become an engineer when I leave school", may well be a poor item because the pupils have no fixed idea of an engineer to respond to. That is the job description 'engineer' may be too vague to allow a consistent response. The cognitive component may be crucial to certain items. A number of items appear from the later constructs (8), (9) and particularly (10), here the cognitive aspect will certainly be of some importance, a fuller comment is made further on concerning this point.

In the second group of items, with the exception of items 1 and 23 and possibly 114, all items exhibit significant numbers of associations to other questionnaire items. Whilst it would not be correct to reject these items on this criterion, it must be noted that these items still represent heavily distorted item responses.

The analysis of the items so far, has served to illustrate which items could be considered as poor, in terms of response distributions, and their association with other items. This is background information for the following analyses.

Table 8.2.1. <u>LIKERT QUESTIONNAIRE DATA</u>

| | | |
|---|---|---|
| MEAN | range 1.89 - 4.69 | average 3.25 |
| S.D. | range 0.71 - 1.56 | average 1.30 |
| Kurtosis | range -1.58 - 8.04 | average -1.00 |
| Skew | range 0.89 - -2.73 | average -0.7 |

(i) <u>Item - Total Correlation</u>

| Construct | Item | Correlation | Number of significant item to item correlations |
|---|---|---|---|
| 1 | 82 | -0.04 | 0 |
| 2 | 108 | 00.00 | 2 |
| 4 | 6 | -0.03 | 0 |
| 5 | 81 | 0.11 | 1 |
| 8 | 97 | -0.02 | 6 |
| 8 | 89 | 0.01 | 0 |
| 8 | 2 | 0.05 | 3 |
| 9 | 111 | 0.12 | 1 |
| 9 | 107 | 0.14 | 3 |
| 10 | 19 | -0.02 | 10 |
| 10 | 18 | -0.09 | 42 |
| 10 | 55 | -0.03 | 3 |
| 10 | 72 | -0.03 | 0 |
| 10 | 30 | 0.07 | 8 |
| 10 | 22 | 0.09 | 6 |
| 10 | 88 | 0.03 | 37 |
| 10 | 41 | -0.01 | 5 |
| 10 | 47 | -0.04 | 18 |
| 10 | 93 | -0.18 | 8 |
| 10 | 49 | -0.13 | 3 |
| 10 | 65 | -0.13 | 37 |

(ii) Item Characteristics

| Construct | Item | Kurtosis | Skew | Number of significant item to item correlations |
|---|---|---|---|---|
| 4 | 78 | 2.17 | -1.59 | 22 |
| 6 | 1 | 2.75 | -1.58 | 10 |
| 6 | 71 | 2.24 | -1.60 | 40 |
| 7 | 56 | 6.81 | -2.60 | 28 |
| 7 | 114 | 3.04 | -1.86 | 14 |
| 7 | 75 | 2.97 | -1.79 | 26 |
| 7 | 11 | 3.62 | -1.99 | 18 |
| 9 | 23 | 3.04 | -2.73 | 7 |

STAGE 2 Scale Analysis

(a) Analysis of the Input Constructs

(i) Reliability Analysis

The input constructs were subjected to a RELIABILITY analysis to establish their performance as scales (see Likert Questionnaire - Input Construct Reliabilities, Table 8.2.2.)

The first three constructs have very high alpha reliability and can be seen as representing constructs which are easily identifiable by school pupils. An examination of the individual scales and their item - total correlation reveals certain items as being weak. These items have already been identified under the item analysis, for example items 82 and 108.

Construct (5) has a fairly high reliability as have constructs (6) and (7). These constructs present different facets of the attitudinal dimensions and would be expected to appear on different factors in the following analyses. Each of these three constructs has one or two items with low item - total correlations which may suggest either weak items or perhaps a sub group within the scale. Later work will examine this point in detail.

Construct (4) has a reasonable reliability value. The value is noticeably lower than the first three constructs. This may be because the items do not form a complete scale and because the pupils have no clear impression of what a scientist is, as a person, or what he does in the form of work. The necessity for a knowledge component to be present before a clear attitude can be formed is an important point which has been made in a number of studies. Particularly those relating to the provision of a model to facilitate the understanding of the formation of attitudes. (Triandis, 1971 and Johnstone and Reid, 1981). This point is particularly valid in the consideration of the performance of constructs (8), (9) and(10).

The latter three constructs require the pupils to have a certain cognitive level of achievement before they can conceptualise their nature and thus respond consistently. Without a clear understanding of the items, the items receive inconsistent responses and will therefore display no clear pattern of relationship or, therefore, reliability as scales. There is a distinction to be made between constructs (8) and (9) and construct (10). Construct (10) has a low, negative reliability value. Thus there is no reliable measurement scale seen here. Constructs (8) and (9) do show a measure of reliability. Perhaps this can be explained by the possibility that some facets of both these constructs do receive some reference within science teaching in schools. Scientific theories and laws are no longer regarded as immutable, they can be changed and adapted to fit new experimental evidence, (see items 51 and 3). The scientific method is seen as one based upon repeated experiments and careful observation, (see items 15 and 16). These ideas may be implicit in the science teaching and recognised by a significant number of the pupils. Construct (10) on the other hand can be seen as being based upon value judgements in essence a matter of opinion, which would not appear in any teaching scheme directly and would be very much left to individual comment. This may be very difficult to ascertain in any objective way.

Construct (4) has a reasonable reliability value. The value is noticeably lower than the first three constructs. This may be because the items do not form a complete scale and because the pupils have no clear impression of what a scientist is, as a person, or what he does in the form of work. The necessity for a knowledge component to be present before a clear attitude can be formed is an important point which has been made in a number of studies. Particularly those relating to the provision of a model to facilitate the understanding of the formation of attitudes. (Triandis, 1971 and Johnstone and Reid, 1981). This point is particularly valid in the consideration of the performance of constructs (8), (9) and(10).

The latter three constructs require the pupils to have a certain cognitive level of achievement before they can conceptualise their nature and thus respond consistently. Without a clear understanding of the items, the items receive inconsistent responses and will therefore display no clear pattern of relationship or, therefore, reliability as scales. There is a distinction to be made between constructs (8) and (9) and construct (10). Construct (10) has a low, negative reliability value. Thus there is no reliable measurement scale seen here. Constructs (8) and (9) do show a measure of reliability. Perhaps this can be explained by the possibility that some facets of both these constructs do receive some reference within science teaching in schools. Scientific theories and laws are no longer regarded as immutable, they can be changed and adapted to fit new experimental evidence, (see items 51 and 3). The scientific method is seen as one based upon repeated experiments and careful observation, (see items 15 and 16). These ideas may be implicit in the science teaching and recognised by a significant number of the pupils. Construct (10) on the other hand can be seen as being based upon value judgements in essence a matter of opinion, which would not appear in any teaching scheme directly and would be very much left to individual comment. This may be very difficult to ascertain in any objective way.

Table 8.2.2. LIKERT QUESTIONNAIRE - INPUT CONSTRUCT RELIABILITY VALUES (CRONBACH'S ALPHA)

| Construct | | ALPHA VALUE |
|---|---|---|
| 1 | Commitment and Enjoyment of Science | 0.87 |
| 2 | Scientific Occupations | 0.82 |
| 3 | Scientific Interests and Pastimes | 0.85 |
| 4 | Characteristics of the Scientist | 0.61 |
| 5 | Difficulties with Science as a School Subject | 0.68 |
| 6 | Science and Society | 0.73 |
| 7 | Science and the Individual | 0.65 |
| 8 | Scientific Theories and Laws | 0.53 |
| 9 | The Scientific Method | 0.55 |
| 10 | The Aims of Science | -0.14 |

Table 8.2.3. (a) LIKERT QUESTIONNAIRE - INPUT CONSTRUCT RELIABILITIES AFTER ITEM ANALYSIS (CRONBACH'S ALPHA)

| Construct | Abbreviation | Alpha Value |
|---|---|---|
| Commitment and Enjoyment of Science | COMSCIL2 | 0.89 |
| Scientific Occupations | SCIOCPL2 | 0.84 |
| Scientific Interests and Pastimes | SCIINTL2 | 0.85 |
| Characteristics of the Scientist | SCIENTL2 | 0.67 |
| Difficulty with Science | SCIDIFL2 | 0.68 |
| Science and Society | SCISOCL2 | 0.70 |
| Science and the Individual | SCIINDL2 | 0.65 |
| Scientific Theories and Laws | THRLAWL2 | 0.61 |
| Scientific Method | SCIMETL2 | 0.60 |
| Aims of Science | AIMSCIL2 | -0.15 |

N.B. Abbreviations noted here appear on later computer analyses. L2 refers to the second generation of the Likert scale.

Table 8.2.3.(b) Likert Questionnaire items removed following item analyses

| Construct | Item | Reason* |
|---|---|---|
| COMSCI | 82 | 1, 2 |
| | 102 | 3 |
| SCIOCP | 108 | 1,2 |
| | 50 | 2,3 |
| SCIINT | 36 | 2,3 |
| | 103 | 3 |
| SCIENT | 06 | 1,2,3 |
| | 28 | 3 |
| SCIDIF | 81 | 1,3 |
| | 109 | 3 |
| SCISOC | 01 | 1 |
| | 84 | 2 |
| SCIINV | 100 | 3 |
| | 56 | 1 |
| THRLAW | 97 | 1,3 |
| | 89 | 1,3 |
| SCIMET | 111 | 1,3 |
| | 107 | 1,3 |
| AIMSCI | 72 | 1,3 |
| | 41 | 1,3 |

*REASONS

1. An item identified as poor in terms of overall response.
2. An isolated item, identified from factor and cluster analyses that follows, which shows poor relationships with the main body of items.
3. An item with low item-total correlation with respect to the construct the item is allocated to.

(ii) Factor Analysis

The FACTOR programme available limited the number of item variables to 100. Twenty items needed to be set aside from the full Likert analysis at least initially. To ensure a representation from each construct two items were removed from every construct to leave the 100 items. The criteria for the removal of the items were as follows:-

(i) A poor item identified from the previous item analysis.

(ii) An isolated item, identified from the cluster analysis that follows, which displays little relation to the main body of items.

(iii) An item with low item - total correlation with respect to the construct the item is allocated to.

In most cases the items removed displayed two of the three possible points. It should be noted that these items may well be incorporated at a later stage in subsequent analyses. A note of these items is presented in table 8.2.3.(b). The removal of these items increased the previous overall reliability values these are presented in table 8.2.3.(a).

The remaining bank of items were subjected to a number of analyses. In each case a principal component analysis, with iteration, followed by an orthogonal rotation of factors was performed. The following analyses were undertaken.

(a) VARIMAX ROTATION

(i) Rotation of factors prescribed by Kaiser's criterion 25 factors representing 57.5% of the variance.(see Table 8.2.4.)

(ii) Rotation of a restricted number of factors. 10 factors representing 39.7% of the variance. (See Table 8.2.5.)

(b) EQUIMAX ROTATION

(i) Rotation of factors prescribed by Kaiser's Criterion 25 factors representing 57.5% of the variance.(See Table 8.2.6.)

(ii) Rotation of a restricted number of factors 10 factors representing 39.7% of the variance.

A note has already been made concerning the possible benefit of the EQUIMAX rotation. The use of a restricted analysis also has potential benefit. The standard criterion for the selection of factors for rotation is usually Kaiser's criterion. Here all factors with eigenvalues greater than 1.0 are selected. In the case of analyses with a large number of variables a large number of factors present themselves for rotation. Certain strong individual items can, under this criterion, be allocated to represent one single factor. A rotation of ten factors was undertaken to ascertain the ten best representations of the data. Although this reduction of factors does tend to 'force' the data, it still allows, as will be seen, a considerable portion of the variance to be accounted for.

In the following analyses the criterion for the significance of a loading on a factor has been initially taken as ± 0.3. Only loadings with values equal to or higher than this value are indicated to enable the underlying structure of the data to be seen. Nominally a loading of ± 0.3 is selected. Calculations of the significance of loadings at the 1% level for a sample of 675, indicate a value of ± 0.1 would reach significance. (Burt & Banks formula, Child, D, 1971). Taking a loading as low as this is not advisable as with any correlation matrix as a certain number of significant loadings are produced as an artefact of the statistical procedure. However loadings approaching the nominal value will be considered.

The results from the analyses are considered in terms of the initial input constructs but first a general impression is presented.

This general impression is presented to gain an indication of the overall factor picture and what the main factors appear to represent. The initial varimax analysis, table 8.2.4. produces the following breakdown.

The first factor contains items connected with the first three constructs. These form a distinct group and represent the personal perceptions of the pupil. The second factor contains items which predominantly relate to the science and society constructs (science and society and science and the individual). The items reflect the positive aspects of science and the benefits it offers to society. A number of other items throughout other constructs relate to this factor and these will be examined within their own section. The third factor relates the opposite perception to the second in that the major items relate the dangers of science to society. Again these items are drawn from the science and society constructs. This division into an apparent 'pro' and 'anti' group is not unusual in the analyses of attitude questionnaires. It has appeared on questionnaires developed by both Gardner and Ormerod (Gardner, 1975 and Ormerod, 1975).

The fourth factor in this analysis contains an independent group of items which reflect the first construct. The exsistence of factors representing the first three constructs is considered in the complete discussion of all the analyses and gives an indication that there may be a sensible sub division between these constructs as proposed in the initial construct dimensions.

Two further factors give immediate perceptions of their nature. Factor six contains a small group of items which are almost identical in nature and they reflect the necessity to learn science in this day and age. Although it is unwise to draw conclusions from so few items it would seem that pupils can perceive the necessity for science education whether they are committed to it or not.

The ninth factor contains a group of items relating to the difficulties of science as experienced by the pupils. A pair of items relating to this area also appear on factor seven. This area will be considered further in the individual analyses.

The general impression presented here has concentrated on what appear to be major groups of items. Two areas are clearly represented.

(i) the personal perception of science and science related activities

and

(ii) the social implication of science.

The extent to which the other items on the questionnaire form identifiable groups will be considered in the following sections relating to the initial constructs.

**Table 8.2.4.** Likert Questionnaire Item Analysis (Varimax Rotation to Kaiser's Criterion) Total Variance = 57.5%

| | FACTOR | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 24 | 50 | | | 39 | | | | | | | | | | | | | | | | | | | | | |
| 86 | 62 | | | 45 | | | | | | | | | | | | | | | | | | | | | |
| 67 | 74 | | | | | | | | | | | | | | | | | | | | | | | | |
| 57 | 40 | | | 31 | | | | | | | | | | | | | | | | | | | | | |
| 116 | 31 | | | | | | | | | | | | | | | | | | | | | | | | |
| 34 | 37 | | | 53 | | | | | | | | | | | | | | | | | | | | | |
| 59 | 50 | | | 35 | | | | | | | | | | | | | | | | | | | | | |
| 27 | 43 | | | 48 | | | | | | | | | | | | | | | | | | | | | |
| 10 | 48 | | | 60 | | | | | | | | | | | | | | | | | | | | | |
| 106 | 33 | | | | | | | | | | | | | | | | | | | | | | | | |
| 117 | 77 | | | | | | | | | | | | | | | | | | | | | | | | |
| 94 | 57 | | | | | | | | | | | | | | | | | | | | | 39 | | | |
| 40 | 70 | | | | | | | | | | | | | | | | | | | | | | | | |
| 73 | 30 | | | | | | | | | | | | | | | | | | | | | | | | |
| 61 | 72 | | | | | | | | | | | | | | | | | | | | | | | | |
| 64 | 59 | | | | | | | | | | | | | | | | | | | | | | | | |
| 70 | 58 | | | | | | | | | | | | | | | | | | | | | | | | |
| 104 | 55 | | | | | | | | | | | | | | | | | | | | | | | | |

n.b. The decimal point is omitted on these values

Table 8.2.4. contd.

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79 | 37 | | | | | | | | | | | | | | | | | | | | | | | | |
| 44 | 36 | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | 65 | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | 65 | | | | | | | | | | | | | | | | | | | | | | | | |
| 53 | 40 | | | | | | | | | | | | | 52 | | | | | | | | | | | |
| 90 | 34 | | | | | | | | | | | | | 48 | | | | | | | | | | | |
| 74 | 53 | | | | | | | | | | | | | | | | | | | | | | | | |
| 54 | 73 | | | | | | | | | | | | | | | | | | | | | | | | |
| 112 | 74 | | | | | | | | | | | | | | | | | | | | | | | | |
| 110 | 58 | | | | | | | | | | | | | | | | | | | | | | | | |
| 96 | 61 | | | | | | | | | | | | | | | | | | | | | | | 37 | |
| 92 | 44 | | | | | | | | | | | | | | | | | | | | | | | | |
| 52 | | | | | | | | | | | | | 31 | | | | | | | | | | | | |
| 60 | | | 30 | | | | | | | | | 31 | | | | | | | | | | | | | |
| 12 | | 35 | | | | | | | | | | | | | | | | | | | | | | | |
| 46 | | | 37 | | | | | | | | | | | | | | | | | | | | | | |
| 91 | | | | | | | | | | | | 49 | | | | | | | | | | | | | |

Table 8.2.4. contd

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 242 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | | | | | | | | | | | | | 58 | | | | | | | | | | | | |
| 78 | | 37 | | | | | | | | | | | | | | | | | | | | | | | |
| 105 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 87 | | 35 | | | | | | 33 | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | 28 | | | | | | | | | | | | | | | | |
| 99 | | | | | | | | | | | | | | | | | | 52 | | | | | | | |
| 118 | | | | | | | -54 | | | | | | | | | | | | | | | | | | |
| 101 | -33 | | | | | | | | 50 | | | | | | | | | | | | | | | | |
| 77 | | | | | | | | | 55 | | | | | | | | | | | | | | | | |
| 83 | | | | | | | -36 | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | 34 | | | | | | | | | | | | | | | | |
| 38 | | | | -39 | | | | | | | | | | | | | | | | | | | | | |
| 31 | | | | | | | | | 28 | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 58 | | | 52 | | | | | | | | | | | | | | | | | | | | | | |
| 43 | | | 57 | | | | | | | | | | | | | | | | | | | | | | |
| 71 | | 57 | | | | | | | | | | | | | | | | | | | | | | | |

<u>Table 8.2.4</u>. contd.

| ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 66 | | 47 | | | | | | | | | | | | | | | | | | | | | | | |
| 42 | | 44 | | | | | | | | | | | | | | | | | | | | | | | |
| 45 | | 48 | | | | | | | | | | | | | | | | | | | | | | | |
| 80 | | | | | | | | | | | 70 | | | | | | | | | | | | | | |
| 8 | 32 | | | | | | | | | | | | | | | 35 | | | | | | | | | |
| 119 | 35 | | 37 | | | | | | | | | | | | | | | | | | | | | | |
| 39 | | | 43 | | | | | | | | | | | | | | | | | | | | | | |
| 69 | | 58 | | | | | | | | | | | | | | | | | | | | | | | |
| 114 | | 48 | | | | | | | | | | | | | | | | | | | | | | | |
| 75 | | 53 | | | | | | | | | | | | | | | | | | | | | | | |
| 120 | | 36 | | | | | | | | | | | | | | | | | | | | | | | |
| 26 | | | 28 | | | | | | | | 33 | | | | | | | | | | | | | | |
| 11 | | 48 | | | | | | | | | | | | | | | | | | | | | | | |
| 29 | 40 | | | | | 30 | | | | | | | | | | | | | | | | | | | |
| 63 | | | | | | 58 | | | | | | | | | | | | | | | | | | | |
| 85 | 44 | | 28 | | | | | | | | | | | | | | | | | | | | | | |
| 113 | | | | | | 64 | | | | | | | | | | | | | | | | | | | |
| 51 | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 8.2.4. contd.

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | | | | | | | 37 | | | | | | | | | | | | | | | | | |
| 32 | | | | | | | | | | 43 | | | | | | | | | | | | | | | |
| 115 | | | | | 43 | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | 31 | | | | |
| 76 | | 54 | | | | | | | | | | | | | | | | | | | | | | | |
| 35 | | 30 | | | | | | | | | | | | | | | | | | 51 | | | | | |
| 95 | | | | | 37 | | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | 41 | | | | | | | | |
| 68 | | 30 | | | | | | | | | | | | | | | | | | | | | | | |
| 25 | | | | | | | | 42 | | | | | | | | | | | | | | | | | |
| 98 | | 31 | | | | | | | | | | | | | | | 31 | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | 34 | | | | | | | | | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23 | | | | | | | | 40 | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | 41 | | | | | | | | | | | | | | | |
| 37 | | | | | | | | | | 30 | | | | | | | | | | | | | | | |
| 48 | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 8.2.4. contd.

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 62 | | | | | | | | | | | | | | | 53 | | | | | | | | | | |
| 19 | | | | | | | | -35 | | | | | | | | | | | | | | | | | |
| 93 | | -31 | | | | | | | | | | | | | | | | | | | | | -41 | | |
| 49 | | | | | 34 | | | | | | | | | | | | | | | | | | | | 32 |
| 65 | | -49 | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | 50 | | | | | | | | | | | | | | | | | | | | | | | |
| 55 | | | | | | | | | | | | | | | | | | | 42 | | | | | | |
| 30 | | | | | -56 | | | | | | | | | | | 34 | | | | | | | | | |
| 22 | | | | | -54 | | | | | | | | | | | | | | | | | | | | |
| 88 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 47 | | 43 | | | | | | | | | | | | | | | | | | | | | | | |

Table 8.2.5. Likert Questionnaire Item Analysis

(Varimax Rotation Restricted Factors (10) )

Total Variance 39.7%

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 49 | | | 37 | 39 | | | | | |
| 86 | 61 | | | | 40 | | | | | |
| 67 | 74 | | | | | | | | | |
| 57 | 39 | | | 30 | 28 | | | | | |
| 116 | 30 | | 34 | | | | | | | |
| 34 | 39 | | | | 46 | | | | | |
| 59 | 49 | | | 29 | 31 | | | | | |
| 27 | 44 | | 29 | | 43 | | | | | |
| 10 | 49 | | | | 54 | | | | | |
| 106 | 30 | | 33 | 33 | | | | | | |
| 117 | 76 | | | | | | | | | |
| 94 | 56 | | | | | | | | | |
| 40 | 68 | | | | | | | | | |
| 73 | 30 | | | | | | | | | |
| 61 | 72 | | | | | | | | | |
| 64 | 57 | | | | | | | | | |
| 70 | 58 | | | | | | | | | |
| 104 | 54 | | | | | | | | | |
| 79 | 35 | | | 33 | | | | | | |
| 44 | 34 | | | | | | | | | |
| 17 | 65 | | | | | | | | | |
| 7 | 64 | | | | | | | | | |
| 53 | 44 | | | | | | | | 41 | |
| 90 | 37 | | | | | | | | 38 | |
| 74 | 54 | | | | | | | | | |
| 54 | 72 | | | | | | | | | |
| 112 | 73 | | | | | | | | | |
| 110 | 57 | | | | | | | | | |

Table 8.2.5. contd

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 96 | 61 | | | | | | | | | |
| 92 | 46 | | | | | | | | | |
| 52 | | | | | | | | | | |
| 60 | | | | 39 | | | | | | |
| 12 | | 39 | | | | | 30 | | | |
| 46 | | | | 46 | | | | | | |
| 91 | | | | 34 | | | | | | |
| 21 | | | | | | | 30 | | | |
| 78 | | 36 | | | | | 36 | | | |
| 105 | | | | | | | 44 | | | |
| 87 | | 43 | | | | | | | | |
| 20 | | | | | | | | -30 | | |
| 99 | | | | | | | | | | |
| 118 | | | -35 | | | | | | | |
| 101 | -30 | | | -37 | | | | -43 | | |
| 77 | | | | | | | | -45 | | |
| 83 | | -34 | | | | | | | | |
| 13 | | | | | | | | | | |
| 38 | | | | | -33 | | | | | |
| 31 | | | | -43 | | | | | | |
| 5 | | | | -41 | | | | | | |
| 58 | | | | 41 | | | | | | |
| 43 | | | 28 | 35 | | | | | | |
| 71 | | 54 | | | | | | | | |
| 66 | | 44 | | | | | | | | |
| 42 | | 48 | | | | | | | | |
| 45 | | 52 | | | | | | | | |
| 80 | | | | 41 | | | | | | |
| 8 | 31 | | | | | | | | | |

Table 8.2.5. contd

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 119 | 32 | | | 42 | | | | | | |
| 39 | | | | 42 | | | | | | |
| 69 | | 50 | | | | | | | | |
| 114 | | 48 | | | | | | | | |
| 75 | | 50 | | | | | | | | |
| 120 | | 38 | | | | | | | | |
| 26 | | | | 41 | | | | | | |
| 11 | | 51 | | | | | | | | |
| 29 | 39 | | | | | 40 | | | | |
| 63 | | | | | | 46 | | | | |
| 85 | 42 | | 33 | 29 | | | | | | |
| 113 | | 30 | | | | 44 | | | | |
| 51 | | | | | | | | | | |
| 3 | | 33 | | | | | | | | |
| 32 | | | 28 | | | | | | | |
| 115 | | | 37 | | | | | | | |
| 9 | | | 39 | | | | | | | |
| 76 | | 54 | | | | | | | | |
| 35 | | 40 | | | | | | | | |
| 95 | | | 50 | | | | | | | |
| 2 | | | | | | | | | | |
| 68 | | 30 | 31 | | | | | | | |
| 25 | | 34 | | | | | | | | |
| 98 | | 39 | | | | | | | | |
| 15 | | | 45 | | | | | | | |
| 4 | | | 30 | | | | | | | |
| 33 | | 33 | | | | | | | | |
| 23 | | | | | | | | | | |
| 16 | | | 50 | | | | | | | |

Table 8.2.5. contd.

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 37 | | | 39 | | | | | | | |
| 48 | | | 30 | | | | | | | |
| 62 | | | | | | | | | | |
| 19 | | | | | | | | | | |
| 93 | | -38 | | | | | | | | |
| 49 | | | 35 | | | | | | | |
| 65 | | -50 | | | | | | | | |
| 18 | | 55 | | | | | | | | |
| 55 | | | | | | | | | | |
| 30 | | | | | | | | | | |
| 22 | | | -47 | | | | | | | |
| 88 | | | -50 | | | | | | | |
| 47 | | 48 | | | | | | | | |

<u>Table 8.2.6.</u> <u>Likert Questionnaire Item Analysis (Equimax Rotation to Kaiser's Criterion (25) )</u>

<u>Total Variance = 57.5%</u>

| | FACTOR | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 24 | | 36 | | | | | | | | | | 37 | | | | | | | | | | | | | |
| 86 | | 50 | | | | | | | | | | | | | | | | | | | | | | | |
| 67 | 34 | | 34 | 35 | | | | | | | | | | | | | | | | | | | | | |
| 57 | | 32 | | | | | | | | | | | | | | | | | | | | | | | |
| 116 | | | | | | | | | | | 30 | | | | | | | | | | | | | | |
| 34 | | 53 | | | | | | | | | | | | | | | | | | | | | | | |
| 59 | | 36 | | | | | | | | | | | | | | | | | | | | | | | |
| 27 | | 48 | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | 63 | | | | | | | | | | | | | | | | | | | | | | | |
| 106 | | | | | | | | | | | 31 | | | | | | | | | | | | | | |
| 117 | 35 | | 50 | 33 | | | | | | | | | | | | | | | | | | | | | |
| 94 | | | | 53 | | | | | | | | | | | | | | | | | | | | | |
| 40 | 36 | | 42 | 40 | | | | | | | | | | | | | | | | | | | | | |
| 73 | | | | 31 | | | | | | | | | | | | | | | | | | | | | |
| 61 | 37 | | 36 | 30 | | | | | | | | | | | | | | | | | | | | | |
| 64 | 32 | | | 33 | | | | | | | | | | | | | | | | | | | | | |
| 70 | | | | 44 | | | | | | | | | | | | | | | | | | | | | |

Table 8.2.6.

| ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 104 | | | | 38 | | | | | | | | | | | | | | | | | | | | | |
| 79 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 44 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | 36 | | 33 | | | | | | | | | | | | | | | | | | | | | | |
| 7 | 60 | | | | | | | | | | | | | | | | | | | | | | | | |
| 53 | | | | | 61 | | | | | | | | | | | | | | | | | | | | |
| 90 | | | | | 55 | | | | | | | | | | | | | | | | | | | | |
| 74 | 34 | | | | 28 | | | | | | | | | | | | | | | | | | | | |
| 54 | 58 | | | | | | | | | | | | | | | | | | | | | | | | |
| 112 | 36 | | 48 | | | | | | | | | | | | | | | | | | | | | | |
| 110 | | | 47 | | | | | | | | | | | | | | | | | | | | | | |
| 96 | | | 61 | | | | | | | | | | | | | | | | | | | | | | |
| 92 | | | | | 33 | | | | | | | | | | | | | | | | | | | | |
| 52 | | | | | | | | | | | | | | | | | | | 32 | | | | | | |
| 60 | | | | | | 33 | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | 32 | | | | | | | | | | 30 | | | | | |
| 46 | | | | | | 40 | | | | | | | | | | | | | | | | | | | |
| 91 | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 8.2.6. contd.

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | | | | | | | | | | | | | | | | | | | 60 | | | | | | |
| 78 | | | | | | | | | | | 32 | | | | | | | | | | | | | | |
| 105 | | | | | | | | | | | | | | | | | 31 | | | | | | | | |
| 87 | | | | | | | | | | | | | | | | | 42 | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | 45 | | | | |
| 20 | | | | | | | | | -30 | | | -34 | | | | | | | | | | | | | |
| 99 | | | | | | | | | | | | | | | | | | | | | | | | -52 | |
| 118 | | | | | | | | | | | -47 | | | | | | | | | | | | | | |
| 101 | | | | | | | | | -54 | | | | | | | | | | | | | | | | |
| 77 | | | | | | | | | -55 | | | | | | | | | | | | | | | | |
| 83 | | | | | | | | | | | -40 | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | -38 | | | | | | | | | | | | | | | |
| 38 | | -35 | | | | | | | | | | | | | | | | | | | | | | | |
| 31 | | | | | | | | | | -28 | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | -26 | | | | | | | | | | | | | | | |
| 58 | | | | | | 45 | | | | | | | | | | | | | | | | | | | |
| 43 | | | | | | 52 | | | | | | | | | | | | | | | | | | | |
| 71 | | | | | | | 36 | | | | | | | | | | | | | | | | | | |

Table 8.2.6. contd.

| ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 66 | | | | | | | 38 | | | | | | | | | | | | | | | | | | |
| 42 | | | | | | | | | | 44 | | | | | | | | | | | | | | | |
| 45 | | | | | | | | | | 30 | | | | | 34 | | | | | | | | | | |
| 80 | | | | | | | | | | | | | 73 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | 34 | | | | | | | | | | | | | |
| 119 | | | | | | 30 | | | | | | | | | | | | | | | | | | | |
| 39 | | | | | | 38 | | | | | | | | | | | | | | | | | | | |
| 69 | | | | | | | 47 | | | | | | | | | | | | | | | | | | |
| 114 | | | | | | | 33 | | | | | | | | | | | | | | | | | | |
| 75 | | | | | | | 41 | | | | | | | | | | | | | | | | | | |
| 120 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | 58 | | | 36 | | | | | | | | | | | | |
| 29 | | | | | | | | 32 | | | | | | | | | | | | | | | | | |
| 63 | | | | | | | | 59 | | | | | | | | | | | | | | | | | |
| 85 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 113 | | | | | | | | 66 | | | | | | | | | | | | | | | | | |

Table 8.2.6. contd.

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | | | | | | | | | | | | | | | | | | | | | | 47 | | | |
| 3 | | | | | | | | | | | | | | | | | | 38 | | | | | | | |
| 32 | | | | | | | | | | | | | | | | | | | | | | | 44 | | |
| 115 | | | | | | | | | | | | | | | | 34 | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | 50 | | | | | |
| 76 | | | | | | | 32 | | | 32 | | | | | | | | | | | | | | | |
| 35 | | | | | | | | | | | | | | | 56 | | | | | | | | | | |
| 95 | | | | | | | | | | | | | | | | | | | | | | | 31 | | |
| 2 | | | | | | | | | | | | | | | | | 40 | | | | | | | | |
| 68 | | | | | | | | | | | | | | | | | | | | | | | 30 | | |
| 25 | | | | | | | | | | | | | | | | | | 43 | | | | | | | |
| 98 | | | | | | | | | | | | | | 34 | | | 37 | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | 39 | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | | | | 34 | | | | | | | |
| 23 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | | | | | 40 | | |
| 37 | | | | | | | | | | | | | | | | | | | | | | | | | 32 |

Table 8.2.6. contd

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 62 | | | | | | | | | | | | | | | | | | | | | 56 | | | | |
| 19 | | | | | | | | | | | | | | | | | | -38 | | | | | | | |
| 93 | | | | | | | | | | | | | | -38 | | | | | | | | | | | |
| 49 | | | | | | | | | | | | | | | | | | | | | | | | | 52 |
| 65 | | | | | | | -36 | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | 34 | | | | | | | | | | | | | | | |
| 55 | | | | | | | | | | | | | | | | | | | | | | 33 | | | |
| 30 | | | | | | | | | | | | 38 | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | | | -46 | | | | | | | | | |
| 88 | | | | | | | | | | | | | | | | -50 | | | | | | | | | |
| 47 | | | | | | | | | | | | | | | 40 | | | | | | | | | | |

Table 8.2.7. Likert Questionnaire - Item Analysis

(Equimax Rotation Restricted Factors (10) )

Total Variance 39.7%

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | | 52 | 30 | 30 | | | | | | |
| 86 | 32 | 51 | | 45 | | | | | | |
| 67 | 58 | 30 | | 32 | | | | | | |
| 57 | | 38 | | 40 | | | | | | |
| 116 | | | | 30 | | | | | | |
| 34 | | 49 | | 32 | | | | | | |
| 59 | | 43 | | 42 | | | | | | |
| 27 | | 56 | | | | | | | | |
| 10 | | 61 | | 33 | | | | | | |
| 106 | | | 30 | 31 | | | | | | |
| 117 | 70 | | | | | | | | | |
| 94 | 43 | | | 35 | | | | | | |
| 40 | 62 | | | | | | | | | |
| 73 | | | | | | | | | | |
| 61 | 61 | | | | | | | | | |
| 64 | 45 | | | | | | | | | |
| 70 | 46 | | | 37 | | | | | | |
| 104 | 49 | | | | | | | | | |
| 79 | 30 | | 37 | | | | | | | |
| 44 | 28 | | | | | | | | | |
| 17 | 50 | 34 | | | | | | | | |
| 7 | 53 | 30 | | | | | | | | |
| 53 | | | | 41 | | | | | | |
| 90 | | | | 33 | | | | | | |
| 74 | 50 | | | | | | | | | |
| 54 | 62 | | | | | | | | | |
| 112 | 59 | 31 | | | | | | | | |
| 110 | 48 | | | | | | | | | |

Table 8.2.7. contd.

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 96 | 50 | | | | | | | | | |
| 92 | | | | 41 | | | | | | |
| 52 | | | | | | | 30 | | | |
| 60 | | | 35 | | | | | | | |
| 12 | | | | | | | 38 | | | |
| 46 | | 36 | 40 | | | | | | | |
| 91 | | | 31 | | | | | | | |
| 21 | | | | | | | 28 | | | 32 |
| 78 | | | | | | | 45 | | | |
| 105 | | | | | | | 48 | | | |
| 87 | | | | | | | 41 | | | |
| 14 | | | | | | | | | | 32 |
| 20 | | | | | | | | | | -36 |
| 99 | | | | | | | | | | |
| 118 | | | | | | | | | | |
| 101 | | | -40 | | | | | | -33 | |
| 77 | | | | | | | | | -35 | |
| 83 | | | | -41 | | | | | | |
| 13 | | | | | | | | | | |
| 38 | | -40 | | | | | | | | |
| 31 | | | -43 | | | | | | | |
| 5 | | | -37 | | | | | | | |
| 58 | | | 40 | | | | | | | |
| 43 | | | 35 | | | | | | | |
| 71 | | | | | 40 | | | | | |
| 66 | | | | | 30 | | | | 31 | |
| 42 | | | | | 43 | | | | | |
| 45 | | | | | 45 | | | | | |
| 80 | | | 44 | | | | | | | |
| 8 | | | | | | | | | | |

Table 8.2.7. contd.

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 119 | | | 41 | | | | | | | |
| 39 | | | 37 | | | | | | | |
| 69 | | | | | 44 | | | | | |
| 114 | | | | | 45 | | | | | |
| 75 | | | | | 33 | | | | | |
| 120 | | | | | 37 | | | | | |
| 26 | | | 39 | | | | | | | |
| 11 | | | | | 42 | | | | | |
| 29 | | | | | | | | 47 | | |
| 63 | | | | | | | | 53 | | |
| 85 | 34 | | 30 | | | | | | | |
| 113 | | | | | | | | 51 | | |
| 51 | | | | | | | | | 35 | |
| 3 | | | | | | | | | 40 | |
| 32 | | | | | | | | | | |
| 115 | | | | | | 30 | | | | |
| 9 | | | | | | 40 | | | | |
| 76 | | | | | 33 | | | | 41 | |
| 35 | | | | | 31 | | | | | |
| 95 | | | | | | 45 | | | | |
| 2 | | | | | | | | | | |
| 68 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| 98 | | | | | | | 40 | | | |
| 15 | | | | | | 45 | | | | |
| 4 | | | | | | 30 | | | | |
| 33 | | | | | | | | | | |
| 23 | | | | | | | 31 | | | |
| 16 | | | | | | 45 | | | | |
| 37 | | | | | | 34 | | | | |

Table 8.2.7. contd.

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 48 | | | | | | | | | 39 | |
| 62 | | | | | | | | | | 35 |
| 19 | | | | | | | | | | |
| 93 | | | | | -31 | | | | | |
| 49 | | | | | | 32 | | | | |
| 65 | | | | | -37 | | | | | |
| 18 | | | | | 36 | | | | | |
| 55 | | | | | | | | | | |
| 30 | | | | | | | | | | 33 |
| 22 | | | | | | -44 | | | | |
| 88 | | | | | | -47 | | | | |
| 47 | | | | | 33 | | | | | |

(1) Commitment and Enjoyment of Science

The analyses indicate that the items on this construct are strongly associated together. In the full varimax analysis, (full here is used to indicate the full number of factors prescribed by Kaiser's criterion, (Table 8.2.4.))the construct forms part of the major or principal factor in association with the items from construct (2), Scientific Occupations, and construct (3), Scientific Interests and Pastimes. Together they can be seen as part of a personal commitment and enjoyment syndrome related to scientific activity at school, scientific interests and pastimes and the desire to follow a science related career. The full varimax analysis also indicates the existence of a 'mirror' factor, where certain items form an association together on a separate factor which reflects the main factor, (see factor 4 on the full varimax analysis. Table 8.2.4.). This seems to indicate that although strongly connected with constructs (2) and (3) the construct possess a slight degree of independence. This is supported by considering factor table 2 on Table 8.2.6, the full equimax analysis. Here factor two, represents the first construct with an independent nature. The factor three seems to display the relationship between the constructs.

The construct thus seems established, but predominently in a domain with constructs two and three. The highest loading items indicate the nature of the scale reflects the original construct.

Two items show weaker associations, 116 and 106, but they show no strong associations elsewhere and they appear related to the common factor on the full varimax analysis (Table 8.2.4.).

(2) Scientific Occupations

The analyses indicate that items on this construct are strongly associated together. As with the first construct a degree of independence is also indicated following the full equimax analysis (see factor 4, Table 8.2.6.)

Three items display particularly weak association. Item 73, which is connected with the lack of desire to become a science teacher, may well reflect the notion that science teachers are not directly thought of as scientists. Item 79, which reflects the hard work required to become a scientist, shows a connection, albeit a weak one, with items which will later be seen to reflect difficulties with school science (see factor 3. Table 8.2.7.).

None of these associations would be strong enough to warrant their removal from this group of items.

The construct is established. A strong item which reflects it's nature would be item 117.

'I should like to become a scientist when I leave school'.

(3) <u>Scientific Interests and Pastimes</u>

The items on this construct display a strong association with one another. As with the first two constructs a degree of independence for some items only, is observed, (see factor one and three, Table 8.2.6.). It can be seen from the restricted equimax analysis, Table 8.2.7. that this set of items relates closely to the scientific occupations construct. The items also form part of the personal syndrome noted for varimax analysis in construct one. Two items, 53 and 90, form a separate factor in a number of the analyses, (see the full varimax analysis, Fig.8.2.4.), these items; 53. If I was helping with the school play I would like to help with wiring the lighting.

90. I would like to build my own radio.

both relate to interests based upon electricity or electronics. These items may provide the beginnings of further, more detailed, sub divisions should this construct be improved for future use.

All the items can be regarded as forming a scale. A further analysis has also indicated that the two items omitted from this construct are related significantly to the main body of items. Typical items which reflect the scale are,

112. I would join a school science club, and

54. I am interested about learning science at home.

(4) Characteristics of the Scientist

Initial indications from the full analyses show the items on this construct to be distributed across a number of factors. Further examination in the light of the two restricted analyses indicates two groups of items which have some measure of consistency.

The items are grouped as follows

Group One

60. Scientists are scatterbrained.

46. Scientists are really boring people.

91. When with other people scientists tend to be shy and withdrawn.
(factor 3, Table 8.2.7.)

Group Two

52. One has to be very intelligent to be a scientist.

12. Scientists are dedicated to their work.

78. When trying to answer a difficult problem a scientist will keep on trying until it is solved.

105. Scientists tell the truth about their work.

87. A scientist will consider all different ways of explaining a discovery before choosing the best.

and also

21. A scientist works in a well planned orderly way.
(factor 7, table 8.2.7.)

These groups reflect the personal and the work characteristics of the scientist respectively. Both were considered as the themes for the original construct. In this analysis they are separated. In terms of the original allocation the first group 'loses' to the second items 52 and 12. The division overall tends to be on the basis of favourable and unfavourable characteristics, as the items in group two and group one indicate. Interestingly the negative perceptions of the scientist are connected at a later stage, in terms of items loading on the same factor, with items connected with the dangers of science. This is evident from both restricted analyses. This division of pro and anti items will be considered later.

In terms of the construct as a group of items, only the work characteristics of the scientist form an identifiable and independent group of items.

(5) <u>Difficulty with Science as a School Subject</u>

The responses to these items displays a degree of fragmentation in all of the analyses. The fragments do, however, show some evidence of independence. A group of items on the full varimax analysis (factor 9, Table 8.2.4.) and also the full equimax analysis (factor 9, Table 8.2.6.) form the largest set.

101. Science lessons contain too many special words that I find hard to understand.

77. If I could only see what all the special words and names meant in science it would be easy to do.

13. I find it hard to see what the results from our practical work means.

31. There is just too much science to learn in school time.

20. I do not find it hard to understand the ideas we are taught in science lessons.

The strength of the loadings for items 31 and 20 are weak. In the full equimax analysis the following item is also related in a similar fashion.

5. Too much work is crammed into too little time in science lessons at school.

The perception of these items as distinct from the others is important even if their strength as a factor scale is not so.

Two further items:

118. It is all the maths in science lessons that makes them so hard.

83. I am no good at science because I cannot set science experiments up right,

form an independent factor on the full analyses (see Factor 7, Table 8.2.4. and Factor 11, Table 8.2.6.). These items retain their independence of the main difficulty items even on the restricted analyses. Item 83 does show a connection with items on the first construct as does item 38,

38. The results of the practical work in science really help you to understand science.

(See Factors 4 and 2, Table 8.2.7.). These items form a tenuous link with the enjoyment of science construct.

A further item 99, is entirely separate. This item forms an independent factor on both full analyses (see Factor 24, Table 8.2.6. and Factor 18, Table 8.2.4.). An examination of the item below indicates that perhaps that the wording may well account for this.

99. One needs to learn science 'off by heart' as it is difficult to understand.

From this analysis despite the fragmentation of the items the construct is an independent scale on the Likert questionnaire. Again further work would be necessary to develop the scale for extensive empirical use.

(6) Science and Society

(7) Science and the Individual

These two constructs are considered together in the analysis undertaken here. This is because the indication from all the analyses is they do not present completely separate and identifiable constructs as initially proposed. Rather the associations between the items on both constructs presents two clear groups of items which transcend the original classification. These two groups reflect:-

(1) The value of science to society and its benefits to society and the individual within society - a PRO SCIENCE FACTOR

(2) The danger of science to society and its ill effects upon society and the individual within society - an ANTI SCIENCE FACTOR.

It should be noted however that themes within both original constructs clearly prescribed the benefit /ill effect aspect.

# THE SCIENCE AND SOCIETY ITEMS - LIKERT QUESTIONNAIRE

## Group One

| Construct | Item | |
|---|---|---|
| 6 | 71 | Science helps mankind |
| 6 | 66 | Science has provided many labour saving devices for industry |
| 6 | 42 | Science has given us the ability to talk and see people all over the world. |
| 6 | 45 | Science provides energy for our needs |
| 7 | 69 | I can travel all over the place easily thanks to science |
| 7 | 114 | Thanks to science our houses are very comfortable compared with years ago. |
| 7 | 75 | Science has provided medicines to keep us healthy. |
| 7 | 120 | Science has provided us with plenty of food to eat. |
| 7 | 11 | Leisure toys such as the T.V. and radio have been provided for us by science. |

other related items

| | | |
|---|---|---|
| 8 | 76 | The theories and laws of science today are stepping stones for the future. |
| 10 | 65 | Science is valuable because it helps solve practical problems |
| 10 | 18 | Science aims to serve mankind. |
| 10 | 47 | Science is about explaining and describing how things happen in the world. |

## Group One(a)

| | | |
|---|---|---|
| 7 | 29 | We should all be involved in science in this day and age. |
| 7 | 63 | Everybody needs to learn and understand science today. |
| 7 | 113 | We all need to learn science to survive in this day and age. |

Group Two

| | | |
|---|---|---|
| 6 | 58 | Science creates more problems than it solves in society |
| 6 | 43 | Science does more harm than good in society |
| 6 | 119 | The money spent on science could be better spent elsewhere |
| 6 | 39 | Money spent on scientific projects is wasted. |
| 7 | 26 | There is too much noise in our everyday lives because of science. |
| 7 | 85 | Science should be left to the scientists as it does not concern me. |
| 6 | 80 | Science produces too many dangerous weapons which could destroy mankind. |

Both Gardner and Ormerod (Gardner, 1975 and Ormerod, 1976) have noticed and commented upon this polarisation of items connected with science and society items on analysis of their attitude based questionnaires.

The full varimax analysis indicates the following grouping of items, (See Science and Society Items, extracted from tables 8.2.4. (factors2, 6 and 3) and from table 8.2.5. (factors 2, 6 and 4.).

Group One

The main group here is pro - science. The analysis establishes both groups one and one (a) with a measure of independence. The restricted varimax analysis indicates a relation between these two groups. The smaller group concerns itself with the theme, identified on the initial construct, connected with the individuals involvement in science. The larger group concerns itself with the many and varied benefits that science can bring to everyday life.
The analysis indicates that certain items from other constructs load heavily on the factor associated with the pro - science expression.
If the items from construct (10) are examined it is found that these are the items which the item analysis indicated may show relationship elsewhere. They are cited here to add further illustration to the description of this factor.

Group Two

The second group are items expressing an anti - science feeling. Items 26, 85 and 80 join the main group through support from the restricted varimax analysis.

The items together express clearly an anti - science or negative reaction to the presence of science in society. Although difficult to evaluate at this stage, the presence of two factors each expressing the opposite of one another does not necessarily mean that the factors are mutually exclusive. It could possibly be argued that it is acceptable for an individual to possess high scores on both factors as an awareness of both aspects is desirable in pupils. The interesting point may well be

how the balance of opinion between the factors ties in with the pupils interest and commitment to science as a school subject.
In this light it is interesting to note how the items connected with group two are also in relation with some of the difficulty items which were identified earlier.

The constructs connected with science and society and science and the individual on the Likert questionnaire are not validated. However two identifiable groups do appear which are based on themes expressed in both constructs. The themes having a stronger degree of association across the two constructs than the proposed division of the constructs.

(8) Scientific Theories and Laws

Initial consideration of the analyses of the items on this construct shows that the items are spread out across a number of factors, (see the full varimax table 8.2.4. and equimax analyses table 8.2.6.) When the items are examined in the restricted analyses two identifiable groups appear.

Group One

3. Laws and theories in science can be changed if new facts emerge.
76. The theories and laws of science today are stepping stones for the future.
35. A useful thing about theories and laws in science is that they tell us what might happen next.
2. Scientific theories and laws help us predict the future.
(see factor 2, table 8.2.5.)

Group Two

115. A scientific theory or law can be set up without bothering what went before.
9. When putting forward new theories scientists throw the old ones away.
95. Scientific theories and laws only tell us what we know already.
68. Scientific theories and laws do not tell us anything new.
(see factor 3, table 8.2.5.)

These groups appear clearly on the restricted varimax analysis. As can be seen they reflect the two poles of the initial construct. In the first case scientific theories and laws are seen as being flexible statements incorporating all current knowledge and possessing predictive properties. In the second group the items reflect that theories and laws are based on restricted knowledge concerned with describing their own particular field.

The positive aspect links clearly with the beneficial aspects of science identified previously. The items are not logically related to this group.

It is a debatable point whether this division of items would occur so readily if there was not already a strong positive - negative division from the previous characteristics or constructs concerning science and society. The items have no clear independent nature.

(9) The Scientific Method

The items on this construct display a similar pattern to the items on the previous construct. Initially the items appear spread out but when considered in the light of the restricted analysis two groups appear. These groups reflect the two poles of the construct.

Group One

25. Scientific ideas are based on observation.

98. The Scientific method is based upon careful observation.

33. A scientist should report exactly what he sees even if it does not seem right to him at the time.

(See factor 2, table 8.2.5.)

Group Two

15. A scientist obtains most of his information through reading and not experimenting.

4. A scientist just guesses at the reasons behind why things happen in the world.

16. When scientists carry out experiments they only need to consider one set of results.

37. As a scientist, I know my experiments will always give me the right answers.

48. Even if a theory has been put forward by a great scientist it may be proved wrong by an unknown scientist.
(see factor 3, table 8.2.5.)

Again the construct forms two groups, based upon themes within the original construct definition, but without a measure of independence for the first group. The second with the 'poor' perception of the method, does link with the 'poor' perception of scientific theories and laws.

A comment made earlier, when considering the reliabilities of the constructs (8) and (9), is worth noting again. Both constructs require a level of knowledge concerning the nature of scientific laws and the scientific method. On the basis of this analyses there is at least some indication that, at least implicitly, ideas on these topics do form a part of the pupils teaching scheme. But the ideas are not well developed. The inclusion of the 'positive' view of scientific theories and laws and the scientific method with the social implications factor is probably an artefact of the restricted analysis rather than a deliberate association. The assessment of these constructs, as with the final construct, cannot be successfully undertaken unless there exists some form of cognitive improvement of these areas.

(10) <u>The Aims of Science</u>

The items on this construct show somewhat confused relationships. Although certain items appear together on the same factor and a pattern similar to the previous two constructs seems to be developing the presence of positive and negative loadings upon one factor indicates a varied response by the pupils. (see factors 2 and 3, table 8.2.5.) The analyses reflect comments made on the suitability of this construct made earlier in the reliability stage. The items which relate to the social implications factor, (65, 18 and 47) have been considered within that factor.

Fig. 8.2.10.

## SUMMARY OF FACTOR ANALYSES OF ITEMS ON THE LIKERT QUESTIONNAIRE

| CONSTRUCT | COMMENT |
| --- | --- |
| (1) Commitment and Enjoyment of Science | Construct identified as proposed with a degree of independence. Strong links with constructs (2) and (3). |
| (2) Scientific Occupations | Construct identified as proposed with a degree of independence. Strong links with constructs (1) and (3). |
| (3) Scientific Interests and Pastimes | Construct identified as proposed with a measure of independence. Strong links with constructs (1) and (2). |
| (4) Characteristics of the Scientist | Two factors are identified connected with themes from the original proposal. (a) Personality characteristics (b) Work characteristics The work characteristic is identified clearly with a limited number of items. |
| (5) Difficulty with Science as a School Subject | A functioning construct in it's own right. Independent but limited number of items. |
| (6) Science and Society & (7) Science and the Individual | The social implications of science items are divided into two categories based upon themes within the original construst. (a) The value of science - PRO SCIENCE (b) The dangers of science - ANTI SCIENCE The benefit / illeffect theme overrides the division based on society and the individual. |

| | |
|---|---|
| (8) Scientific Theories and Laws<br>&<br>(9) The Scientific Method | The construct items appear, when forced, as two factors representing opposite poles of the construct originally identified. A similar pattern is identified with construct (9) and the favourable aspects of both constructs are linked. These relate together to the PRO.SCIENCE items. The unfavourable aspects of both constructs show links and have a measure of independence. |
| (10) The Aims of Science | Conflicting and mixed results which reflect varied responses to the items. Little evidence of construct validity for this construct on this questionnaire. |

(iii) Factor Analysis of the Input Constructs

The analysis of the input constructs as scales used Kaisers Criterion for the selection of factors. Both the varimax and the oblique rotations present similar results, (see tables, 8.2.8. and 8.2.9.). The factor analysis produced three clear factors using this criterion which accounted for a total of 69.7% of the variance. The groups of constructs seem to have main orientations,

(i) The personal reaction to science

(ii) An awareness of the relation between science and society, and an appreciation of the working of scientists and scientific work. (see factors 2 and 1 on table 8.2.9.).

The strong personal component is composed of the three initial constructs COMSCI, SCIOCP and SCIINT with an association with SCIDIFF and the two social implications constructs SCISOC and SCIINV. The scientists construct is also a minor component, (table 8.2.8.). However the resolution becomes clearer on the oblique rotation (table 8.2.9.) where the personal component is a clear second factor with just a minor connection with difficulty. The difficulty construct would be expected to link to a greater extent here but seems to reflect the subject rather than the personal aspects.

The effect and the nature of the scientific function link together on the second factor of the varimax analysis (table 8.2.8.). This is again clearer on the oblique analysis but expressed as the major factor.

There is a factorial relationship between the scientists construct and the effects of science on the individual and on society. This may reflect a judgement on the value of a scientists work in terms of it's benefit or otherwise to society (table 8.2.8. factor 3).

The construct relating to the aims of science is undoubtably unclear in it's factorial relationship with the material of the other constructs.

The major point emerging from this analysis is that two areas seem established;

Table 8.2.8. LIKERT QUESTIONNAIRE INPUT CONSTRUCTS

(VARIMAX ROTATION TO KAISER'S CRITERION)

Total Variance = 68.7%

| CONSTRUCT | FACTOR 1 | 2 | 3 |
|---|---|---|---|
| COMSCI | 78 | 36 | |
| SCIOCP | 88 | | |
| SCIINT | 76 | | |
| SCIENT | 35 | 40 | 47 |
| SCIDIF | -40 | -37 | |
| SCISOC | 48 | 52 | 41 |
| SCIIND | 47 | 42 | 49 |
| THRLAW | | 79 | |
| SCIMET | | 71 | |
| AIMSCI | | | |

Table 8.2.9 LIKERT QUESTIONNAIRE INPUT CONSTRUCTS

(OBLIQUE ROTATIONS TO KAISER'S CRITERION)

Total Variance = 68.7%

| CONSTRUCT | FACTOR 1 | 2 | 3 |
|---|---|---|---|
| COMSCI | | -72 | |
| SCIOCP | | -89 | |
| SCIINT | | -85 | |
| SCIENT | 60 | | |
| SCIDIF | -37 | 32 | |
| SCISOC | 62 | | |
| SCIIND | 52 | | 41 |
| THRLAW | 83 | | |
| SCIMET | 72 | | |
| AIMSCI | | | |

(i) Personal area, relating to the individuals attitudes and interests

(ii) Social implications are, relating to the effects of science on society but also including an appreciation of the functioning or nature of scientific work.

(iv) Cluster Analysis

Three major groups of clusters are formed and noted as A, B, and C. The analysis following (see Likert Questionnaire Cluster Analysis, table 8.2.11.) examines how these clusters relate, in terms of the items they contain, to the initial input constructs. It was noted immediately that the first cluster contained a large number of items. Attempts were made to 'break' this cluster by stepping the analysis back and beginning with a larger number of initial clusters. The cluster remains consistent to 35 initial clusters when the analysis stopped. As can be seen the cluster pattern divides the constructs up into three groups.

(A) The nature and functioning of science and scientists.
The interaction of science and society.
Major constructs :- 4,6,7,8,9,10

(B) Personal commitment to school science, scientific hobbies and career aspirations in connection with science.
Major constructs :- 2,3.

(C) Personal difficulties with school science
Major construct :- 5

The first construct is divided between (A) and (B). This points to the fact that a personal commitment to school science has, as a background consideration, the pupil's perception of science and it's function in society.

A number of constructs have a majority of their items located on one cluster. This provides support for their overall consistency. However the analysis does not indicate ten clear constructs, each construct is not completely independent. The majority of the items in each cluster group fall on the central cluster in that group. What is indicated is that there are perhaps three major areas of the attitude and interest domain revealed through this analyses. These areas correspond well with the factor analyses.

Table 8.2.11 LIKERT QUESTIONNAIRE CLUSTER ANALYSIS

(McQUITTY'S HIERARCHICAL METHOD)

| CLUSTER | CONSTRUCT 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 6 | 2 | 3 | 10 | 1 | 11 | 9 | 12 | 12 | 7 |
| B | 5 | 8 | 7 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| C | 1 | 2 | 2 | 2 | 11 | 1 | 2 | 0 | 0 | 5 |

The numbers represent items from particular constructs occurring within a particular cluster.

KEY TO CONSTRUCTS

1. Commitment and Enjoyment of Science
2. Scientific Occupations
3. Scientific Interests and Pastimes
4. Characteristics of the Scientist
5. Difficulties with Science
6. Science and Society
7. Science and the Individual
8. Scientific Theories and Laws
9. The Scientific Method
10. The Aims of Science

(b) Analysis of the Derived Constructs

(i) Factor Analysis

Following the analyses carried out on the initial input items a number of scales became apparent as possessing validity for further investigation These scales were composed from the core items on the major factors. The scales all possess a certain degree of independence. The following scales were identified for further consideration.

| SCALE NAME | ABBREVIATION |
|---|---|
| Commitment and Enjoyment of School Science | COMSCIL3 |
| Scientific Occupations | SCIOCPL3 |
| Scientific Interests and Pastimes | SCIINTL3 |
| Characteristics of the Scientist | SCIENTL3 |
| Difficulties with Science | SCIDIFL3 |
| The value of Science to Society | SCIVALL3 |
| The danger of Science to Society | SCIDANL3 |

The items representing these scales are noted below.

COMSCIL3

24. I am always glad when school science lessons are over.
86. I enjoy school science lessons.
67. Science is my favourite subject at school
57. I would rather do any other subject than science at school
34. I look forward to doing science experiments in science lessons.
59. In general I do not like science.
27. Science is fascinating.
10. I think science is interesting.
116. Science lessons in which we do experiments are boring.
106. Science is not worth bothering about.

SCIOCPL3

117. I should like to become a scientist when I leave school.

94. Being a scientist is the last job that I would like.

40. A scientific job is the job for me when I leave school.

73. I would not like to become a science teacher.

61. I would like to work in a science laboratory.

64. I would rather be a scientist than a newspaper reporter.

70. Working in an office would be better for me than working in a laboratory.

104. I would rather join the police force than become a scientist.

79. There is too much hard work involved in becoming a scientist.

44. There is too much practical work in the job of a scientist to interest me.

SCIINTL3

17. I would help form a science hobbies club after school.

07. I enjoy science as a hobby at home.

74. If someone gave me some money I would like to buy a chemistry set to do all sorts of experiments at home.

54. I am interested about learning science at home.

112. I would join a school science club.

110. I like listening to science talks on the radio.

96. I take books on science subjects out of the library.

92. It would be fun to visit a science museum.

53. If I was helping in the school play I would like to help with wiring the lighting.

90. I would like to build my own radio.

SCIENTL3

52. One has to be very intelligent to be a scientist.

12. Scientists are dedicated to their work.

78. When trying to answer a difficult problem a scientist will always keep on trying until it is solved.

105. Scientists tell the truth about their work.

87. A scientist will consider all the different ways of explaining a discovery before choosing the best.

21. A scientist works in a well planned orderly way.

SCIDIFL3

20. I do not find it hard to understand the ideas we are taught in science lessons.

101. Science lessons contain too many special words that I find hard to understand.

77. If I could only see what all the special words and names meant in science it would be easy to do.

13. I find it hard to see what the results from our practical work means.

31. There is just too much science to learn in school time.

05. Too much work is crammed into too little time in science lessons at school.

SCIVALL3

71. Science helps mankind.

66. Science has provided many labour saving devices for industry.

42. Science has given us the ability to talk and see people all over the world.

45. Science provides energy for our needs.

69. I can travel all over the place easily thanks to science.

114. Thanks to science our houses are very comfortable compared to years ago.

75. Science has provided us with medicines to keep us healthy.

120. Science has provided us with plenty of food to eat.

11. Leisure toys such as the T.V. and radio have been provided for us by science.

65. Science is valuable because it helps solve practical problems.

18. Science aims to serve mankind.

56.* Science has provided many helpful devices at home to make our lives easier.

SCIDANL3

58. Science creates more problems than it solves in society.

43. Science does more harm than good in society.

119. The money spent on science could be better spent elsewhere.

39. Money spent on scientific projects is wasted.

80. Science produces too many dangerous weapons which could destroy mankind.

26. There is too much noise in our everyday lives because of science.

85. Science should be left to the scientists as it does not concern me.

*100. The clean and peaceful countryside has been spoiled for us by science.

*Items 56 and 100 were added to these scales after a re-examination of initial items deleted through the item analysis.

The items allocated to these scales are based upon,

(i) the loadings on the factor analyses and

(ii) the interpretation of the content of the item with respect to it's factor allocation.

The latter items, separated by a space on some scales, are judged to be weak items and will be reviewed after the reliability analysis in the next section.

(ii) Reliability Analysis

The values of alpha for the scales in the section above were calculated. From these values and the examination of the item - total correlations only one item was in fact removed, item 65, from scale SCIVAL. The reliabilities of the scales are listed below as the resulting scales from the Likert questionnaire.

Figure 8.2.12.

Likert Questionnaire Derived Construct Reliability Values (Cronbach's Alpha).

SCIDANL3

58. Science creates more problems than it solves in society.

43. Science does more harm than good in society.

119. The money spent on science could be better spent elsewhere.

39. Money spent on scientific projects is wasted.

80. Science produces too many dangerous weapons which could destroy mankind.

26. There is too much noise in our everyday lives because of science.

85. Science should be left to the scientists as it does not concern me.

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Figure 8.2.12.

Likert Questionnaire Derived Construct Reliability Values (Cronbach's Alpha).

| SCALE (Number of items) | ABBREVIATION | ALPHA |
|---|---|---|
| Commitment and Enjoyment of School Science(10) | COMSCIL3 | 0.89 |
| Scientific Occupations (10) | SCIOCPL3 | 0.84 |
| Scientific Interests and Pastimes (10) | SCIINTL3 | 0.85 |
| Characteristics of the Scientist (6) | SCIENTL3 | 0.63 |
| Difficulties with Science (6) | SCIDIFL3 | 0.64 |
| The value of Science to Society (11) | SCIVALL3 | 0.80 |
| The danger of Science to Society (8) | SCIDANL3 | 0.74 |

Of these scales only those relating to the personal domain and science and society domain can be said to possess respectable reliability values. The characteristics of the scientist scale and the difficulties with science scale contain too few items which contributes to their poor value overall. Despite this the scales will be retained for comparative purposes as they do represent independent areas of assessment for this questionnaire.

STAGE 3 Overall Comment Likert Questionnaire

The analyses of the Likert questionnaire has produced evidence that this particular technique can produce valid and reliable modes of assessment of a number of the original input constructs. The constructs COMSCI, Commitment and Enjoyment of Science, SCIOCP, Scientific Occupations, SCIINT, Scientific Interests and Pastimes, and to a lesser extent SCIDIF,Difficulties with Science, are close to the original prescription. Although the first three constructs are more likely divisionsof one domain.

The technique identifies the work characteristic aspect of the scientist as separate from the personal characteristics of the scientist. Although only the work characteristic of the scientist is identified here as a clear scale, the personal characteristic side could be developed further into a complete scale without difficulty. The division between the value and the danger of science is clear in the responses to the items and overrides the original division proposed between the general societal view and the individual. This has occured in previous research studies, as noted earlier, and indicates that perhaps pupils can sensibly posses both expressions in their own opinions. The area is clearly established as a facet of attitudinal expression separate from the personal domain.

It is difficult to argue for the existence of the latter constructs as initially proposed. The constructs, SCIMET, Scientific Method, THRLAWS, Theories and Laws, and certainly AIMSCI,Aims of Science, have little clear independent nature. The analyses indicate that whenever possible pupil s respond to their perceptions of positive or negative aspects of the items in accordance with their positive or negative interpretation. It is also necessary to reiterate that these aspects of the attitudinal domain may well depend heavily on the cognitive development of the pupil and whether the science teaching they receive actually promotes thought and therefore opinion on these areas. At a later stage in the pupils education it would be interesting to observe whether these constructs have developed a more independent nature.

The nature of the derived constructs reflects clearly the strength of the personal attitude domain and also the science and society domain. These two areas produce valid and reliable scales for future use. The reliability of the difficulty and the scientist scale could be improved by the addition of further items.

SECTION 2 ANALYSIS OF THE FIXED RESPONSE QUESTIONNAIRES

(b) The Semantic Differential Questionnaire

STAGE I Item Analysis

(i) Item Total Correlation Data

A level of ± 0.12 was selected as a guide for significant correlations (1% significance level being ± 0.115) A total of four items was identified. (see table 8.2.12). All other items were judged satisfactory.

(ii) Item Characteristics

Using the information provided by the frequency analysis, a total of seven items were identified (see table 8.2.12) using the criteria noted previously.

(iii) Item-Item Correlation Data

Each of the items noted above was examined for significant correlations using the complete correlation matrix.

In the first group of items, those items which displayed little relationship with their assigned construct, the items are associated with difficulty in connection with pursuing scientific work or becoming a scientist. This group of items forms a separate set of items from the construct as a whole but the items may well show association with the difficulty construct. As there are a large number of item-item correlations these items are not eliminated at this stage.

In the second group of items there is one common item (item 69) to the groups, this item has been considered above . All the other items have a high number of further association within the data. In the case of these items only items 01 and 74 have excessive response patterns. The first item on the questionnaire 01."Science in our Society", "useful-useless" is an interesting item to show such a resounding vote for the usefulness of science in our society. Perhaps this response reflects the 'halo' effect early on? Item 74. "Scientists, clever-dull" shows a favourable perception of the capabilities of the scientist. As one would not wish to disagree intuitively (!) with either of these items and their perceptions both will remain for the purpose of further analysis. Their weaknesses, as with the other items, are however noted.

Table. 8.2.12. SEMANTIC DIFFERENTIAL DATA

| | | | | |
|---|---|---|---|---|
| Mean | range | 2.33 to 6.14 | average | 4.75 |
| S.D. | range | 1.27 to 2.17 | average | 1.80 |
| Kurtosis | range | 1.31 to 3.56 | average | -0.50 |
| Skew | range | 1.36 to -2.01 | average | -0.70 |

(i) Item - Total Correlation

| Construct | Item | Correlation | Number of significant item to item correlations |
|---|---|---|---|
| 2 | 25 | -0.08 | 18 |
| 2 | 51 | 0.07 | 7 |
| 2 | 69 | 0.04 | 9 |
| 2 | 84 | -0.13 | 20 |

(ii) Item Characteristics

| Construct | Item | Kurtosis | Skew | Number of significant item to item correlations |
|---|---|---|---|---|
| 2 | 69 | 0.71 | -1.20 | 9 |
| 4 | 74 | 3.56 | -2.01 | 46 |
| 4 | 13 | 0.89 | -1.29 | 21 |
| 6 | 01 | 2.88 | -1.68 | 38 |
| 6 | 26 | 0.57 | -1.22 | 52 |
| 7 | 18 | 0.69 | -1.29 | 46 |
| 7 | 58 | 1.37 | -1.25 | 62 |

## STAGE 2 SCALE ANALYSIS

### (a) Analysis of the Input Constructs

#### (1) Reliability Analysis

The input constructs were subjected to a Reliability analysis to establish their performance as scales (see Table 8.2.13.) Semantic Differential Questionnaire - Input Construct Reliability Values)

All of the input construct scales with the exception of the second, Scientific Occupation, have respectable reliability values. The second scale is weak due to the presence of the four items identified earlier which seem to relate more to difficulty aspects rather than to the desirability of pursuing scientific based careers. The items within each construct are generally well correlated and at this stage the scales would seem to offer a consistent assessment of the original construct.

Table 8.2.13

SEMANTIC DIFFERENTIAL QUESTIONNAIRE - INPUT CONSTRUCT RELIABILITY VALUES

(CRONBACH'S ALPHA)

| CONSTRUCT (Abbreviation) | ALPHA VALUE |
|---|---|
| (1) Commitment and Enjoyment of Science (COMSCISD) | 0.88 |
| (2) Scientific Occupations (SCIOCPSD) | 0.66 |
| (3) Scientific Interest and Pastimes (SCIINTSD) | 0.79 |
| (4) Characteristics of the Scientist (SCITSSD) | 0.77 |
| (5) Difficulty with Science as a School Subject (DIFSCISD) | 0.75 |
| (6) Science and Society (SCISOCSD) | 0.83 |
| (7) Science and the Individual (SCIINVSD) | 0.86 |

(ii) Factor Analysis

The factor analyses of the semantic differential questionnaire followed the same programme of analyses as outlined for the previous questionnaire.

(a) Varimax Rotation

(i) Rotation of factors prescribed by Kaiser's Criterion 21 factors representing 60.2% of the total variance. (Table 8.2.14)

(ii) Rotation of a restricted number of factors 10 factors representing 45.1% of the total variance (table 8.2.15)

(b) Equimax Rotation

(i) Rotation of factors prescribed by Kaiser's Criterion 21 factors representing 60.2% of the total variance.(table 8.2.16)

(ii) Rotation of a restricted number of factors 10 factors representing 45.1% of the total variance (table 8.2.17)

In all the analyses of these results a loading of ± 0.3 is selected as being significant. With a sample of this size (N = 671) values ± 0.1 can reach significance. However, as noted previously loadings as low as this will not be reported directly but consideration is given to loadings approaching the ± 0.3 value.

The general impression of the analyses is considered first The full varimax analysis indicates certain groupings of items on its major factors (see table 8.2.14). The major factor contains items which form part of the constructs relating to scientific occupations and scientific interests. Neither of these is completely represented, but the initial factor seems again to relate to the personal domain of the pupil. The second factor incorporates a large body of items referring to the 'science and society' and 'science and the individual' constructs. An examination of these items reveals that they refer generally to the benefits science offers society and the individual. Once again a 'pro' science factor emerges. In connection with this the fourth factor relates the 'anti' science items. The third factor contains two sets of items which belong to two different constructs, the first, commitment and enjoyment of science and the fifth, difficulties associated with science. The linking factor is that all the items relate to practical work in science. The fifth factor contains a body of items relating to the characteristics of the scientist. The items represent the full range of the construct and demonstrates its independance on this technique. Factor six contains two groups of items relating to difficulties. The first set are related to the scientific occupations construct and they concern themselves with difficulties associated with becoming a scientist and scientific work. The second set concerns itself with school based difficulties. In the same way as the earlier factor three, the association between the two sets, this time in relation to stimulus words, are paramount.

The other factors contain small numbers of items which make interpretation limited. However there are two further points of general importance. Factor seven contains a few items relating to the first construct and are related to the enjoyment of school science. Factors nine and twelve each contain a pair of items which relate to a particular aspect of science interest. This division of the interest related items

Table 8.2.14

Semantic Differential - (Varimax Rotation Kaiser's Criterion) Questionnaire

Total Variance = 60.2%

n.b. The decimal point is omitted on these values

| CONST. | ITEM. | FACTOR NUMBER 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 36 | | | | | | 57 | | | | | | | | | | | | | | |
| | 39 | 30 | | 31 | | | | 58 | | | | | | | | | | | | | | |
| | 23 | 30 | | 28 | | | | 61 | | | | | | | | | | | | | | |
| | 78 | 31 | | | | | | | | | | | | | | | | | | | | |
| | 60 | | | 57 | | | | 31 | | | | | | | | | | | | | | |
| 1 | 21 | 29 | | 61 | | | | | | | | | | | | | | | | | | |
| | 49 | 31 | | 57 | | | | 30 | | | | | | | | | | | | | | |
| | 35 | | | 50 | | | | | | | | | | | | | | | | | | |
| | 80 | | | | 51 | | | | | | | | | | | | | | | | | |
| | 16 | 46 | | | | | | | | | | | | | | | | | | | | |
| | 06 | 28 | 32 | | | | | | | | | | | | | | | | | | | |
| | 53 | | | | | | | | | | | | | 53 | | | | | | | | |
| | 61 | 69 | | | | | | | | | | | | | | | | | | | | |
| | 44 | 63 | | | | | | | | | | | | | | | | | | | | |
| | 67 | 64 | | | | | | | | | | | | | | | | | | | | |
| | 54 | 30 | | | | | | | | | | | | 41 | | | | | | | | |
| | 27 | 40 | | | | | | 47 | | | | | | | | | | | | | | |

Table 8.2.14 contd.

| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | FACTOR NUMBER | | | | | | | | | | | | | |
| | 82 | 53 | | | | | | 30 | | | | | | | | | | | | | | |
| 2 | 84 | | | | | | 31 | | | | | | | | | | | | | | | |
| | 25 | | | | | | 68 | | | | | | | | | | | | | | | |
| | 51 | | | | | | 60 | | | | | | | | | | | | | | 38 | |
| | 32 | 31 | | | | | | | | | | | | | | | 49 | | | | | |
| | 72 | | | | | | | | | | 59 | | | | | | | | | | | |
| | 69 | | | | | | 68 | | | | | | | | | | | | | | | |
| | 11 | 63 | | | | | | | | | | | | | | | | | | | | |
| | 04 | | | | | | | | | | 47 | | | | | | | | | | | |
| | 75 | | | | | | | | | | 29 | | | | | | | | | | | |
| | 41 | 41 | | | | | | | | | | | 30 | | | | | | | | | |
| | 20 | 31 | | | | | | | | | | | | | | | | | | | | 34 |
| 3 | 28 | 48 | | | | | | | | | | | | | | | | | | | | |
| | 76 | 44 | | | | | | | | | | | 30 | | | | | | | | | |
| | 57 | 27 | | | | | | | | | | | | | | | | | | | | |
| | 50 | | | | | | | | | 60 | | | | | | | | | | | | |
| | 56 | | | | | | | | | | | | 42 | | | | | | | | | |

Table 8.2.14 contd.

n.b. the decimal point is omitted on these values.

| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 45 | | | | | | | | | 58 | | | | | | | | | | | | |
| | 43 | | | | | | | | | | | | 31 | | | | | | | | | |
| | 74 | | | | | 49 | | | | | | | | | | | | | | | | |
| | 81 | | | | | 37 | | | | | | | | | | | | | | | | |
| | 08 | 51 | | | | | | | | | | | | | | | | | | | | |
| | 71 | | | | | 58 | | | | | | | | | | | | | | | | |
| | 17 | | | | | | | | | | | 42 | | | | | | | | | | |
| 4 | 42 | | | | | 52 | | | | | | | | | | | | | | | | |
| | 03 | | | | | | | | | | | 38 | | | | | | | | | | |
| | 13 | | | | | 49 | | | | | | | | | | | | | | | | |
| | 31 | | | | | 50 | | | | | | | | | | | | | | | | |
| | 52 | | 35 | | | | | | | | | | | | | | | | | | | |
| | 40 | | | | | 28 | | | | | | | | | | | | | | | | |
| | 10 | | | | | | | | | | | | | | | | | | | 41 | | |
| | 12 | | | | | | 44 | | | | | | | | | | | | | | | |
| | 46 | | | | | | 33 | | | | | | | | | | | | | | | |
| | 62 | | | | | | | | 83 | | | | | | | | | | | | | |
| | 34 | | | | | | | | 78 | | | | | | | | | | | | | |

Table 8.2.14 contd.

| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 48 | | | | | | 43 | | | | | | | | 54 | | | | | | | |
| | 30 | | | | | | 42 | | | | | | | | 46 | | | | | | | |
| 5 | 36 | | | | | | | | | | | | | | | | | | -40 | | | |
| | 55 | | | | | | | | | | | | | | | 37 | | | | | | |
| | 09 | | | -63 | | | | | | | | | | | | | | | | | | |
| | 65 | | | -52 | | | | | | | | | | | | | | | | | | |
| | 19 | | | -57 | | | | | | | | | | | | | | | | | | |
| | 02 | | | -42 | | | | | | | | | | | | | | | | | | |
| | 79 | | 45 | | 45 | | | | | | | | | | | | | | | | | |
| | 70 | | 30 | | 57 | | | | | | | | | | | | | | | | | |
| | 01 | | 29 | | | | | | | | | | | | | | | | | | | |
| | 26 | | 57 | | | | | | | | | | | | | | | | | | | |
| | 22 | | 48 | | | | | | | | | | | | | | | | | | | |
| 6 | 68 | | | | 57 | | | | | | | | | | | | | | | | | |
| | 73 | | 42 | | 32 | | | | | | | | | | | | | | | | | |
| | 33 | | | | 49 | | | | | | | | | | | | | | | | | |
| | 05 | | | | 34 | | | | | | | | | | | | | | | | | |
| | 63 | | | | 39 | | | | | | | | | | | | | | | | | |

<u>Table 8.2.14</u> contd.

| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 66 | | | | | | | | | | | | | | | | | | | | | |
| | 37 | | 32 | | 31 | 33 | | | | | | | | | | | | | | | | |
| | 24 | | 30 | | | | | | | | | | | | | | | | | | | |
| | 77 | | 61 | | | | | | | | | | | | | | | | | | | |
| | 59 | 32 | 61 | | | | | | | | | | | | | | | | | | | |
| | 29 | 33 | 59 | | | | | | | | | | | | | | | | | | | |
| | 47 | | | | 40 | | | | | | | | | | | | | | | | | |
| 7 | 64 | | 50 | | | | | | | | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | 29 | | | | | | | | | | |
| | 07 | | | | | | | | | | | | | | | | | 51 | | | | |
| | 18 | | 43 | | | | | | | | | | | | | | | | | | | |
| | 83 | | 49 | | | | | | | | | | | | | | | | | | | |
| | 38 | | 49 | | | | | | | | | | | | | | | | | | | |
| | 58 | 29 | 47 | | | | | | | | | | | | | | | | | | | |

Table 8.2.15 QUESTIONNAIRE

SEMANTIC DIFFERENTIAL - (VARIMAX ROTATION NF=10)

Total Variance = 45.1%

| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 51 | 46 | | | | | | | | |
| | 39 | 46 | 51 | | | | | | | | |
| | 23 | 47 | 50 | | | | | | | | |
| | 78 | 44 | 29 | | | | | | | | |
| | 60 | 30 | 63 | | | | | | | | |
| 1 | 21 | | 61 | | | | | | | | |
| | 49 | 33 | 63 | | | | | | | | |
| | 35 | | 52 | | | | | | | | |
| | 80 | | | 53 | | | | | | | |
| | 16 | 44 | | | | | | | | | |
| | 06 | 31 | | | | 30 | | | | | |
| | 53 | 30 | | 32 | | | | | | | |
| | 61 | 73 | | | | | | | | | |
| | 44 | 65 | | | | | | | | | |
| | 67 | 70 | | | | | | | | | |
| | 54 | 38 | | | | | | | | | |
| | 27 | 52 | 29 | | | | | | | | |
| 2 | 82 | 64 | 28 | | | | | | | | |
| | 84 | | | | | | 39 | | | | |
| | 25 | | | | | | 61 | | | | |
| | 51 | | | | | | 59 | | | | |
| | 32 | 39 | | | | | | | | | |
| | 72 | 33 | | | | | | | | | |
| | 69 | | | | | | 61 | | | | |
| | 11 | 59 | | | | | | | | | |
| | 04 | 35 | | | | | | | | | |
| | 75 | 29 | | | | | | | | | |
| | 41 | 42 | | | | | | | | | |

Table 8.2.15. contd.

| Const. | Item. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 43 | | | | | | | | | |
| 3 | 28 | 48 | | | | | | | | | |
| | 76 | 54 | | | | | | | | | |
| | 57 | 36 | | | | | | | | | |
| | 50 | | | | | | | | | 49 | |
| | 56 | 33 | | | | | | | | | 34 |
| | 45 | | | | | | | | | 50 | |
| | 43 | 38 | | | | | | | | | 38 |
| | 74 | | | | | 49 | | | | | |
| | 81 | | | | | 36 | | | | | |
| | 08 | 41 | | | | | | | | | |
| | 71 | | | | | 55 | | | | | |
| | 17 | | | | | | | | | | |
| 4 | 42 | | | | | 50 | | | | | |
| | 03 | | | | | | | | | | |
| | 13 | | | | | 51 | | | | | |
| | 31 | | | | | 49 | | | | | |
| | 52 | | | | 34 | | | | | | |
| | 40 | | | | | 32 | | | | | |
| | 10 | | | 27 | | 28 | | | | | |
| | 12 | | | | | | 46 | | | | |
| | 46 | | | | | | 42 | | | | |
| | 62 | | | | | | 28 | 78 | | | |
| | 34 | | | | | | 26 | 76 | | | |
| | 48 | | | | | | 60 | | | | |
| 5 | 30 | | | | | | 56 | | | | |
| | 36 | | | | | | | | | | |
| | 55 | | | | | | | | | | 31 |
| | 09 | | -55 | | | | | | | | |
| | 65 | | -44 | | | | | | | | |

Table 8.2.15 contd.

| Const. | Item. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 19 | | -53 | | | | | | | | |
| | 02 | | -44 | | | | | | | | |
| | 79 | | | 48 | 38 | 24 | | | | | |
| | 70 | | | 55 | 28 | | | | | | |
| | 01 | | | | | 31 | | | | | |
| | 26 | | | | 54 | | | | | | |
| | 22 | | | 23 | 43 | 34 | | | | | |
| 6 | 68 | | | 60 | | | | | | | |
| | 73 | | | 42 | 35 | | | | | | |
| | 33 | | | 46 | | | | | | | |
| | 05 | | | 32 | | | | | | | |
| | 63 | | | 34 | | | | | | | |
| | 66 | | | 21 | | | | | | | |
| | 37 | 29 | | 38 | | 30 | | | | | |
| | 24 | | | 34 | | | | | | | |
| | 77 | 29 | | | 56 | | | | | | |
| | 59 | 36 | | | 57 | | | | | | |
| | 29 | 35 | | | 55 | | | | | | |
| | 47 | | | 45 | | | | | | | |
| 7 | 64 | 30 | | 31 | 40 | | | | | | |
| | 15 | | 19 | | | | | | | | |
| | 07 | | | 32 | | | | | | | |
| | 18 | 30 | | | 36 | | | | | | |
| | 83 | 37 | | | 40 | | | | | | |
| | 38 | | | | 45 | | | | | | |
| | 58 | 39 | | | 39 | 28 | | | | | |

Table 8.2.16 Semantic Differential - (Equimax Rotation - Kaiser's Criterion) Questionnaire

Total Variance = 60.2%

| | | FACTOR NUMBER | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | 14 | 55 | | | | | | | | | | | | | | | | | | | |
| | 39 | 58 | | | | | | | | | | | | | | | | | | | |
| | 23 | 61 | | | | | | | | | | | | | | | | | | | |
| | 78 | | | | | | | | | 32 | | | | | | | | | | | |
| | 60 | 43 | 43 | | | | | | | | | | | | | | | | | | |
| 1 | 21 | 35 | 49 | | | | | | | | | | | | | | 35 | | | | |
| | 49 | 42 | 46 | | | | | | | | | | | | | | 35 | | | | |
| | 35 | | 40 | | | | | | | | | | | | | | | | 32 | | |
| | 80 | | | | | | | | 45 | | | | | | | | | | | | |
| | 16 | | | 30 | | | | | | | | | | 38 | | | | | | | |
| | 06 | | | | | | | | | | | | | | | | | | 32 | | |
| | 53 | | | | | | | | | 60 | | | | | | | | | | | |
| | 61 | | | 48 | | | | | | 32 | | | | | | | | | | | |
| | 44 | | | 45 | | | | | | | | | | | | | | | | | |
| | 67 | | | 45 | | | | | | 31 | | | | | | | | | | | |
| | 54 | | | | | | | | | 40 | | | | | | | | | 34 | | |

<u>Table 8.2.16</u> contd.

| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 27 | 43 | | 29 | | | | | | | | 35 | | | | | | | | | |
| | 82 | 32 | | 32 | | | | | | | | | | | | | | | | | |
| 2 | 84 | | | | | | | | | | | | | | | | | 36 | | | |
| | 25 | | | | | | 65 | | | | | | | | | | | | | | |
| | 51 | | | | | | 63 | | | | | | | | | | | | | | |
| | 32 | | | | | | | | | | | | | | | | | | 53 | | |
| | 72 | | | | | | | | | | | | | | | | | | | 61 | |
| | 69 | | | | | | 63 | | | | | | | | | | | | | | |
| | 11 | | | 51 | | | | | | | | | | | | | | | | | |
| | 04 | | | | | | | | | | | | | | | | | | | 50 | |
| | 75 | | | | | | | | | | | | | | | | | | | 29 | |
| | 41 | | | | | | | | | | | | | 50 | | | | | | | |
| | 20 | | | | | | | | | | | | 38 | 32 | | | | | | | |
| 3 | 28 | | | 35 | | | | | | | | | | | | | | | | | |
| | 76 | | | | | | | | | | | | | 39 | | | | | | | 36 |
| | 57 | | | | | | | | | | | | | | | | | | | | |
| | 50 | | | | | | | | | | | | | | | 61 | | | | | |

Table 8.2.16 contd.

| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 56 | | | | | | | | | | | | | 36 | | | | | | | | |
| | 45 | | | | | | | | | | | | | | | 60 | | | | | | |
| | 43 | | | | | | | | | | | | | 36 | | 29 | | | | | | |
| | 74 | | | | | | | 52 | | | 38 | | | | | | | | | | | |
| | 81 | | | | | | | | | | 35 | | | | | | | | | | | |
| | 08 | | | 43 | | | | | | | | | | | | | | | | | | |
| | 71 | | | | | | | | | | 53 | | | | | | | | | | | |
| | 17 | | | | | | | | | | | | | | | | | | | | | 40 |
| 4 | 42 | | | | | | | | | | 43 | | | | | | | | | | | |
| | 03 | | | | | | | | | | | | | | | | | | | | | 42 |
| | 13 | | | | | | | | | | 45 | | | | | | | | | | | |
| | 31 | | | | | | | | | | 44 | | | | | | | | | | | |
| | 52 | | | | | | | | | | | | | | | | | | | | | 28 |
| | 40 | | | | | | | | | | | | | | | | | | | | | |
| | 10 | | | | | | | | | | | | | | | | 51 | | | | | |
| | 12 | | | | | | 32 | | | | | | | | | | | 37 | | | | |
| | 46 | | | | | | 29 | | | | | | | | | | | 33 | | | | |
| | 62 | | | | | -85 | | | | | | | | | | | | | | | | |

<u>Table 8.2.16</u> contd.

| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 34 | | | | | -80 | | | | | | | | | | | | | | | | |
| | 48 | | | | | | | | | | | | | | | | | 64 | | | | |
| | 30 | | | | | | | | | | | | | | | | | 56 | | | | |
| 5 | 36 | | | | | | | | | | | | | | | | | | | | -40 | |
| | 55 | | | | | | | | | | | | | | | | | | | | -34 | |
| | 09 | | -61 | | | | | | | | | | | | | | | | | | | |
| | 65 | | -50 | | | | | | | | | | | | | | | | | | | |
| | 19 | | -55 | | | | | | | | | | | | | | | | | | | |
| | 02 | | -32 | | | | | | | | | | | | | | | | | | | |
| | 79 | | | | | | | 34 | 34 | | | | | | | | | | | | | |
| | 70 | | | | | | | | 44 | | | | | | 40 | | | | | | | |
| | 01 | | | | | | | | | | | | 44 | | | | | | | | | |
| | 26 | | | | | | | | | | | | 29 | | | | | | | | | |
| | 22 | | | | | | | 32 | | | | | | | | | | | | | | |
| 6 | 68 | | | | | | | 46 | | | | | | | 35 | | | | | | | |
| | 73 | | | | | | | 32 | | | | 30 | | | 27 | | | | | | | |
| | 33 | | | | | | | | 43 | | | | | | | | | | | | | |
| | 05 | | | | | | | | | | | | | | | | | | | | | |

Table 8.2.16 contd.

| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 63 | | | | | | | | 36 | | | | | | | | | | | | | |
| | 66 | | | | | | | | | | | | | | | | | | | | | |
| | 37 | | | | | | | | | | | 37 | | | | | | | | | | |
| | 24 | | | | | | | | | | | 33 | | | 39 | | | | | | | |
| | 77 | | | | 53 | | | | | | | | | | | | | | | | | |
| | 59 | | | | 48 | | | | | | | | | | | | | | | | | |
| | 29 | | | | 54 | | | | | | | | | | | | | | | | | |
| | 47 | | | | | | | | 30 | | | | | | 33 | | | | | | | |
| 7 | 64 | | | | 39 | | | | | | | 34 | | | | | | | | | | |
| | 15 | | | | | | | | | | | | | | | | | | 29 | | | 30 |
| | 07 | | | | | | | | | | | | | | 58 | | | | | | | |
| | 18 | | | | | | | | | | | | 29 | | | | | | | | | |
| | 83 | | | | 29 | | | 33 | | | | | 28 | | | | | | | | | |
| | 38 | | | | 38 | | | | | | | | | | | | | | | | | |
| | 58 | | | | | | | 34 | | | | | 31 | | | | | | | | | |

TABLE 8.2.17 QUESTIONNAIRE

SEMANTIC DIFFERENTIAL - (EQUIMAX ROTATION NF = 10)

(Total Variance = 45.1%)

| | | FACTOR NUMBER | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CONST. | ITEM. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | 14 | 45 | 46 | | | | | | | | |
| | 39 | 48 | 45 | | | | | | | | |
| | 23 | 48 | 40 | | | | | | | | |
| | 78 | | 32 | | | | | | | | |
| | 66 | 60 | | | | | | | | | |
| 1 | 21 | 57 | | | | | | | | | |
| | 49 | 62 | | | | | | | | | |
| | 35 | 46 | | | | | | | | 34 | |
| | 80 | | | | 52 | | | | | | |
| | 16 | | | | | | 32 | | | | |
| | 06 | | | | | | | | | | |
| | 53 | | | | 29 | | 28 | | | 29 | |
| | 61 | | 53 | | | | 33 | | 30 | 28 | |
| | 44 | | 47 | | | | 32 | | | | |
| | 67 | | 51 | | | | 34 | | | | |
| | 54 | | | | | | | | | 31 | |
| | 27 | | 44 | | | | | | | | |
| 2 | 82 | | 48 | | | | 33 | | | | |
| | 84 | | | | | 40 | | | | | |
| | 25 | | | | | 62 | | | | | |
| | 51 | | | | | 58 | | | | 29 | |
| | 32 | | 30 | | | | | | | 33 | |
| | 72 | | | | | | 34 | | | | |
| | 69 | | | | | 61 | | | | | |
| | 11 | | 42 | | | | 33 | | | | |
| | 04 | | | | | | 30 | | | | |

Table 8.2.17 contd.

| CONST. | ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 75 | | | | | | | | | | |
| | 41 | | | | | | 40 | | | | |
| | 20 | | | | | | 39 | | | | |
| 3. | 28 | | 37 | | | | | | 34 | | |
| | 76 | | 29 | | | | 36 | | 33 | | |
| | 57 | | | | | | | | | | |
| | 50 | | | | | | | | 53 | | |
| | 56 | | | | | | 43 | | | | |
| | 45 | | | | | | | | 55 | | |
| | 43 | | | | | | 52 | | 30 | | |
| | 74 | | | 27 | | | | 47 | | | |
| | 81 | | | | | | | 32 | | | |
| | 08 | | 33 | | | | | | | | |
| | 71 | | | | | | | 52 | | | |
| | 17 | | | | | | | | | | |
| 4. | 42 | | | | | | | 48 | | | |
| | 03 | | | | | | | | | 32 | |
| | 13 | | | | | | | 49 | | | |
| | 31 | | | | | | | 48 | | | |
| | 52 | | | 30 | | | | | | 37 | |
| | 40 | | | | | | | 31 | | | |
| | 10 | | | | | | | 27 | | | |
| | 12 | | | | | 46 | | | | | |
| | 46 | | | | | 41 | | | | | |
| | 62 | | | | | 28 | | | | | 68 |
| | 34 | | | | | 28 | | | | | 69 |
| | 48 | | | | | 61 | | | | | |
| 5. | 30 | | | | | 57 | | | | | |

Table 8.2.17 contd.

| CONST. | ITEM | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 36 | | -28 | | | | | | | | |
| | 55 | | | | | | | | | | |
| | 09 | -53 | | | | | | | | -28 | |
| | 65 | -42 | | | | | | | | -29 | |
| | 19 | -53 | | | | 29 | | | | | |
| | 02 | -42 | | | | | | | | | |
| | 79 | | | 39 | 46 | | | | | | |
| | 70 | | | | 52 | | | | | | |
| | 01 | | | | | | | 27 | | | |
| | 26 | | | 51 | | | | | | | |
| | 22 | | | 41 | | | | 31 | | | |
| 6 | 68 | | | | 58 | | | | | | |
| | 73 | | | 36 | 40 | | | | | | |
| | 33 | | | | 45 | | | | | | |
| | 05 | | | | 31 | | | | | | |
| | 63 | | | | 31 | | | | | 31 | |
| | 66 | | | | | | | | | | |
| | 37 | | | | 37 | | | | | | |
| | 24 | | | | 32 | | | | | | |
| | 77 | | | 54 | | | | | | | |
| | 59 | | | 55 | | | | | | | |
| | 29 | | | 54 | | | | | | | |
| | 47 | | | | 43 | | | | | | |
| 7 | 64 | | | 39 | 28 | | | | | | 28 |
| | 15 | | | | | | | | | 34 | |
| | 07 | | | | 30 | | | | | | |
| | 18 | | | 36 | | | | | | | |
| | 83 | | | 41 | | | | | | | |
| | 38 | | | 42 | | | | | | | |
| | 58 | | | 37 | | | | | | | |

indicate that there are a number of facets to this construct which could be expanded upon.

Overall the initial impression provides certain key areas of pupil response. These are:

(i) A personal response relating primarily to scientific occupation and interests.

(ii) A response relating to science and its effect on society in two ways, a 'pro' and an 'anti' factor.

(iii) A response recognising the characteristics of a scientist.

The areas of difficulty in science again is present but would not be regarded as a key area from the pupil's responses.

The results from the analyses are now considered in terms of the initial input constructs to enable further detail to be added to the above impression.

(1) Commitment and Enjoyment of Science

The analyses indicate that the first construct is divided in the responses according to the stem of the item. Consider the first four items:

| | | |
|---|---|---|
| 14 | science lessons | enjoyable - not enjoyable |
| 39 | science lessons | unpleasant - pleasant |
| 23 | science lessons | interesting - boring |
| 78 | science lessons | stimulating - monotonous |

These items are connected to science lessons and appear together (see factor 7, table 8.2.14) item 78 is weak in its relationship to the other items, perhaps this is a reflection on the words in the stimulus pair. These items also form part of the major factor in the analysis in that they are represented by minor loadings. (see factor 1, table 8.2.14).

The following four items group together on the basis of their stem:

| | | |
|---|---|---|
| 60 | practical work in science | not enjoyable - enjoyable |
| 21 | practical work in science | dull - exciting |
| 49 | practical work in science | interesting- boring |
| 35 | practical work in science | tedious - stimulating |

They are related clearly (factor 3, table 8.2.14), but the items are similar and would not provide a diverse scale. The responses to these items appear consistent throughout the questionnaire. To emphasise the importance of the stem, the items are related to the 'practical work in science' items from the fifth construct relating to difficulty with science (factor 3, table 8.2.14). A high level of practical difficulty is associated with a low level of enjoyment as indicated by the negative loadings.

The remaining four items on this construct relate to the content and the stimulus words used. They relate however to other groups of items and not immediately to each other.

Item 80:science in our world : pleasant - unpleasant,
relates to items which are connected later with the social implications of science (see factor4, table 8.2.14).

Item 16:science in our world : interesting - boring,
relates to science interest items appearing on the first factor of table 8.2.14.

Item06: science in our world : dull - exciting
relates primarily to items connected with positive aspects of the social implications of science but also to the science interest area noted for item sixteen.

Finally item 53: science in our world : stimulating - monotonous this is a mixed item on a number of factors which may well reflect the uncertainty over the stimulus words as much as any other interpretation. (see factors 1 and 3, table 8.2.15).

Overall there is little evidence from this analysis that the construct exists as originally proposed. There are two distinct sub-groups within the construct which are established as separate factors but they are groups of similar items.

(2) Scientific Occupations

Two groups of items are suggested from the analyses.

Group (1)

| | | |
|---|---|---|
| 61 | a job as a scientist | boring - interesting |
| 44 | a job as a scientist | exciting - dull |
| 67 | a scientific career | interesting - boring |
| 27 | scientific work | enjoyable - not enjoyable |
| 82 | Scientific work | boring - exciting, and also |
| 54 | a scientific career | monotonous - stimulating |
| 32 | working in a science laboratory | tedious - stimulating |
| 72 | working as an engineer | interesting - boring |
| | | (see factor 1, on table 8.2.14, 8.2.15) |

Group(2)

| | | |
|---|---|---|
| 34 | scientific work | hard - easy |
| 25 | becoming a scientist | difficult - straight forward |
| 51 | becoming a scientist | complex - simple |
| 69 | becoming a scientist | easy - hard |
| | | (see factor 6, table, 8.2.14, 8.2.15) |

The two groups reflect interest in scientific occupations and difficulties associated with becoming a scientist and scientific work. The second group forms a link with further difficulty items on the latter construct, this is emphasised on the restricted analysis (factor 6, on table 8.2.15) This suggests a common perception of the difficulty of work in science. The first group contains the items relating to scientific careers. The two weaker items from the loadings on the analyses (54,32) have again a problem with their understanding. Similarly the idea, or lack of a clear concept, of an engineer (item 72) is present. The items in this group have a strong link with the items on the first and third construct with interest and enjoyment as their stimulus words.

In considering the varimax analyses (table 8.2.14. 8.2.15), the responses seem to indicate that the overall response is to an interest/ enjoyment of activities relating to science. Whether these activities relate to school science, scientific careers or science interests seems unimportant. However the equimax analyses (tables 8.2.16 and 8.2.17) suggest that these three facets have a measure of independence from one another. It would seem that there may be three different aspects here, as prescribed initially, but that the pupils attitude and interest and their thoughts on scientific careers are themselves connected. The other consideration is that the stimulus words also govern the responses to an extent. This latter point adds confusion.

The first group of items relating to scientific occupations displays a measure of independence but only in the equimax analyses. The second group is clearly related to the common difficulty perception and remains separate from the first group.

(3) <u>Scientific Interests and Pastimes</u>

The analyses indicate a pattern of interrelationships with other constructs and within the construct itself. The varimax analyses (see table 8.2.14, 8.2.15) indicate that this is a strong component of the major factor. The items below form an initial core:

| | | |
|---|---|---|
| 11 | Taking up a scientific hobby | stimulating - dull |
| 41 | watching programmes on science on TV | exciting - dull |
| 28 | running a science club | tedious - exciting |
| 76 | taking scientific books out of the library | interesting - boring |

These items are supplemented by considering the restricted analyses by

| | | |
|---|---|---|
| 57 | studying the weather | stimulating - monotonous |
| 20 | a visit to a science museum | pleasant - unpleasant |
| 4 | building a radio | boring - interesting |
| 75 | working with a chemistry set | not enjoyable - enjoyable |
| 56 | reading a science fiction book | entertaining - dull |
| 43 | studying the stars and planets | enjoyable - not enjoyable |

The items (4,75) are initially somewhat independent (see factor 10, table 8.2.14) and relate to very active and specific scientific hobbies. There is no real relationship between the latter stems (56,43) apart perhaps from common association with astronomy! The equimax analyses include these latter two within the main group. The remaining two items:

| | | |
|---|---|---|
| 50 | collecting and studying plants | entertaining - dull |
| 45 | collecting fossils and rocks | boring - interesting |

share the common theme of collecting. This is perceived as different and the two items form a separate factor on all analyses.

The equimax analyses tend to spread the item in a similar pattern but certain items (11, 28) are removed from the main group it is not easy to ascertain a clear reason for this.

It is only the equimax analyses which give this construct independence. The main group of items could be said to be a valid scale but with a clear relationship to scientific occupations.

(4) <u>Characteristics of the Scientist</u>

The items relating to this construct are closely related and appear generally on one factor. The items which do not follow this pattern seem to present the student with difficulties in English with the exception of one item which is clearly related to the interest and attitude constructs.

The items below are representative of the construct as indicated by the analyses (see factor 5, table 8.2.14)

| | | |
|---|---|---|
| 74 | scientists | clever - dull |
| 81 | scientists | scatterbrained - thoughtful |
| 71 | scientists | sociable - unsociable |
| 42 | scientists | honest - dishonest |
| 13 | scientists in their work | organised - disorganised |
| 31 | scientists in their work | unco-operative - co-operative |
| 40 | scientists in their work | open-minded - narrow-minded |
| 10 | a scientist's family life | unhappy - happy |

The latter items are weak, item 40 has English difficulties. Item 10 is weak, perhaps due to understanding of the situation. The three items below show weak or non existent relationship with the core:

| | | |
|---|---|---|
| 3 | scientists in their work | easily diverted - persevering |
| 8 | scientists | boring - interesting |
| 52 | scientists in their work | indifferent - dedicated |

Item 3 is of a difficult nature whereas items 8,52 show relation elsewhere. Item 8 relates through the stimulus words to science interest items earlier and item 52 shows a relationship with items relating to the value of science at a later stage. The construct has a measure of independence across the range of its initial description.

(5) Difficulties with Science as a School Subject

The items relating to this construct are split into three identifiable groups, (see factors 6, 8 and 3, table 8.2.14)

Group (1)

| | | |
|---|---|---|
| 12 | scientific ideas | easy - hard |
| 46 | scientific ideas | complex - simple |
| 48 | scientific terms and names | easy - hard |
| 30 | scientific terms and names | difficult - simple |

Group (2)

| | | |
|---|---|---|
| 62 | science lessons involving maths | difficult - easy |
| 34 | science lessons involving maths | simple - hard |

Group (3)

| | | |
|---|---|---|
| 09 | practical work in science | confused - clear |
| 65 | practical work in science | difficult to - easy to perform perform |
| 19 | practical work in science | straightforward - difficult |
| 02 | practical work in science | helps my understanding of science - does not help my understanding of science |

Items 36, 55 are separate from these groups (see Table 8.2.14, 8.2.16) and are concerned with the pace of work.

The first two groups deal with difficulties associated with school science work. They are connected, albeit weakly, on the restricted equimax (table 8.2.16). The second group deals specifically with mathematical problems. The first group concerns itself with concepts and terminology. There is a sharp division between these two groups and the third. The latter group refers to practical work in science and it is firmly associated with the items from the first construct of a similar item. The loadings are however negative here which indicates that the enjoyment of practical work is coupled with an 'ease' of understanding. This would appear logical.

There are four items which relate to the first group from the second construct.

| | | |
|---|---|---|
| 84 | scientific work | hard - easy |
| 25 | becoming a scientist | difficult - straightforward |
| 51 | becoming a scientist | complex - simple |
| 69 | becoming a scientist | easy - hard |

The perception of scientific work is obviously taken in the school context. Item 84 and the other three items, connected with becoming a scientist, are thus assessed in the light of school based difficulties rather than the difficulties associated with the further academic work required to become a scientist. Perhaps at this age it is unfair to expect any other real perception of a career nature.

The evidence from the analysis suggests that the construct has an independent nature but that the items relating to practical work need to be assessed separately from the main construct.

(6) **Science and Society**

(7) **Science and the Individual**

Items 36, 55 are separate from these groups (see Table 8.2.14, 8.2.16) and are concerned with the pace of work.

The first two groups deal with difficulties associated with school science work. They are connected, albeit weakly, on the restricted equimax (table 8.2.16). The second group deals specifically with mathematical problems. The first group concerns itself with concepts and terminology. There is a sharp division between these two groups and the third. The latter group refers to practical work in science and it is firmly associated with the items from the first construct of a similar item. The loadings are however negative here which indicates that the enjoyment of practical work is coupled with an 'ease' of understanding. This would appear logical.

There are four items which relate to the first group from the second construct.

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The evidence from the analysis suggests that the construct has an independent nature but that the items relating to practical work need to be assessed separately from the main construct.

(6) Science and Society

(7) Science and the Individual

In a similar fashion to the Likert questionnaire the evidence from the analyses again indicates that these constructs are best considered together. Essentially the initial division whilst convenient and valid at face value, is not supported by the analyses. The items on these constructs divide into two main categories which reflect

(1) the value of science to society and the individual and

(2) the danger of science to society and the individual.

(Group 1 and Group 2, following item lists)

The allocation of items is based upon their allocation to factors 2 and 4 on the full varimax analysis. (table 8.2.14) The additional items are allocated after the examination of the restricted analyses, (table 8.2.15 and 8.2.17). The two items which relate to the money spent on science (66, 37) also relate to the second group overall but, particularly in the case of:

Group (1)

| | | |
|---|---|---|
| Science in our society | unimportant - important | 26 |
| science in our society | worthless - valuable | 22 |
| science in our society | productive - wasteful | 73 |
| science in relation to me | useless - useful | 77 |
| science in relation to me | unimportant - important | 59 |
| science in relation to me | worthless - valuable | 29 |
| science in relation to me | productive - wasteful | 64 |
| learning about science | unimportant - important | 18 |
| learning about science | useful - useless | 83 |
| science in my home | useless - useful | 38 |
| learning about science | wise - foolish | 58 |

and

| | | |
|---|---|---|
| science in our society | useful - useless | 01 |

Group (2)

| | | |
|---|---|---|
| science in our society | harmful - helpful | 70 |
| science in our society | threatening - comforting | 68 |
| science in our society | safe - dangerous | 33 |
| science in our society | destructive - constructive | 05 |
| science in our society | chaotic - orderly | 63 |
| science in relation to me | comforting - threatening | 47 |
| and | | |
| science in our society | good - bad | 79 |
| science in relation to me | helpful - harmful | 24 |
| science in relation to my health | helpful - harmful | 07 |

Item 37; money spent on science:well spent - wasted

they do seem shared between the two aspects. The items perhaps tie the two areas together with the overall bids from the response being towards the negative pole.

There is evidence therefore of two scales of items which appear as separate factors. The first group contains items which relate to the positive value of science to society and the individual. The second group contains items which relate the dangers of science to society and the individual. In the examination of the items it is difficult not to associate the overall pattern of response to the stimulus words rather than the particular stem. In the responses to the items what can be seen is that science has both a 'valuable' and a 'dangerous' aspect apparent.

Within the analyses some interrelations are apparent with other constructs. Item 80: science in our world : pleasant - unpleasant, from the first construct is linked with the dangers of science. The wording here, particularly the stimulus words, encourages this interelation.

## SUMMARY OF FACTOR ANALYSES ON THE SEMANTIC DIFFERENTIAL QUESTIONNAIRE

| CONSTRUCT | COMMENT |
|---|---|
| 1 | Although a group of items does exhibit independence on a particular aspect of this construct - enjoyment of science - there are insufficient items for a scale. Weak evidence for existance of the construct. Practical items relate to practical work difficulty. |
| 2 | Two groups of items independent of each other but related to other items on other constructs<br>(1) scientific careers<br>(2) difficulty in becoming a scientist.<br>Neither independent as a single construct. |
| 3 | The majority of the items are related to a single factor. Major scale is science interest. The scale relates to scientific careers. A combined scale with two divisions would seem possible here. |
| 4 | Independent set of items overall. Language only barrier to a strong set of items. |
| 5 | Evidence provided for two independent groups of items associated with difficulty. Support for the constructs independence.<br>1. Difficulty with concepts, terminology and maths.<br>2. Difficulty with practical work. Due to association of (2) with items in C1 a valid scale is not produced. |
| 6/7 | Original constructs overridden by clear division of items into two areas.<br>(1) Value of science<br>(2) Danger of science<br>These form two clear scales which are relatively independent factorially. |

(iii) Analysis of the Input Constructs

The original input constructs were subjected to a factor analytic investigation to examine the possible sub structure of the constructs, An initial rotation of the input constructs to the standard Kaiser criterion produced one clear factor as the best representation of the input constructs as scales. This indicates that the construct displays a close relationship. A further rotation was attempted where two factors for consideration were prescribed. This analysis is presented in tables 8.2.18 and 8.2.19. The second factor here has a low eigen value (0.87) before rotation and this is considerably below the nominal value expected. The two factors account for a total variance of 73.2%.

The information presented indicates two groups of constructs

1) a personal group
2) a group concerning scientists and the social implications of science.

These groups are resolved to represent factors one and two respectively (see table 8.2.18). The resolution of these groups is improved by the adoption of the oblique technique (see table 8.2.19). Essentially the first factor is composed of the first three constructs and the difficulty of science construct. The negative loading associating high levels of difficulty with low levels of personal satisfaction with science and science related activities. The second factor, when forced, is composed of constructs relating to the characteristics of a scientist and the implications the work of science has upon society and the individual. Despite the reservations expressed concerning the unimportance of the division between 'science and society' and 'science and the individual' in the item analyses. The individual factor retains a factorial loading with the group of constructs on factor one which are of a personal nature.

Table 8.2.18 SEMANTIC DIFFERENTIAL QUESTIONNAIRE INPUT CONSTRUCTS

(Varimax Rotation to Two Factors)

Total Variance = 73.2%

| CONSTRUCT | FACTOR 1 | FACTOR 2 |
|---|---|---|
| COMSCI | 81 | 41 |
| SCIOCP | 61 | 39 |
| SCIINT | 72 | 29 |
| SCITS | 37 | 61 |
| DIFSCI | -45 | |
| SCISOC | 31 | 87 |
| SCIINV | 58 | 65 |

Table 8.2.19 SEMANTIC DIFFERENTIAL QUESTIONNAIRE INPUT CONSTRUCTS

(OBLIQUE ROTATION TO TWO FACTORS)

Total Variance = 73.2%

| CONSTRUCT | FACTOR 1 | FACTOR 2 |
|---|---|---|
| COMSCI | 88 | |
| SCIOCP | 61 | |
| SCIINT | 83 | |
| SCITS | | 58 |
| DIFSCI | -49 | |
| SCISOC | | 98 |
| SCIINV | 42 | 51 |

(iv) Cluster Analysis

The cluster analysis of the items from the semantic differential resulted in three major groups of clusters forming. As in the previous analysis of the Likert Questionnaire attempts were made to break up a large initial cluster but this proved unsuccesful.

The three major cluster groups were examined in terms of the number of items they contained relating to each of the input constructs (table 8.2.28). As can be seen the majority of items are connected together on the first cluster. This supports the close relationship between the data as a whole. All aspects are related in this cluster. The second cluster contains items relating to science interest and science occupations. The third cluster contains items relating just to the difficulty with practical work in science. The individual clusters within the major groups contain a mixed group of items relating to a number of initial constructs. The analysis does not indicate clear clusters corresponding to individual input constructs. The analysis, although of limited value in the resolution of the structure of the data, does reinforce the general perception of two areas of personal interest and of science, scientists and society within the pupils response pattern.

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Table 8.2.20 CLUSTER ANALYSIS SEMANTIC DIFFERENTIAL CONSTRUCT

| CLUSTER | CONSTRUCT 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| A | 12 | 8 | 3 | 12 | 8 | 11 | 12 |
| B | | 4 | 9 | | | | |
| C | | | | | 4 | | |

Key

| Construct | Title | |
|---|---|---|
| 1 | Commitment and Enjoyment of Science | (CONSCI) |
| 2 | Scientific Occupations | (SCIOCP) |
| 3 | Scientific Interests | (SCIINT) |
| 4 | Characteristics of the Scientist | (SCITS) |
| 5 | Difficulties with Science | (SCIDIF) |
| 6 | Science and Society | (SCISOC) |
| 7 | Science and the Individual | (SCIINV) |

SEMANTIC DIFFERENTIAL QUESTIONNAIRE

(b) Analysis of the Derived Constructs

(i) Factor Analysis

Following the analyses carried out on the input constructs a number of scales suggest themselves. These scales are noted below together with the items which represent them.

| SCALE NAME | ABBREVIATION |
|---|---|
| Scientific Occupations | SCIOCSD2 |
| Scientific Interests | SCIINSD2 |
| Difficulties with Science | SCIDIFSD2 |
| Characteristics of the Scientist | SCITSSD2 |
| Value of Science to Society | VALUESD2 |
| Danger of Science to Society | DANGSD2 |

The additional 'SD2' to the abbreviation indicates the second generation of the questionnaire scales.

SCIOCSD2

| | | |
|---|---|---|
| 61. | a job as a scientist | boring - interesting |
| 44. | a job as a scientist | exciting - dull |
| 67. | a scientific career | interesting - boring |
| 27. | scientific work | enjoyable - not enjoyable |
| 82. | scientific work | boring - exciting |
| 54. | a scientific career | monotonous - stimulating |
| 32. | working in a science laboratory | tedious - stimulating |
| 72. | working as an engineer | interesting - boring |

SCIINTSD2

| | | |
|---|---|---|
| 11. | taking up a scientific hobby | stimulating - dull |
| 41. | watching programmes on science on television | exciting - dull |
| 20. | a visit to a science museum | pleasant - unpleasant |
| 28. | running a science club | tedious - exciting |

| | | |
|---|---|---|
| 76. | taking scientific books out of the library | interesting - boring |
| 56. | reading a science fiction book | entertaining - dull |
| 43. | studying the stars and planets | enjoyable - not enjoyable |
| 04. | building a radio | boring - interesting |
| 75. | working with a chemistry set | not enjoyable - enjoyable |

These two scales are related on the varimax analyses but as the equimax indicates a degree of independence they will be considered as such for subsequent consideration.

SCITSSD2

| | | |
|---|---|---|
| 74. | scientists | clever - dull |
| 81. | scientists | scatterbrained - thoughtful |
| 71. | scientists | sociable - unsociable |
| 42. | scientists | honest - dishonest |
| 13. | scientists in their work | organised - disorganised |
| 31. | scientists in their work | unco-operative - co-operative |
| 40. | scientists in their work | open-minded - narrow-minded |
| 10. | a scientist's family life | unhappy - happy |

SCIDIFSD2

| | | |
|---|---|---|
| 12. | scientific ideas | easy - hard |
| 46. | scientific ideas | complex - simple |
| 48. | scientific terms and names | easy - hard |
| 30. | scientific terms and names | difficult - simple |
| 62. | science lessons involving maths | difficult - easy |
| 34. | science lessons involving maths | simple - hard |

VALUESD2

| | | |
|---|---|---|
| 26. | science in our society | unimportant-important |
| 22. | science in our society | worthless - valuable |
| 73. | science in our society | productive - wasteful |
| 77. | science in relation to me | useless - useful |
| 59. | science in relation to me | unimportant - important |
| 29. | science in relation to me | worthless - valuable |
| 64. | science in relation to me | productive - wasteful |
| 18. | learning about science | unimportant - important |
| 83. | learning about science | useful - useless |
| 38. | science in my home | useless - useful |
| 58. | learning about science | wise - foolish |
| | | |
| 01. | science in our society | useful - useless |

DANGSD2

| | | |
|---|---|---|
| 70. | science in our society | harmful - helpful |
| 68. | science in our society | threatening - comforting |
| 33. | science in our society | safe - dangerous |
| 05. | science in our society | destructive - constructive |
| 63. | science in our society | chaotic - orderly |
| 47. | science in relation to me | comforting - threatening |
| | | |
| 79. | science in our society | good - bad |
| 24. | science in relation to me | helpful - harmful |
| 07. | science in relation to my health | helpful - harmful |

A number of further possible scales were considered which emerged from the analyses. In the case of the first construct there was a group of four items which related directly to science lessons. These formed an identifiable group but were too small in number and too similar to consider as a viable scale.

A further group of four items relating to practical work in science on the first construct were associated on the same factor with a group of items relating to practical work difficulties on construct five. It is apparent that the stem of these items is the linking association and this could provide, with further work, a further suitable scale. At present the opposition of the loadings would indicate that there are in fact two separate sub scales here and at this stage neither aspect is sufficiently developed to justify a full scale.

(ii) Reliability Analysis

The reliabilities of the scales identified were calculated and these are presented in the following table.

Table 8.2.21

Semantic Differential Questionnaire Derived Construct Reliability Values (Cronbach's Alpha)

| SCALE (Number of items) | ABBREVIATION | ALPHA |
|---|---|---|
| Scientific Occupations (3) | SCIOCSD2 | 0.84 |
| Scientific Interests (9) | SCIINTSD2 | 0.78 |
| Difficulties with Science (6) | SCIDIFSD2 | 0.72 |
| Characteristics of the Scientist (3) | SCITSSD2 | 0.75 |
| Value of Science to Society (12) | VALUESD2 | 0.89 |
| Danger of Science to Society (9) | DANGSD2 | 0.80 |

In the analyses of the scales no items were judged to be sufficiently weak to remove them.

All the values are repeatable but certain scales, particularly difficulty, would require additional items before use.

STAGE 3 Overall Comment Semantic Differential Questionnaire

The suitability of the semantic differential technique for assessing the initial input constructs would appear high on consideration of the initial reliability values (see table 8.2.13). The factor analysis, however, reveals that all the scales in this form do not have full psychological validity. The constructs which have support are SCIOCP, Scientific Occupations, SCIINT, Scientific Interests, SCIDIF, Difficulties with Science, and SCITS Characteristics of the Scientist. The construct CONSCI does not receive support in its full form and neither do SCISOC, Science and Society, and SCIINV, Science and the Individual in their original format. The latter two constructs do clearly appear but in a pro and anti science format as in the previous questionnaire. It is apparent that further work with the first construct, within its sub sections relating to school science attitude and practical work in science, could produce further viable scales. On the examination of the derived construct reliabilities the values are not a great deal improved. This is undoubtably a function of their length and further work would be necessary here to extend the shorter scales. The overall perception of these scales presents two main areas of assessment. Personal perception and a perception of the scientist and science in society. There are some clear resemblences to the first technique considered, the Likert questionnaire, and thus both instruments provide initially a framework for further assessment on a common basis.

Section 2 Analysis of the Fixed Response Questionnaire

(c) The Forced Choice - Free Response Questionnaire

The analyses of these questionnaires proceeds in a different fashion to the previous work. Initially the two forms of questionnaire are considered for comparative purposes in relation to issues raised earlier in this study. The full scale analysis of the free response questionnaire will then be considered in a manner corresponding to the last two questionnaires.

Earlier in the study questions were raised as to the suitability of the forced choice technique for the assessment of attitudes. Arguments were advanced which suggested that this particular technique could encourage a greater discrimination between constructs due to the conscious decision-making process undertaken by the pupil in responding to a forced choice item. As the statistical analyses of forced choice items is limited, due to the scores being of an ipsative nature, a comparable free response questionnaire was constructed to enable comparisons of 'forced' and 'free' responses to identical items to be examined. In the initial analyses of these questionnaires the question must first be raised as to whether there are any significant differences in the responses to the two questionnaires. Three analyses have been undertaken to shed light on this issue, and these are detailed below.

(1) Initially an examination of each item in terms of it's overall response was undertaken. The value of the mean on each item in both questionnaires is considered in table 8.2.22.

(2) The tetrads themselves are then examined and the responses to the four items are considered. The forced choice questionnaire places each item within a tetrad in an overall sequence. The free response questionnaire allows a free vote so that more than one item can share a rating. The size of the vote for each of the item effectively places a form of rank order upon the tetrad. It is possible to compare the ordering of the free response item with the rank order

Table 8.2.22

Forced Choice and Free Response Questionnaires — Item Mean Values

| Item | Mean F.C. | Mean F.R. | Item | Mean F.C. | Mean F.R. |
|---|---|---|---|---|---|
| P1 | 2.531 | (3.109) | P7 | 2.250 | (2.175) |
| H1 | 1.766 | (2.422) | H7 | 2.469 | (3.048) |
| E1 | 3.109 | (2.906) | E7 | 2.297 | (2.484) |
| N1 | 2.594 | (2.484) | N7 | 2.984 | (2.891) |
| P2 | 2.016 | (2.313) | P8 | 2.266 | (2.734) |
| H2 | 2.484 | (2.750) | H8 | 1.953 | (2.406) |
| E2 | 2.734 | (2.484) | E8 | 2.813 | (3.250) |
| N2 | 2.766 | (2.609) | N8 | 2.969 | (3.156) |
| P3 | 2.063 | (2.391) | P9 | 1.656 | (2.016) |
| H3 | 2.281 | (2.672) | H9 | 2.594 | (2.781) |
| E3 | 3.000 | (3.063) | E9 | 2.859 | (2.859) |
| N3 | 2.672 | (2.875) | N9 | 2.891 | (2.953) |
| P4 | 2.203 | (2.313) | P10 | 2.016 | (2.172) |
| H4 | 2.156 | (2.656) | H10 | 2.625 | (2.875) |
| E4 | 2.812 | (2.719) | E10 | 2.406 | (2.219) |
| N4 | 2.844 | (2.969) | N10 | 2.953 | (2.719) |
| P5 | 2.344 | (2.406) | P11 | 2.125 | (2.172) |
| H5 | 2.125 | (2.906) | H11 | 2.703 | (3.031) |
| E5 | 2.656 | (2.656) | E11 | 2.438 | (3.000) |
| N5 | 2.375 | (2.891) | N11 | 2.734 | (2.875) |
| P6 | 2.078 | (2.578) | P12 | 2.750 | (2.953) |
| H6 | 2.344 | (2.813) | H12 | 2.359 | (2.891) |
| E6 | 2.859 | (3.000) | E12 | 2.531 | (2.703) |
| N6 | 2.719 | (3.422) | N12 | 2.391 | (2.438) |

Table 8.2.22

| Item | Mean F.C | Mean F.R | Item | Mean F.C | Mean F.R |
|---|---|---|---|---|---|
| P13 | 2.297 | (2.391) | P19 | 1.719 | (2.328) |
| H13 | 2.344 | (2.734) | H19 | 2.375 | (3.016) |
| E13 | 3.109 | (3.453) | E19 | 3.078 | (3.234) |
| N13 | 2.234 | (2.438) | N19 | 2.828 | (2.891) |
| P14 | 2.250 | (2.406 | P20 | 2.063 | (2.266) |
| H14 | 2.406 | (2.984) | H20 | 2.344 | (3.016) |
| E14 | 3.156 | (3.125) | E20 | 2.422 | (2.656) |
| N14 | 3.203 | (2.730) | N20 | 2.672 | (2.781) |
| P15 | 1.703 | (2.125) | P21 | 2.219 | (2.703) |
| H15 | 2.766 | (3.094) | H21 | 2.516 | (2.391) |
| E15 | 2.672 | (2.609) | E21 | 3.016 | (3.313) |
| N15 | 2.859 | (3.095) | N21 | 2.250 | (2.578) |
| P16 | 1.969 | (2.031) | P22 | 2.587 | (2.844) |
| H16 | 2.625 | (2.922) | H22 | 2.254 | (2.922) |
| E16 | 2.656 | (2.703) | E22 | 2.524 | (2.438) |
| N16 | 2.750 | (2.766) | N22 | 2.603 | (2.875) |
| P17 | 2.109 | (2.453) | P23 | 2.571 | (2.594) |
| H17 | 2.891 | (3.141) | H23 | 2.206 | (3.141) |
| E17 | 2.609 | (2.938) | E23 | 2.683 | (2.563) |
| N17 | 2.359 | (2.922) | N23 | 2.556 | (2.688) |
| P18 | 1.813 | (2.219) | P24 | 1.651 | (2.219) |
| H18 | 2.938 | (3.234) | H24 | 2.667 | (3.000) |
| E18 | 2.469 | (3.266( | E24 | 3.000 | (3.094) |
| N18 | 2.750 | (3.203) | N24 | 2.714 | (3.006) |

of the forced choice. For example consider the two responses to the items for one tetrad below.

| | a | b | c | d |
|---|---|---|---|---|
| Free Response | 4 | 1 | 3 | 2 |
| Forced Choice | 4 | 3 | 2 | 1 |

In the case of the forced choice the rank order places

a > b > c > d. A total of six comparisons are made.

a > b, c, d. b > c, d. c > d.

In the case of the free response the responses indicate

a > b, c, d and c > d.

Thus four out of the six comparisons are repeated. For perfect agreement a comparative score of six out of six would be required. If it is accepted that three out of six would represent a random response then any value greater than this would indicate increasing similarity. Taking each tetrad as an individual case and working through the data then,

$$\frac{\text{sum of the positive comparison}}{\text{number of tetrads} \times 6} = 1 \text{ for a perfect comparison}$$

This score provides an indication of a test response comparability.

(3) Finally the two questionnaires themselves are examined by considering the relationship between the scores on the completed scales on each questionnaire. This analysis is of a limited use as it ultimately reports on a full correlation analysis which strictly cannot be performed for the forced choice technique. However this will give an indication of the relationship between the scores on the different methods with one another rather than just internally.

The results from the first of these analyses is presented in table 8.2.22. Strictly a full statistical test of the differences should have been performed. The initial examination reveals that there seems to be no great differences between the scores on one technique with respect to the other. It is noted that the pupil tends to give votes more freely in the open response technique such that the means for the free response technique are greater overall than the forced choice. The rating within each technique seems similar in that the ordering of the size of the means within a tetrad is comparable from one technique to another, this is investigated further in the similarity analyses. A number of items are unbalanced however and would be questionable, because of the apparent preference for certain items within a tetrad over others. The first item is a good example of this and so is the nin th, (see table 8.2.22) fifteenth and the last. If this questionnaire was to proceed on the basis of these constructs, these items would certainly be altered for a forced choice technique alone.

A calculation of the overall sequence analysis value for the items within each tetrad across the sample reveals a value of 0.58. As noted any value greater than 0.50 indicates a similarity in response pattern. The value is not conclusive and serves only to indicate that the pupils are tending to repeat their judgements on the free response technique.

On each questionnaire a composite score reflecting the four aspects of each tetrad can be calculated. The values of these scores, expressed as a mean, for the sample is noted in table 8.2.23.

Table 8.2.23 Forced Choice - Free Response Questionnaires
Means and Standard Deviations for Tetrad-Totals

| | MEAN | STANDARD DEVIATION |
|---|---|---|
| FORCED CHOICE | | |
| PERSONAL (PTI) | 51.56 | 8.86 |
| HUMAN (HTI) | 59.00 | 8.98 |
| EFFECT (ETI) | 66.23 | 7.83 |
| NATURE (NTI) | 64.44 | 9.90 |
| FREE RESPONSE | | |
| PERSONAL (PT2) | 58.02 | 9.40 |
| HUMAN (HT2) | 69.44 | 8.01 |
| EFFECT (ET2) | 69.16 | 9.26 |
| NATURE (NT2) | 68.01 | 8.61 |

Table 8.2.24 — Forced Choice - Free Response Questionnaires

Correlation Matrix for Tetrad Totals

| | PTI | HTI | ETI | NTI | PT2 | HT2 | ET2 | NT2 |
|---|---|---|---|---|---|---|---|---|
| PTI | | - | -34 | -63 | 59 | | -32 | -33 |
| HTI | | | -54 | -50 | | 34 | | -23 |
| ETI | | | | | | | 38 | |
| NTI | | | | | -45 | | | 51 |
| PT2 | | | | | | | | |
| HT2 | | | | | | | 28 | 27 |
| ET2 | | | | | | | | 39 |

Abbreviations identified above. Decimal points are omitted.
Values shown are 1% significant.

The values produced indicate that the free response questionnaire produces higher scores overall. This was also emerging from the initial examination of the individual items. In terms of the overall response to each of the items within the tetrads within the questionnaire, apart from the personal items, which has the lowest mean on both questionnaires, the other item totals do not follow an identical ordering. To examine the relationship between these two questionnaires a correlation matrix was calculated. This appears as table 8.2.24.

The calculation of correlations for the internal relationships of the items on the forced choice questionnaires is suspect, as noted before. However it is interesting to examine the relationship between the item totals on the two questionnaires. In the case of each of the questionnaires the corresponding item total is related significantly. The largest of these relationships is demonstrated by the personal aspect. It is of interest that there exist only small correlations between the free response tetrad items.

Overall these analyses indicate that the two techniques are not producing vastly different or, equally identical results. It would seem possible therefore to consider further the forced choice technique in terms of additional development as an attitude assessment instrument at some stage. It is not noticeably different in it s assessment from the free response technique, however, it is, at this stage, easier to pursue one further important point. In the initial construction of these questionnaires the constructs for the tetrads possessed only face validity. Whether these areas emerge as representing four areas of pupil perceptions is yet to be seen for this particular questionnaire. The responses to the different aspects of the tetrad will have to undergo a further investigation of their validity as have the other questionnaires in this study. An examination of this is reported in the following stage.

Analysis of the Free Response Questionnaire

The aim of this analysis was to investigate whether the format of the tetrads provided in these questionnaires had a sound basis in the pupils perceptions. Initially the procedure followed was as outlined for the previous analyses. A reliability analysis followed by a factor analysis. It was however considered an important further aim to establish four key areas of response if the original construct areas did not demonstrate validity. This will enable further development of this particular format of questionnaire on either of the response formats. In view of this consideration, this questionnaire was analysed first to enable it to be incorporated into the empiricial study twice if required. Some refinements of the analyses proposed earlier in the review are absent (for example additional equimax analyses) but later checks and re-analyses provided confirmation of the analyses now presented.

Reliability Analysis

The reliability analyses for the items which make up the tetrads for the free response questionnare are summarised in table 8.2.25.

Table 8.2.26 Free Response Questionnaire - Input Reliability Values (Cronbach's Alpha)

| CONSTRUCT | ALPHA VALUE |
|---|---|
| PERSONAL | 0.74 |
| HUMAN | 0.71 |
| EFFECT | 0.77 |
| NATURE | 0.75 |

Considering that these values are for scales with 24 items they do not suggest that they are particularly cohesive as scales in their own right. Examination of the individual item - total correlation tables enabled a number of the weaker items to be identified. Although these scales could be improved upon, the importance was still to examine their performance on a factor analysis.

Table 8.2.27 Free Response Questionnaire - Item Analysis (Varimax Rotations to Kaisers Criterion)

First Seven Factors — Total Variance = 40.0%

| | FACTOR 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | P3 | E1 | H4 | H7 | N9 | E1 | N3 |
| | P6 | E2 | E6 | H10 | H10 | H2 | N8 |
| I | P8 | E5 | H16 | H12 | H20 | H6 | H14<br>H15 |
| T | P9 | E12 | H18 | H20 | | H9 | H18 |
| E | P10 | E15 | E19 | N23 | | | H24 |
| M | P11 | E16 | | H9 | | | |
| S | H13 | E17 | | | | | |
| | P15 | E19 | | | | | |
| | P16 | E20 | | | | | |
| | P18 | H23 | | | | | |
| | P22 | | | | | | |

Item numbers refer to the allocation within the tetrad and scale. P18 represents the PERSONAL item in the 18th tetrad. H, HUMAN, E, EFFECT and N represents NATURE item.

Factor Analyses

The data from the free response questionnaire was entered into a principal component analysis with varimax rotation to Kaiser's criterion. This produced a solution where twenty nine factors were selected for rotation accounting for 85.2% of the total variance. The analyses provided large groups of items, with loadings greater than ± 0.3, on the earlier factors and very few on the later factors. This would be expected from this format of analysis but it was noticeable that the large number of factors selected for rotation under the standard criteria reflected the diverse nature of some of the item responses. A restricted table of results is presented in table 8.2.27. In this format it can be observed that two of the groups identified earlier, Personal and Effect, produce some measure of factorial independence on the first two factors. The remaining factors produce a mixture of items loading on them representing mainly the Human aspect. These items were selected for further analyses in an attempt to refine the scales to represent a small number of clear factors. These items were entered into a similar factor analysis, as initially prescribed, and produced a solution presented in full in table 8.2.28.

The items loading on the factors are considered on terms of their factors.

Table 8.2.28 Free Response Questionnaire Restricted Item Analysis

(Varimax Rotation) Total Variance 50.3%

| ITEM | FACTOR 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| PB3 | 63 | | | | | |
| PB6 | 50 | | | | | |
| PB8 | 67 | | | | | |
| PB9 | 68 | | | | | |
| PB10 | 81 | | | | | |
| PB11 | 75 | | | | | |
| PB15 | 57 | | | | | -39 |
| PB16 | 54 | | | | | |
| PB18 | 61 | | | | | |
| PB22 | 52 | 38 | | | | |
| HB4 | | | | 50 | | |
| HB7 | | | | 42 | | |
| HB12 | | | | 50 | | |
| HB13 | 35 | | | 26 | | |
| HB20 | | | | 34 | | 53 |
| HB21 | | | | 49 | | |
| HB23 | | 37 | | | | -54 |
| NB23 | | | | 39 | 46 | 37 |
| EBI | | 46 | | | 39 | |
| EB2 | | 60 | | | | |
| EB5 | | 41 | | | | |
| EB6 | | 50 | | | -44 | |
| EB12 | | 49 | | 34 | | |
| EB15 | | 71 | | | | |
| EB16 | | 44 | | | | |
| EB17 | | 58 | | | | |

contd....

Table 8.2.28 contd.

| ITEM | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| EB19 | | 50 | 39 | | | |
| EB20 | | 65 | | | | |
| HB2 | | | | | 52 | |
| HB6 | | | 47 | -37 | 53 | |
| HB9 | | | 37 | -35 | | |
| HB10 | | | 45 | 30 | | |
| HB14 | | | 56 | | | |
| HB15 | | | 56 | | | |
| HB16 | | | 49 | | | |
| HB18 | | | 68 | | | |
| HB24 | | | 50 | 30 | | |
| NB3 | | | 50 | | | |
| NB8 | | | 41 | | | 43 |

n.b. All decimal points have been omitted.

8

Factor One

PB3 Building a radio can be an interesting thing to do.

PB6 It could be enjoyable to own a chemistry set to do home experiments.

PB8 The experimental work in science lessons is usually interesting.

PB9 Science is amongst the most popular subjects at school.

PB10 Compared to other school subjects, science is generally one of the most interesting.

PB11 School science is usually interesting.

PB15 The school science lessons are usually worth looking forward to.

PB16 The science lessons are amongst the most enjoyable in the school.

PB18 A science hobbies club could provide a good after school activity.

PB22 Doing experimental work in science is usually enjoyable.

The major factor on the analysis reflects the personal domain. Here items reflect aspects of enjoyment of school science (PB9) and hobby interest (P33). The items are all of a related nature and indicate a consistent scale for further use.

Factor Two

EB1 Money spent on scientific projects is usually money well spent.

EB2 Science itself cannot be blamed for pollution,

EB5 The work of science in our society is usually worth rewarding.

EB6 Because of the inventions of science, homes are now more comfortable than they used to be.

EB12 The problems of our society cannot just be put down to the presence of science.

EB15 The cause of the worlds troubles cannot just be put down to the work of science.

EB16 Although weapons are produced by science, it is not the aim of science to use these weapons to destroy man.

EB17 The presence of science in our society is generally beneficial.

EB19 The inventions of science can be used to help mankind.

EB20 The wasting of our natural resources cannot just be put down to the work of science.

The second factor contains items which primarily reflect the 'EFFECT' domain of the original tetrad. The items are all related to science and society. The group of items reflects beneficial aspects (EB17, EB6) and the value of science in terms of monetary support (EB1). The factor is clear in interpretation.

Factor Three

NB3 Even if a famous scientist claims a theory is true, this does not mean that everyone will accept it.

HB6 Scientists are usually serious people, dedicated to their work.

NB8 It is always possible for an unknown scientist to prove the theories of a famous scientist wrong.

HB9 Generally scientists are dedicated to their work.

HB10 In their approach to work scientists are usually thoughtful and precise.

HB14 The scientist is usually thoughtful about his actions,

HB15 All scientists, it seems, have to do well at school and college.

HB16 A scientist usually works out all possible ways to answer a problem before choosing the best.

HB18 To become a scientist a lot of hard work at school and college is required.

HB24 Generally scientists do not give up a problem easily.

The third factor contains items which reflect the scientist and his approach to work. There are on this factor items drawn from the 'NATURE' group of items which deal with the scientific method. In this instant the functioning of science is perceived through the work of a scientist rather than as an activity on it's own. The items relate the actions of a scientist, perseverance (HB24), thoughtful (HB14) and dedicated (HB9), as well as the workings of science, (NB3, NB8). The items thus reflect the work characteristics of a scientist as opposed to personal characteristics. In terms of factors three and four there are some examples of shared loadings (HB6, HB9), as will be seen by considering the items on factor four, they tend to reflect the personal aspects of the scientist. It is debateable whether some of these items are really interchangeable for either scale. For example, is dedication a personal characteristic or a work characteristic requirement.

Factor Four

| | |
|---|---|
| HB4 | Scientists do not 'show-off' any more than other people. |
| HB7 | Scientists live a normal life at home just like anyone else. |
| HB12 | Scientists are no more absent minded than are other people. |
| HB13 | Just like other people scientists can be interesting to talk and listen to. |
| HB20 | Scientists are generally intelligent people. |
| HB21 | Scientists may often work together and share their findings. |
| NB2 | Everyone working in the field of science allows their work to be criticised by others. |

Of the factors analysed so far this factor shows the weakest set of items although those noted above have repeatable loadings. The items reflect the personal characteristics of a scientist and relate both characteristics (HB20, HB4) and social behaviour. Again the problem arises as to the clear definition of 'personal'. The latter two items (HB21 and NB23) are work orientated but reflect co-operation and critical fairness in an individual. The division is perhaps too fine to be recognised permanently in the way that the division between the first two factors is readily accepted. Nevertheless it may well provide some interesting contrasts at a later stage.

Two further items:

HB5 Scientists are no less friendly and sociable than are other people.

HB8 In their view of life scientists are generally broad minded.

were related onto this factor through further analysis to increase its size.

In conclusion the analyses up to this point have attempted to examine the viability of the original construct prescription. To a certain extent two of the original areas 'PERSONAL' and 'EFFECT' have been validated through the analysis of the pupils' responses. The breadth of these tetrads has however been reduced by the analysis. In efforts to establish a suitable four fold tetrad, a number of items were removed to allow a restricted analysis to occur. The results from this confirmed the predominance of the two areas noted above but also added two areas related to the scientist and his work and personal characteristics. These four areas are the basis for further work in this area.

## Analysis of the Derived Scales

Following the identification of four main areas of pupil response in the previous analysis the scales were subjected to further improvement using the reliability procedure. As the intention was to construct a further instrument for the study the areas were all to have identical numbers of items representing them. This proved difficult for the personal characteristic of the scientist area. Eventually eight items representing this area were selected and this governed the numbers of items on the remaining areas. In the case of the first two areas this required 'good' items to be set aside. The reliability values for the four areas are noted below (table 8.2.29).

Table 8.2.29 Free Response Questionnaire Derived Construct Reliability Values (Cronbach's Alpha)

| SCALE | ABBREVIATION | ALPHA VALUE |
|---|---|---|
| Interest | INTFR | 0.86 |
| Science and Society | SCISOCFR | 0.79 |
| Work characteristics of the Scientist | SCIWRKFR | 0.74 |
| Personal characteristics of the Scientist | SCIPERFR | 0.67 |

These have overall acceptable values with concern being expressed only over the later scale. Once again the two prominent areas represent the personal perceptions of the pupil, termed 'Interest' in this case, and the social implications of science. The items representing these scales have already been detailed in the previous section. Those items with an asterisk where those removed at this stage of the analysis.

## Analysis of the Improved Forced Choice - Free Response Questionnaire

A second version of each of the forced choice and free response questionnaires was quickly constructed and administered to a further sample of pupils. This additional sample was composed of 230 pupils, of whom 115 were girls and 115 boys.

The means and standard deviations for the scales making up the new tetrads are presented in table 8.2.30. The overall means on the free response are higher than the forced choice but the order of the means taken in size is similar in this case. Thus the average response to the scales on both techniques follows a similar pattern.

An examination of the correlation matrix, table 8.2.31, indicates significant correlations between the scales on the free response and forced choice technique with the exception of the scale relating to the personal characteristics of a scientist. In the case of the scales relating to interest and the social implications of science the correlations are larger in value. This tends to indicate that on the total scores for certain individual scales there exists a similarity in overall response between the techniques. It is difficult within the limited statistical framework that is legitimate for the forced choice technique to advance much further in this analysis. If it is accepted that the free response technique possesses, for certain scales, reliability and validity then as there is a significant association with the overall response from the forced choice scales it can be inferred that there may well measure effectively as well. In addition to this if the forced choice technique has the additional advantages advanced by other authors, for example greater construct discrimination and reduction of 'halo' effect, then the technique could form a useful addition to the techniques for the assessment of attitudinal variables. It must be emphasised that some reservation needs to be stressed over the scales which produce the items for each tetrad. It is still uncertain as to whether wide ranging constructs such as those employed here are suitable for direct comparison on this technique it may be the case that wide ranging constructs such as 'PERSONAL' and 'NATURE' considered earlier require such different background knowledge that comparative assessments are not logical. The technique would perhaps be better employed in assessing distinctions on sub scales within each of the major constructs specified. Within the 'PERSONAL' area for example the technique could assess the strengths or weaknesses of different aspects of school science work such as experimental work, written work and investigation or project work. In a similar way different perceptions of the process of science could be advanced in each item on the tetrad.

The analysis presented here has been of limited value but serves to indicate that a forced choice technique may have potential as an assessment instrument within a specified set of constructs.

## Overall Comment

The analysis of these instruments has proceeded in a different format from that of the previous questionnaires. Nevertheless comment can be made on a number of similar issues. It is apparent that only certain aspects of the initial determination of the constructs received support. The personal domain, reflecting enjoyment and interest in science and science activities and the social implications domain, reflecting the perception of science within society are within the pupil's general perceptions. In terms of the 'HUMAN' and 'NATURE' aspects of the original division the analyses indicate that the pupils interrelate these areas in a perception of the personal and the work characteristics of the scientist. These latter areas are weaker in their independence than the previous two. It is perhaps a difficult division to maintain. It does provide an indication of the direction in which the working of science could be assessed however. Although by no means conclusive it does suggest that the areas connected with the working of science, scientific theories and laws and the scientific method, are more favourably received if the items representing them reflect a scientist, a person, performing an appropriate action for the pupil to comment on. This does not suggest that such items would overcome the presence of a cognitive component necessary for these perceptions to be assessed. It suggests that items for assessment may be improved by 'personalising' them in terms of a scientist at work.

In terms of the free response questionnaire the four scales of:

Interest in Science

Social Implications of Science

Personal characteristics of a scientist

and Working characteristics of a scientist,

are advanced as valid and reliable scales for future consideration.

Finally, the issue of the comparison between the forced choice and the free response technique has received some consideration. It has been argued that the forced choice technique could well provide a further assessment procedure which should be developed with certain construct scales within the tetrads.

Table 8.2.30 Improved Forced Choice -.Free Response Questionnaires - Means and Standard Deviations

| TECHNIQUE | SCALE | MEAN | STANDARD DEVIATION |
|---|---|---|---|
| FORCED | INTFC | 17.35 | 4.73 |
| CHOICE | SCISOCFC | 22.71 | 4.29 |
| | SCIPERFC | 17.57 | 3.27 |
| | SCIWRKFC | 22.35 | 3.38 |
| FREE | INTFR | 20.50 | 5.26 |
| RESPONSE | SCISOCFR | 24.35 | 4.67 |
| | SCIPERFR | 22.21 | 4.55 |
| | SCIWRKFR | 24.35 | 4.08 |

Table 8.2.31 Improved Forced Choice - Free Response Questionnaire Correlation Matrix for Tetrad Scales

| | INTFC | SCIPERFC | SCISOCFC | SCIWRKFC | INTFR | SCIPERFR | SCISOCFR | SCIWRKFR |
|---|---|---|---|---|---|---|---|---|
| INTFC | | - | -63 | -54 | 47 | - | -33 | -29 |
| SCIPERFC | | | -46 | -31 | - | - | -19 | -19 |
| SCISOCFC | | | | - | -25 | - | 49 | 22 |
| SCIWRKFC | | | | | -25 | - | - | 32 |
| INTFR | | | | | | 39 | - | - |
| SCIPERFR | | | | | | | 27 | 41 |
| SCISOCFR | | | | | | | | 49 |
| SCIWRKFR | | | | | | | | |

The decimal point has been omitted on these values.

All values recorded at the 1% significance level.

## (d) The Science - Situations Test

The analysis of this particular instrument requires the same consideration as the previous questionnaires but with less items, detailed analyses of scales for reliability and factorial validity are not warranted.

### Stage 1 - Item Analysis

An examination of the statistics of mean, standard deviation kurtosis and skew for each item on this questionnaire reveals that all the items are consistent in their 'normal' response pattern. None of the items demonstrates excessive responses in accordance with items assessed on previous questionnaires.

### Stage 2 - 'Scale'Analysis

The number of items present make a full scale analysis impractical. Nevertheless as the items represent specific constructs it is instructive to see how the items relate to one another. A factor analytic investigation of the items was thus undertaken.
(See table 8.2.30).
This analysis incorporated a six factor rotation (one additional factor in comparison with Kaiser's criterion) to account for 52.8% of the variance.

In this analysis the items correspond to the initial input construct as follows:

| Item | Construct | Abbreviation |
|---|---|---|
| 1, 2, 3, 4 | Commitment and Enjoyment of Science | COMSCI |
| 5, 6 | Scientific Occupations | SCIOCP |
| 7, 8 | Scientific Interests | SCIINT |
| 9, 10 | Characteristics of the Scientist | SCIENTS |
| 11, 12, 13 | Difficulties with Science | SCIDIFF |
| 14 | Science and Society | SCISOC |
| 15 | Science and the Individual | SCIINV |
| 16 | Scientific Theories and Laws | THRLAW |
| 17 | The Scientific Method | SCIMET |
| 18 | Aims of Science | AIMSCI |

Commitment and enjoyment of science items appear together on the first factor as do the two items relating to science interest. The two items relating to scientific careers, although related in a minor way with this first factor, take up separate factors for each aspect. The first item relating to scientists also related to this first factor. On the examination of the item concerned, the word 'interesting' appears in relation to a scientist. It may well be that this governs the response rather than the direct relation to the scientist. The second shows no significant association with any other items. The first factor again shows the prominence of the personal domain.

Two of the difficulty based items show a clear relation on factor 3 (see table 8.2.30). These items are clear of the other items. Item 13 however, is not closely related here. This may well be because this is not a clearly experienced area of difficulty at this age. That is, the pace of work may well not increase substantially until later in the pupil's science course.

The items relating to social implications of science appear as separate factors (factors 5 and 6). In this analysis they do present themselves as separate items which give some support for the initial division of these items into separate scales. This division is maintained even if the analysis is forced to rotate a lesser number of factors.

The remaining three items all show little relation with the other factors. The weak relationship of the item connected with scientific method to an item relating to science occupations is not clear from the content of the item. The weak value of this relation mitigates against further detailed consideration.

The questionnaire provides a clear, quick assessment on a number of areas which show a degree of factorial independence.

(a) Personal attitude and interest in relation to science at school and as a hobby. (Item 1,2,3,4,7,8 on factor 1)

(b) Occupational Interest.(Item 5, factor 2 and Item 6,factor 4).

(c) Difficulty with school science.(Item 11,12. factor 3).

(d) Social Implications of Science.(Item 14, factor 5, & Item 15, Factor 6).

The areas (a) and (b) join together when a lesser number of factors are rotated and should be considered together as a personal domain.

The important point is that these items, although few in number, seem to assess their particular areas with some factorial independence from one another. If one considers the ease of the application of this questionnaire, this must make this format of the questionnaire a very useful addition to the standard range of techniques available. With further refinement this could be an important assessment instrument for future use.

Table 8.2.30 Science Situations Questionnaire - Item Analysis

(Varimax Rotation to Six Factors) Total Variance = 52.8%

| Item | | FACTOR 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| | 1 | 58 | | | | | |
| COM | 2 | 51 | | | | | |
| | 3 | 42 | | | | | |
| | 4 | 66 | | | | | |
| OCP | 5 | 44 | 64 | | | | |
| " | 6 | 30 | | | 43 | | |
| INT | 7 | 52 | | | | | |
| " | 8 | 45 | | | | | |
| SCIT | 9 | 36 | | | | | |
| " | 10 | | | | | | |
| | 11 | | | -44 | | | |
| DIF | 12 | | | -51 | | | |
| | 13 | | | | | | |
| SOC | 14 | | | | | 54 | |
| INV | 15 | | | | | | 43 |
| THR | 16 | | | | | | |
| MET | 17 | | | | 30 | | |
| AIM | 18 | | | | | | |

There are no further scale analyses reported, as such, here because of the restricted number of items present. In the next section a comparison, in terms of assessment, is considered for this and the other techniques employed.

## Section 3 Combined Analysis of the Fixed Response Questionnaires

### STAGE I Analyses of the Input Construct Scales

(a) Individual Input Constructs

In this section the responses to the Likert and Semantic Differential questionnaires are considered. As noted in the review of the analyses to be carried out, these particular questionnaires contain a number of identical constructs which can be directly compared. The results from the individual construct scales for each questionnaire were compared using first a calculated correlation matrix followed by a factor analysis where an oblique rotation to Kaisers criterion was performed.

The results from the factor analysis are presented in table 8.3.1. The analysis selected four clear factors which accounted for 70.5 percent of the variance. The pattern produced is very clear. The first factor contains loadings which reflect totally the Semantic Differential questionnaire, (see factor one, table 8.3.1.) The remaining three factors represent various facets of the Likert questionnaire with one exception, that of the construct, difficulty with science, on the third factor, (factors two, three and four, table 8.3.1.) It is evident from this initial examination that evidence of vertical grouping exists. In other words the questionnaires themselves tend to govern the pupil's response rather than the nature of the response category. It also seems evident that the Likert questionnaire can produce, through the pupil's responses, a discernable structure reflecting different facets of the attitude domain. The loading of all the Semantic Differential constructs onto one major factor indicates that the technique is not discriminating in the responses to different constructs. This result is similar to the results noted for the individual questionnaire analyses, (refer to tables 8.2.9. for the Likert questionnaire and table 8.2.19 for the Semantic Differential questionnaire, but note that the analysis presented in table 8.2.19 was for a 'forced' rotation of two factors).

The discernable structure within the Likert questionnaire reflects three main areas:-

(i) A personal commitment and interest in science, school science and careers relating to science, (see factor three, table 8.3.1.)

(ii) The effects of science on society and the individual together with the nature and working of science and scientists, (see factor two, table 8.3.1.)

(iii) The difficulties associated with school based science work, (see factor four, table, 8.3.1.)

The construct relating to the aims of science does not load significantly on any of the main factors noted here, again, perhaps this reflects the poor nature of its understanding.

This analysis represents the underlying nature of the pupil's responses. There are significant links between the two questionnaires and within the Likert questionnaire itself. These can be examined by considering the correlation matrix, (see table 8.3.2.) The table indicates significant correlations between the scales representing almost all the constructs with the exception of the aims of science construct scale on the Likert questionnaire. There are fairly high degrees of correlation between certain similar scales, for example the constructs commitment and enjoyment of science, scientific interests, difficulties with science and science and the individual; the values for these are underlined on the table. However these values do not approach the size of the correlations that exist within the scales on a particular questionnaire. This is particularly evident for the majority of scales on the Semantic Differential questionnaire, these are represented by the correlations noted for scales eleven to seventeen on table 8.3.2. Whilst it is possible to examine statistically the significance of the difference in the size of correlation coefficients, this was not pursued. It is fairly evident from this examination taken together with the factor analysis, that the overall response to the scales on the questionnaire exhibits test dependence.

Table 8.3.1. Likert and Semantic Differential Questionnaires Major Input Constructs (Oblique Rotation to Kaiser's Criterion)

Total Variance = 70.5%

| QUESTIONNAIRE | CONSTRUCT SCALE | FACTOR 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| LIKERT | 1. COMSCI | | 43 | -55 | |
| | 2. SCIOCP | | | -70 | |
| | 3. SCIINT | | | -83 | |
| | 4. SCIENT | | 74 | | |
| | 5. SCIDIF | | | | 55 |
| | 6. SCISOC | | 70 | | |
| | 7. SCIIND | | 68 | | |
| | 8. THRLAW | | 77 | | |
| | 9. SCIMET | | 60 | | |
| | 10. AIMSCI | | | | |
| SEMANTIC | 11. COMSCI | 91 | | | |
| DIFFERENTIAL | 12. SCIOCP | 73 | | | |
| | 13. SCIINT | 70 | | | |
| | 14. SCIENT | 79 | | | |
| | 15. SCIDIF | -43 | | 38 | |
| | 16. SCISOC | 77 | | | |
| | 17. SCIINV | 85 | | | |

n.b. the decimal points have been omitted from the loadings.

Key:

COMSCI Commitment and Enjoyment of Science (scales, 1,11)

SCIOCP Scientific Occupations (scales 2,12)

SCIINT Scientific Interests and Pastimes (scales 3,13)

SCIENT Characteristics of the Scientist (scales 4,14)

SCIDIF Difficulties with Science as a School Subject (scales 5,15)

SCISOC Science and Society (scales 6,16)

Key: contd

SCIINV Science and the Individual (scales, 7,17)

THRLAW Scientific Theories and Laws (Scale, 8)

SCIMET The Scientific Method (scale, 9)

AIMSCI The Aims of Science (scale, 10)

(b) Grouped Input Constructs

For the comparison of further techniques, tetrad groups were established within the Likert and Semantic Differential questionnaires. These reflected the construction of the Forced Choice and Free Response questionnaires. The four categories and their related constructs are noted below:

| | | |
|---|---|---|
| PERSONAL | : | Commitment and Enjoyment of Science |
| | | Scientific Occupations |
| | | Scientific Interests and Pastimes |
| | | Difficulty with Science as a School Subject |
| HUMAN | : | Characteristics of the Scientist |
| EFFECT | : | Science and Society |
| | | Science and the Individual |
| NATURE | : | Scientific Theories and Laws |
| | | The Scientific Method |

It should be noted that the Aims of Science construct is not included in this scheme and that the Semantic Differential questionnaire will have three groups as the original questionnaire did not reflect the nature aspect. A brief examination of these groups as scales of measurement was undertaken. This consisted of a reliability analysis the results of which are presented in table 8.3.3. As can be noted the reliability values, particularly of the personal and effect groups are acceptable. The high values of these two groups reflects the large number of items now present.

**Table 8.3.2.** Likert & Semantic Differential Questionnaires - Correlation Matrix of Major Input Constructs

N = 252

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 66 | 58 | 53 | -55 | 64 | 59 | 53 | 37 | - | 49 | 35 | 35 | 29 | -46 | 34 | 45 |
| 2 | | | 61 | 28 | -40 | 41 | 41 | 34 | 17 | - | 38 | 29 | 29 | - | -45 | 24 | 37 |
| 3 | | | | 31 | -19 | 28 | 42 | | | | 33 | 32 | 42 | | -40 | 27 | 36 |
| 4 | | | | | -26 | 58 | 65 | 51 | 37 | - | 26 | 19 | 30 | 34 | -21 | 33 | 33 |
| 5 | | | | | | -50 | -33 | -46 | -31 | | -44 | -30 | -19 | -24 | 45 | -29 | -44 |
| 6 | | | | | | | 60 | 60 | 44 | | 37 | 16 | 21 | 34 | -25 | 38 | 39 |
| 7 | | | | | | | | 52 | 38 | | 38 | 29 | 32 | 30 | -24 | 38 | 44 |
| 8 | | | | | | | | | 62 | | 31 | 21 | 12 | 27 | | 34 | 38 |
| 9 | | | | | | | | | | | 29 | 19 | 15 | 20 | | 26 | 35 |
| 10 | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | 72 | 68 | 72 | -57 | 68 | 77 |
| 12 | | | | | | | | | | | | | 63 | 52 | -24 | 58 | 69 |
| 13 | | | | | | | | | | | | | | 55 | -39 | 54 | 69 |
| 14 | | | | | | | | | | | | | | | -37 | 66 | 65 |
| 15 | | | | | | | | | | | | | | | | -38 | -49 |
| 16 | | | | | | | | | | | | | | | | | 81 |
| 17 | | | | | | | | | | | | | | | | | |

Table 8.3.2. contd.

N.b. (i) the decimal points have been omitted.

(ii) Scale numbers are defined on table 8.3.2.

(iii) 1% level of significance (N = 250, r= 0.163) interpoluted from Fisher, G.H. The New Form Statistical Tables for Pearson-Product Moment Correlation.

Table 8. 3. 3. Likert, Semantic Differential and Free Response Questionnaires Tetrad Group Reliability Values (Cronbach's Alpha)

| TETRAD GROUP | QUESTIONNAIRE (Number of items in brackets) | | |
|---|---|---|---|
| | LIKERT | SEMANTIC DIFFERENTIAL | FREE RESPONSE |
| PERSONAL | 0.93 (40) | 0.91 (48) | 0.74 (24) |
| HUMAN | 0.67 (10) | 0.77 (12) | 0.71 (24) |
| EFFECT | 0.80 (20) | 0.91 (24) | 0.77 (24) |
| NATURE | 0.76 (20) | - | 0.75 (24) |

The factor analysis of these groups produced three factors which accounted for 70.3 percent of the variance. The first factor carries significant loadings for the groups representing the Likert and Semantic Differential questionnaires together with the effect and nature aspects of the Free Response questionnaire, (see factor one, table 8.3.4). The second factor has loadings from the personal aspects of each of the questionnaires involved. In terms of the Free Response questionnaire the loading is isolated from the other factors. The Likert and Semantic Differential questionnaires both have this personal aspects loading on other factors. In the case of the Likert the personal aspect shares its loading between the first and second factors. In the case of the Semantic Differential the personal aspect shares its loadings across all three factors. In consideration of this second factor it is possible to interpret the loadings of all the personal aspects, from each of the questionnaires, as providing some limited evidence of horizontal grouping or test independance of the group of constructs representing personal aspects, (see factor two, table 8.3.4.). The third factor on this analysis contains significant loadings in relation to the human aspect of the Free Response questionnaire, and the personal and effect aspects of the Semantic Differential questionnaire. The latter two loadings being negative are indicative of an opposite response pattern for pupil responses to these groups. It is difficult to assign any clear indication to these groups. The correlation matrix for this analysis (table 8.3.5.) indicates very weak relationships overall and so the factor is left without clear interpretation at this stage. A further examination of the correlation matrix (table 8.3.5.) indicates that in comparison of like tetrad groups there are significant relationships. In terms of the personal group, the size of the correlations between the personal groups for the Likert and Free Response questionnaires are greater than any internal correlations on these questionnaires (these are underlined in row one and five of the table 8.3.5.) Although the personal groups on the Likert and Free Response correlates well with the personal group on the Semantic

Table 8.3.4. Free Response, Likert and Semantical Differential Questionnaires. Tetrad Groups (Oblique Rotation to Kaiser's Criterion)

Total Variance 70.3%

| QUESTIONNAIRE | TETRAD SCALE | FACTOR 1 | 2 | 3 |
|---|---|---|---|---|
| FREE | 1 PERSONAL | | -93 | |
| RESPONSE | 2 HUMAN | | | 74 |
| | 3 EFFECT | 55 | | |
| | 4 NATURE | 57 | | |
| LIKERT | 5 PERSONAL | 44 | -53 | |
| | 6 HUMAN | 54 | | |
| | 7 EFFECT | 80 | | |
| | 8 NATURE | 87 | | |
| SEMANTIC | 9 PERSONAL | 59 | -33 | -58 |
| DIFFERENTIAL | 10 HUMAN | 60 | | |
| | 11 EFFECT | 77 | | -48 |

Table 8.3.5. Free Response, Likert and Semantic Differential Questionnaires Correlation Matrix for Tetrad Groups

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | 54 | | | | 34 | | |
| 2 | | | 26 | 21 | | 24 | 27 | 29 | -26 | | |
| 3 | | | | 34 | 20 | | 44 | 48 | 24 | 21 | 38 |
| 4 | | | | | 35 | | 41 | 60 | 31 | 28 | 32 |
| 5 | | | | | | 34 | 50 | 45 | 68 | 38 | 44 |
| 6 | | | | | | | 63 | 42 | 30 | 68 | 35 |
| 7 | | | | | | | | 65 | 49 | 52 | 64 |
| 8 | | | | | | | | | 53 | 48 | 65 |
| 9 | | | | | | | | | | 58 | 74 |
| 10 | | | | | | | | | | | 49 |
| 11 | | | | | | | | | | | |

n.b.(i) The decimal points have been omitted from this table.

(ii) The scales corresponding to the numbers are noted on table 8.3.4.

(iii) All values are to the 1% level of significance (values are calculated according to numbers available for comparison, see table 7.2.1.)

Differential, there is still a great degree of interrelation between the groups on the Semantic Differential itself. The analysis of the other tetrad groups reveals that apart from the human aspect, both the effect and nature also correlate well across all questionnaires, (these are circled on the table 8.3.5.) The human aspects of the Likert and Semantic Differential questionnaire are however well related. The factor analysis reflects this picture in providing only the personal aspect as clear independent factor.

The factor analysis indicates that the free response questionnaire exhibits a discernable structure between the different aspects of the tetrad. This structure is as follows:-

(i) The effect and nature aspects, the social implications of science and the nature and functioning of scientific work.

(ii) The personal aspects, the individuals enjoyment and interest in science and science related careers, as well as perceptions of difficulties experienced.

(iii) The human aspect, the perception of the characteristics of the scientist.

It is interesting to speculate at this point. The Free Response questionnaire is the only one to demonstrate discernible structure. This particular questionnaire was developed in conjunction with a forced choice questionnaire whose structure was imposed upon the free response items, although the response procedure was left open. It would appear that the discrimination between the different aspects of the tetrad is improved on the free response questionnaire through presenting the items in this particular way. The way the items are presented in this questionnaire reflects not only the grouping of items into tetrads but also the wording of the items, in this case, as favourable, non-controversial statements. Certainly for the different aspects of the tetrad in comparison with those on the Likert and Semantic Differential questionnaire it seems to be the case. It would be expected that the Likert and Free Response questionnaires should exhibit similar characteristics of pupil response as they share a similar response structure. It is apparent here that the overall questionnaire format can produce somewhat different results despite the questionnaires being centred around common groups of constructs. Thus the Free Response questionnaire exhibits factorial structure whereas the other two questionnaires do not. Whether the factorial structure of the other two questionnaires could be improved, in relation to the tetrad groups would require a further study. It would be possible to group Likert and Semantic Differential items but it would not be possible to alter the nature of the item, in other words to present all favourable, non controversial techniques, without undermining the basic concept of the questionnaire.

A further analysis was undertaken to examine the fourth fixed response technique, the Structured - Situations questionnaire. It was noted earlier that this analysis was only undertaken with caution as the number of items representing the last three aspects of the tetrad are very few. The numbers of items representing each tetrad are again noted below.

| | |
|---|---|
| PERSONAL | 11 items |
| HUMAN | 2 items |
| EFFECT | 2 items |
| NATURE | 2 items |

The particular purpose of this analysis was to indicate the relationship between this potentially useful new questionnaire format and the questionnaire formats previously employed.

The factor analysis for all the tetrad groups is presented in table 8.3.6. The analysis produced five clear factors which represented 79.9. percent of the variance. The structure of the data presented here has to some extent already been considered in relation to table 8.3.4. The free response questionnaire produces a similar pattern of loadings on the first three factors, for example. The main difference between the arrangement of the loadings for the questionnaires, other than the additional Structured -

Situations questionnaire, is the appearance of a factor which comprises the human tetrad groups for the Likert and Semantic Differential questionnaires. These two, together with a major loading from the effect group from the Likert questionnaire, appear as the fifth factor on table 8.3.6. The relationship between these human aspects was noted on the correlation matrix for the last analysis (see table 8.3.5.) There is no factorial relationship between the human aspects on these questionnaires with the human aspects on either of the other two questionnaires examined.

In terms of the Structured - Situations the most noticeable point is the addition of the personal aspect to the main factor associated with the personal aspects of the other questionnaires (see factor two, table 8.3.6.) Overall this produces the only clear factor in the analysis. The human aspect of the questionnaire appears on the first factor but not in any direct factorial relation with the other human aspects. The effect and nature aspects appear together on a separate factor (see factor four, table 8.3.6.) Taken together they represent an assessment of science and its functioning but it is difficult to see why they should be in isolation from similar groups representing the Likert and Free response questionnaires on factor one. The questionnaire reflects a structure in the division of the various aspects similar to the Free Response questionnaire, that is, personal separated from human, which are, in turn, separated from the effect and nature aspects on the factor analysis. However the analysis overall indicates that the underlying assessment, which reflects the pupil's response, is different as the two questionnaires do not follow the same pattern of distribution, for similar aspects, on the factors.

The overall pattern emerging from this and the previous analysis in this particular discussion, is that the particular measurement technique which a questionnaire adopts has a pronounced effect on the relationships between different aspects or constructs within the questionnaire. This is despite the specific contents of the questionnaires considered having a common theoretical base. The only exception to this appears to be in relation to the personal aspects area. Only in this area is the overall response similar from questionnaire to questionnaire. This is evident from both factor and correlation analysis. At this stage it is difficult to ascertain the effect of questionnaire approach upon the pupil's response. This is partly due to the fact that the tetrad division is based on aspects which have not received full empirical validation. This will obviously confuse the issue. Evidence from the individual analyses of the questionnaires has suggested certain valid and reliable operational scales. Further comment on the effect of the questionnaire measurement technique upon the pupil's response will be made following the analysis of these, derived constructs.

Table 8.3.6. Free Response, Likert, Semantic Differential and Structured Situations Questionnaires - Tetrad Groups (Oblique Rotation to Kaiser's Criterion)

Total Variance 79.9%

| QUESTIONNAIRE | TETRAD SCALE | FACTOR 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| FREE | 1 PERSONAL | | -80 | | | |
| RESPONSE | 2 HUMAN | | | 67 | | |
| | 3 EFFECT | 72 | | | | |
| | 4 NATURE | 54 | | | | |
| LIKERT | 5 PERSONAL | 32 | -81 | | | |
| | 6 HUMAN | | | | | 106 |
| | 7 EFFECT | 34 | | | | 48 |
| | 8 NATURE | 66 | | | | |
| SEMANTIC | 9 PERSONAL | 32 | -50 | -56 | | |
| DIFFERENTIAL | 10 HUMAN | | | | | 57 |
| | 11 EFFECT | 38 | | -72 | | |
| STRUCTURED | 12 PERSONAL | | -66 | -31 | | |
| SITUATIONS | 13 HUMAN | 76 | | | | |
| | 14 EFFECT | | | -44 | 47 | |
| | 15 NATURE | | | | 76 | |

STAGE 2 Analyses of the Derived Construct Scales

Analyses of the fixed response questionnaires produced from the Likert, Semantic Differential and Free Response questionnaires defined derived scales. A summary of these scales and their reliabilities is presented in table 8.3.7. The nature of the individual items, obviously reflected in the scale name, leads to three areas of assessment which appear to be common to the questionnaires.

(1) Personal

(a) Commitment and interest in Science and Science Related Occupations.

Likert Scales COMSCI, SCIOCP, SCIINT.

Semantic Differential Scales SCIOCP, SCIINT

Free Response Scales INTEREST

(b) Perception of difficulty with school science work

Likert Scales SCIDIFF

Semantic Differential Scales SCIDIFF

(2) Scientists

The personal and work characteristics of scientists

Likert Scales SCIENT

Semantic Differential Scales SCITS

Free Response Scales SCITPERS, SCITWRK

(3) Social Implications of Science

The benefits and illeffects of science within our society.

Likert Scales SCIVAL, SCIDAN

Semantic Differential Scales VALUE DANG

Free Response Scales SCISOC

These areas represent common spheres of assessment and it would be expected that, if they are independent of technique of assessment used on the questionnaires, then these derived construct scales would show overriding relationships in a combined analysis. If, however, the technique of assessment is effecting the nature of their assessment, then the relationship between the scales on one technique will be greater than the cross - scale relationship.

The factor analytic examination of the derived scales is presented in table 8.3.8. Four clear factors were rotated accounting initially for 74.5 percent of the total variance. The first major factor contains loadings which reflect scales from all of the questionnaires, (see factor one, table 8.3.8.)

Table 8.3.7. Derived Construct Scale Summary

| TECHNIQUE | SCALE | ITEMS | ALPHA (CRONBACH) |
|---|---|---|---|
| LIKERT | COMSCI | 10 | 0.89 |
| | SCIOCP | 10 | 0.84 |
| | SCIINT | 10 | 0.85 |
| | SCIENT | 6 | 0.63 |
| | SCIDIF | 6 | 0.64 |
| | SCIVAL | 11 | 0.80 |
| | SCIDAN | 8 | 0.74 |
| SEMANTIC | SCIOCP | 8 | 0.84 |
| DIFFERENTIAL | SCIINT | 9 | 0.78 |
| | SCIDIF | 6 | 0.72 |
| | SCITS | 8 | 0.75 |
| | VALUE | 12 | 0,89 |
| | DANG | 9 | 0.80 |
| FREE | INTEREST | 8 | 0.86 |
| RESPONSE | SCITPERS | 8 | 0.67 |
| | SCITWRK | 8 | 0.74 |
| | SCCSOC | 8 | 0.79 |

Key:

| | |
|---|---|
| COMSCI | Commitment and Enjoyment of School Science |
| SCIOCP | Scientific Occupations |
| SCIINT | Scientific Interests and Pastimes |
| SCIENT/SCITS | Characteristics of the Scientist |
| SCIDIF | Difficulties with Science |
| SCIVAL/VALUE | Value of Science to Society |

Key contd.

| | |
|---|---|
| SCIDAN/DANG | Danger of Science to Society |
| INTEREST | Interest and enjoyment in science related activities |
| SCIPER | Personal Characteristics of a Scientist |
| SCIWRK | Work Characteristics of a Scientist |
| SCISOC | Science and Society |

The personal characteristics from each of the questionnaires combine together, although it should be noted that whilst the Likert and Free Response scales are major loadings, the Semantic Differential scales are minor loadings. This corresponds well with the initial division and seems to indicate the clear existence of a personal attitude domain which transends test technique.

The second factor comprises loadings which, again, reflect scales from all the questionnaires (see factor two, table 8.3.8.) The scales with the highest loadings here are the characteristics of the scientist scales from the Likert and Semantic Differential questionnaires and the personal characteristics of a scientist scale from the Free Response questionnaire. It is worth noting that it is personal characteristics that are in the majority on both Likert and Semantic Differential Scales. These clearly reflect the second dimension noted earlier and, again, the nature of the dimension lies across questionnaire boundaries. A number of other scales have loadings on this factor. The social implications of science scales from the Likert questionnaire are related here and with factor four. This is also true of the positive aspects of the social implication of science registered on the Semantic Differential. A possible explanation of this is offered in connection with the fourth factor. Finally, a loading representing the difficulty concept appears on this factor from the Semantic Differential instrument. It is noted that this scale spreads across these factors which tends to indicate a broad base for the pupil's perception of difficulty.

Table 8.3.8. Likert, Semantic Differential and Free Response Questionnaires Derived Scales.

(Oblique Rotation to Kaiser's Criterion)

Total Variance = 74.5%

| QUESTIONNAIRE | DERIVED SCALE | FACTOR 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| LIKERT | 1 CONSCI | 72 | | | 37 |
| (L3) | 2 SCIOCP | 72 | | | |
| | 3 SCIINT | 92 | | | |
| | 4 SCIENT | | 79 | | |
| | 5 SCIDIF | 35 | | | 68 |
| | 6 SCIVAL | | 50 | | 49 |
| | 7 SCIDAN | | 34 | | 60 |
| SEMANTIC | 8 SCIOCP | 44 | | -57 | |
| DIFFERENTIAL | 9 SCIIN | 42 | 38 | -53 | |
| (SD2) | 10 SCIDIF | 66 | -41 | -34 | |
| | 11 SCITS | | 87 | | |
| | 12 VALUE | | 36 | -47 | 34 |
| | 13 DANG | | | -85 | |
| FREE | 14 INT | 76 | | | |
| RESPONSE | 15 SCIPER | | 51 | 48 | |
| (FR) | 16 SCISCC | | | | 60 |
| | 17 SCIWRK | | | | 58 |

n.b. the decimal points are omitted from this analysis.

**Table 8.3.9. Likert, Semantic Differential & Free Response Questionnaires - Derived Scales Correlation Matrix**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 73 | 65 | 29 | 51 | 51 | 64 | 63 | 65 | 44 | 35 | 29 | 21 | 51 | 23 | | |
| 2 | | | 71 | | 28 | 15 | 44 | 49 | 51 | 58 | 21 | 24 | 25 | 43 | 26 | | |
| 3 | | | | 17 | 22 | 15 | 22 | 49 | 46 | 57 | 15 | 25 | | 70 | | | -27 |
| 4 | | | | | | 54 | 36 | | 30 | -15 | 69 | 28 | | | 39 | | |
| 5 | | | | | | 34 | 53 | 20 | | 28 | | 32 | -17 | | 21 | 31 | 23 |
| 6 | | | | | | | 59 | 18 | | | 49 | 56 | 17 | | 36 | 38 | 35 |
| 7 | | | | | | | | 52 | 50 | 24 | 54 | 66 | 35 | | 27 | 40 | 34 |
| 8 | | | | | | | | | 64 | 51 | 28 | 65 | 57 | 36 | | | |
| 9 | | | | | | | | | | 35 | 56 | 60 | 44 | 32 | | | |
| 10 | | | | | | | | | | | | 15 | 36 | 41 | -29 | | -36 |
| 11 | | | | | | | | | | | | 49 | 30 | | 42 | | |
| 12 | | | | | | | | | | | | | 43 | | | | 31 |
| 13 | | | | | | | | | | | | | | | -25 | 33 | |
| 14 | | | | | | | | | | | | | | | 21 | -26 | |
| 15 | | | | | | | | | | | | | | | | | 39 |
| 16 | | | | | | | | | | | | | | | | | 31 |

n.b. over page....

Table 8.3.9.

n.b. (i) the decimal points are omitted on this table.

(ii) all values are to 1% significance, adjusted individually for the numbers according to the comparison matrix.

(iii) the numbers relating to the individual scales are noted on table 8.3.8.

The third factor is comprised almost totally of scales located on the Semantic Differential questionnaire (see factor three, table 8.3.8.) The analyses which have involved this questionnaire to date have all given a strong indication that the internal relationships within the questionnaire are stronger than any relationships, even on similar constructs, with any other questionnaire. In the analysis undertaken here the derived construct scales, which are taken clearly from the pupils perception of the initial items, are tending to form fairly clear overall groups relating to the major underlying dimensions of the pupil's perception. To an extent the Semantic Differential scales are falling in line with this overall analysis. However, the presence of this third factor once again gives support to the notion that scales on a Semantic Differential questionnaire are not capable of fully independent function. The item content of the Semantic Differential scales, when examined clearly reflects the nature of the scales and establishes each scale as distinctly different. The operational use, in a combined content with like scales on other questionnaire techniques however still results in the existence of strong inter relations. Initially the Semantic Differential technique was not developed for the main purpose of measuring attitudes alone, although this soon became one of its major functions. Early factor analytic work by Osgood and his co-workers has revealed that the stimulus words used tend to fall into three main categories; evaluation, potency and activity, and that it is convenient to think of these categories as forming a three dimensional space (Osgood et al, 1957). The construct scales that have been used are of an evaluative nature. An examination of the bi-polar scales on all of the items used tends to confirm this. In comparative analyses the evaluative nature of the scale as an underlying dimension seems to be paramount. This underlying dimensionality forces a close relationship between the scales when compared with other measurement techniques.

The fourth factor contains loadings representing all three questionnaires. The common area which the scales tend to represent relates to the social implications of science. The scales value of science and danger of science to society, from the Likert questionnaire, value of science from the Semantic Differential questionnaire and science and society, from the Free Response questionnaire are represented on this factor, (see factor four, table 8.3.8.) The mixture of scales relating what have been identified as 'pro' and 'anti' science scales, with no indication of negative loading, is a notable point, as this indicates that the recognition of both aspects may play a part in the pupil's perception. It is above all quite conceivable that pupil s can hold both viewpoints. To adopt a position whereby they automatically form the opposite ends of a bi-polar scale may tend to result in a very 'average' response.

Certain other scales relate to this set noted above. The work characteristics of a scientist scale, from the Free Response questionnaire relates here. The work of a scientist is perhaps perceived in terms of its social implications rather than as a recognisable activity of scientific endeavour. It is interesting to note that earlier in the consideration of the second factor from this analysis, the social implication scales from the Likert questionnaire were associated with scales concerning the personal characteristics of a scientist. It is possible that pupil s can only perceive the scientist in terms of the outcomes of his or her endeavours. Another point relates to this, in the analyses presented it would have been logical to expect that positive characteristics of a scientist would link clearly with a desire to become a scientist. This has not been the case. Here the pupils tend to associate too closely classroom science with their perception of future scientific occupations. It seems that their conception of the science in school is more closely related to their desire to follow science based careers than is their perception of what a scientist is actually like or of what a scientist actually does. Can it be said that the classroom based science a pupil receives actually presents any sense of perception of the working life of a scientist? It is possible for pupils to use a classroom teacher as a model, perhaps for perceptions of the personal characteristics of a scientist, hence the existence of the second factor which relates primarily to the personal characteristics of a scientist. It seems that it is not possible for that model to work for the professional or work characteristics, these tend to relate to the implications of the work rather than it's nature.

Finally, on this fourth factor, two scales relating to personal perceptions. The scale relating to the commitment and enjoyment of science on the Likert questionnaire provides a minor loading. In a number of ways the perception of science a pupil possesses is governed by the school environment but the general social environment must obviously affect the personal attitude overall.

The difficulty scale from the Likert questionnaire is also connected through its major loading with the fourth factor. The perception of difficulty has usually associated itself with school based perceptions of enjoyment and interest. Thus it has become natural to expect that a pupil experiencing great difficulty with the subject may well exhibit a poor attitude towards science and lack interest in the subject. There is evidence for this in that both difficulty scales associated with the Likert and Semantic Differential questionnaires have shown association with the first factor, (see factor one, table 8.3.8.) The loading on the fourth factor is difficult to interpret. There may be some association here with levels of perceived difficulty being connected with overall perceptions of science. The brighter the pupil, the less their difficulties, the broader the pupils conception of the dangers and benefits of science. In the case of the Semantic Differential a similar problem arises in that the of the science in school is more closely related to their desire to follow science based careers than is their perception of what a scientist is actually like or of what a scientist actually does. Can it be said that the classroom based science a pupil receives actually presents any sense of perception of the working life of a scientist? It is possible for pupils to use a classroom teacher as a model, perhaps for perceptions of the personal characteristics of a scientist, hence the existence of the second factor which relates primarily to the personal characteristics of a scientist. It seems that it is not possible for that model to work for the professional or work characteristics, these tend to relate to the implications of the work rather than it's nature.

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In this analysis the Likert and Free Response questionnaires appear to produce distinct sub structures within their scales as illustrated on the factor analysis, (table 8.3.8.). The broad overview indicates that this sub-structure is allocated as follows:

Factor One : Personal attitudes and interests in connection with school, hobbies and scientific careers.

Factor Two : The personal characteristics of the scientist

Factor Four : The social implications of science.

The Semantic Differential shows some intermediate relationships with these factors, particularly on factor two in respect of the scientist, but again seem to demonstrate the strength of its internal relationships through it's almost factorial independent grouping on the third factor.

The correlation matrix for these scales is presented in table 8.3.9. These underlying strengths of the correlations are reflected in the factor analysis under discussion. In terms of the major areas identified the correlations for the scales within these areas are generally of increased size in comparison with the internal relationships between scales on the same questionnaire. The personal area for example demonstrates this, consider the correlation between scales 1, 2, 3, 8, 9 and 14 on the first row of the matrix (see row one, table 8.3.9.) A similar pattern is identified for the scientists factor, (see scales, 4, 11 and 15 on row four, table 8.3.9.) and the social implications of science, (see scales 7, 12 and 16 on row six, table 8.3.9.)

The matrix provides an interesting point with regard to the three areas of assessment identified above in relation to the individual questionnaires. The scales on the Semantic Differential questionnaire have already been identified as demonstrating close relationships. The Likert and Free Response questionnaires provide evidence of sub structure within the individual questionnaire. Of these two, the correlation matrix indicates that the scales on the Free Response questionnaire demonstrate the lowest internal correlations (see correlations between scales, 14, 15 16 and 17 on table 8.3.9.) This indicates that perhaps further investigations in this area may well benefit from the use of the Free Response questionnaire if relatively independent assessments are required on the major dimensions of pupil perception of the attitude domain.

It is evident from this analysis that certain construct areas are established across the realm of measurement techniques. In the case of these areas, appropriate questionnaire techniques can now be identified to assess these areas. This will be considered in the next stage.

## Stage 3 The Assessment of Attitudinal Constructs - appropriate techniques for their measurement

In the previous stages of this section consideration has been given to the combined analysis of the different fixed response questionnaires which have been used to assess attitudinal based constructs. This stage considers a brief summary of that work and concludes with recommendations as to appropriate techniques to be employed in further work.

The evidence presented in the first stage of this section produces an overall pattern which suggested that when the constructs are conceptually clear within the pupil's minds, the response to the different questionnaires was likely to be influenced by the particular technique employed as much as by the actual content of the questionnaire. The extent of this effect could not be exactly prescribed but similar construct scales within different questionnaires displayed different internal relationships (see table 8.3.3.). Only in the case of the personal group of constructs was there any evidence of test independence. In essence the assessment of identical constructs using different techniques of measurement is unlikely to give equivalent results unless the particular constructs used are viable for the pupil population considered.

In the second stage of this section, a number of clearly identified construct scales were employed which had derived their nature from the individual analyses of the questionnaires employed in this study. There emerges from the comparitive analysis of these constructs, three areas representing different facets of the attitude domain of the pupils' considered. These areas are fairly independent and seem to transcend the boundaries of the individual assessment questionnaires. These areas are:-

ONE : Personal attitude to school science and interest in science related activities and scientific occupations.

TWO : A perception of the personal characteristics of a scientist.

THREE : An appreciation of the impact the work of science and scientists has upon our society.

These areas draw upon scales on a number of different questionnaires (see table 8.3.8.) In terms of the assessment of these areas a number of scales offer acceptable reliability values, (see table 8.3.7.). The selection of a suitable instrument cannot be based upon these values alone. The Semantic Differential questionnaire although offering reliable scales, has strong internal scale associations which are a function of the particular technique. The use of scales from this instrument would not produce a reasonable degree of discrimination between the areas identified above. Whilst it is appreciated that all these areas are related in some way or another, there exists an underlying structure of the pupil's response and it is desireable to obtain as independent a measure of the three facets as possible. It has been indicated that the Free Response questionnaire seems to provide an assessment of each of these facets in the most independent way. As a new technique, however, it still requires further development to strengthen the scales used in terms of item numbers. The Likert questionnaire also offers an overall discrimination between the various facets and, in terms of the first and third areas, a number of clearly defined and reliable scales of measurement. It would appear that this form of questionnaire would provide the most appropriate form of assessment at present but the future form of questionnaire to assess pupil's attitudinal dimensions may well require the development of a Free Response style questionnaire.

## Section 4 Analysis of the Open Ended Response Questionnaire

### Stage I Frequency Analysis of the Identified Major Items

In the use of fixed response techniques the tests have all initially had a set of pre-determined constructs. The tests therefore were designed around a set of constructs selected and defined by the test designer. The pupils responses therefore could only correspond to the areas imposed by the investigator. Even after detailed factor analyses the scale item could only be rearranged to reflect certain areas which the pupils could choose, preferentially, from amongst the definite items offered.

The extent to which these constructs reflect the pupils own perceptions can be examined by providing an open ended format on a questionnaire and then analysing the types of response. In some studies this technique has been used to generate areas and items for questionaires as an initial stage in test design. In this particular study the technique is used to examine the extent the pupils own perceptions reflect the theoretical and empirical framework derived from the extensive study of pupil assessment instruments.

In an earlier section, a description of the procedure for the analysis of this free response questionnaire was provided (see Chapter 7, Section 3b). This procedure was an iterative one and led to a classification of the pupil's open responses. Obviously, to an extent, there is still a structure imposed upon the response but this structure genuinely mirrors the areas of pupil response within specified areas prompted by the items presented. The percentage of pupils responding to the questionnaire items in each of the identified categories is presented in table 8.4.1. Each area is considered as providing a possible response category for the items on the questionnaire. In the case of the main area for each item it was possible to not only register a response but also to grade the response given. The first point to note is that certain areas are well responded to and reinforce the notion that these areas are understandable to the pupils and form part of their perception of these areas.

| Area | % Response |
|---|---|
| 1. Like/Dislike of School Science | 99.0 |
| 2. Becoming a scientist | 99.0 |
| 3. Interest in science as a hobby | 98.0 |
| 5. Difficulty with science | 92.2 |
| 6. Science and its impact on society | 97.1 |
| 7. Science and the individual within society | 86.3 |

Some of these perceptions are further qualified with further detail, depending on the strength of feeling and capabilities of the pupil to respond. These values represent graded responses, that is, written answers which are interpreted.

Two further areas are also highly responded to:

4. Scientists and their work 73.5 and

10. Aims of science 78.4.

This latter area is an interesting response as it is the first noticeable time that responses in this area have been able to be quantified to any extent.

The areas 8) Scientific Theories and Laws

and 9) Scientific Method

are the items which have the weakest response. In the case of 8) over a quarter directly responded with a phrase reflecting no understanding.

Each area is now considered in turn

1) Like or Dislike of School Science

A consistent response by almost all pupils. A range of values are present. A high proportion follow statements by a positive response to practical aspects of school science. Irrespective of their position on the like/dislike scale, all pupils who responded here liked the practical aspects. Written work was seen as a reason for dislike for a number of pupils (15.7%). Only a small percentage (2.9) saw the teacher as being a negative influence. Difficulty with the subject was directly associated with enjoyment for a relatively small number of pupils (10.7%)

Overall this area reflects a meaningful dimension to the pupils. The major qualifying factor for enjoyment of science as a subject was the practical aspects. Against this a smaller number thought written work and the difficulty of the subject as reasons for their dislike.

2) Becoming a Scientist

A consistent response although the majority were not in favour of pursuing a career in science (66.6%). The activity itself and the demands of such a career registered as being the most likely reasons for such a decision. A meaningful dimension in the pupil's view.

3) Interest in Science as a Hobby

Again a consistent response overall with a mixed opinion for the sample. Experimental work is noted as being the most promising aspect of an interest in science as a hobby. A small but noteworthy group (11.8%) were against the subject as a possible recreational activity because it was perceived as being dangerous.

A meaningful dimension of assessment,

4) Scientists and their Work

A slightly weaker response rate to the main scale. Two conceptions occurred i) the work of a scientist

ii) the social implication of a scientists work.

A comment noted earlier on the construction of the assessment is valid here. The question following the situation was poorly phrased as a prompt to the general area; "what are your thoughts about scientists and their work?" it invites comments on the outcomes of a scientists work and not simply on their mode of working or their own characteristics.

The responses indicate that approx. one third reacted to the social implication facet. The response here is generally beneficial with little qualification. The detailed comments which follow the later items (6,7) concerning this area do not appear here, the prompt items are obviously not specific enough.

The perception of a scientist as hard working is evident as a number of responses (17.6%). The other characteristics such as intelligence, their interest as people and their secretive nature have few comments overall. In terms of their mode of working, over half of the response takes the mixed mode, of sometimes working alone. The lone scientist is not a clear perception here.

Overall the assessment area is still a positive one with a rephrasing of the items the pupils comments could be directed to within a certain area. It is important to note here that however free this technique is, the situations and the stimulus words will always encourage responses within their boundaries and may well provide the necessary words for the pupil to use.

5) <u>Difficulty with Science</u>

A consistent response to this question reflects the importance of this area. A large proportion (73.5%) of the responses identified some problems with school science. It must be stated that this is an indication of difficulties if and when experienced and not an intensity measure directly. However only 3.9% had no problems or difficulty at all.

The major area of difficulty identified was a linguistic one, particularly the comprehension area but also the problem with understanding scientific symbols. Mathematical calculation also figures fairly prominently as a problem. The time-work ratio has a small response as does power of concentration. Perhaps it is too early for these pupils to appreciate these as areas of difficulty. It is interesting to speculate as to whether this pattern of difficulty reflects the way the subject is projected. At this level it probably is the language that presents the greatest barrier. After a few more years of experience perhaps the balance in terms of difficulty will turn towards the mathematical side?

A small response considered the teacher as a contributor to this area either as a help or a hinderance to learning. The responses indicate an equal division. Overall the area represents an important area of assessment. It provides useful comparitive information on the difficulties experienced by the pupils.

(6) Science and its impact on Society

(7) Science and its impact on the Individual within Society

These two areas are considered together to allow immediate contrast in the responses. A high response rate was recorded for area (6) Overall pupils noted the beneficial aspects here and a large response was noted for the global beneficial area (69.6%).Of the areas where harmful effects were noted, the effects here were of approximately equal magnitude in their response.

In comparison the responses to area (7) show some changes. It has been apparent from earlier questionnaires that the aspects of science affecting the individual do not withstand further statistical analysis for it to stand as a separate dimension. The overall effect of science, being good or bad, has been paramount. It is interesting in this light to note that the overall response to the main item displays a lot less conviction as to the beneficial effect. Another point of interest is in the rise in responses to pollution aspects and also the communications facet. This may well be due to the situation providing further stimulation in this area. The pupils may use this second item to qualify some of their responses to item (6). Overall, however, the beneficial aspects are paramount with the exception of the pollution area.

It may be difficult to justify the responses to these two items as being separate. Responses to the general idea are similar. In the area of pollution and communications maybe the question is beginning to educate an opinion rather than just assess the presence of one. A strongly supported area with clear meaning for the pupils.

(8) Scientific Theories and Laws

(9) Scientific Method

(10) Aims of Science

These last three items have their responses clearly categorised rather than rates as in the case of a number of the other items. The situation provided gives the basis for the answers in these items and when they were answered the pupils tended in each case to agree or disagree with a participant in the situation. A free response here was hardly in evidence. A number of reasons have been advanced as to the purpose of this pattern of responses. Undoubtably a certain cognitive level is necessary to even begin to form a basis for a competent answer. In the case of item (8) the response pattern is low and a quarter clearly responded with expression of complete lack of understanding. The spread of responses for those that answered displays little positive indication of opinion. Likewise item (a) is weak in response although it is possible to identify with science practical lessons in answering the question. The category with the most responses reflects the experimental approach common to schools at this level. Item (10) has a good response rate and, as noted earlier, perhaps presents a first opportunity to assess an answer in this area. Pupils given further information via the situation example can make a judgement in this area.

Undoubtably what is important here is that the areas are of some note and value but present conceptually difficult areas for pupil response. In the light of other techniques this format (or science situation fixed) may well form the only possible techniques which are clear enough to assess the pupils opinions. The overall analysis of the responses to the response questionnaire allow comment to be made on an important area, i.e. the extent to which the pupil's own response, guided by the stimulus situations, mirror the original construct dimensions identified. A table has been drawn up to facilitate this comparison. (see table 8.4.2.)

As can be observed the responses in the open ended questionnaire produce confirmatory evidence for a number of initial dimensions. These are, (1), (2), (3), (5), and (6). Also (4) and (7) with modifcations. The dimensions (8), (9), (10) are unlikely.

1) General opinion on enjoyment or like and dislike construct is upheld. The pupils do not tend to draw comparisons with other subjects or comment on science in general. They do respond well in the area of practical activities and it would seem could also comment on written work as a contrast if required.

2) This dimension receives a positive response although the pupils do not tend to relate their general opinion to specific careers. As the pupils overall do not have a keen desire to pursue such careers, specific occupations may not be in mind. However it would be of interest to identify the description of the occupation which the majority would not wish to pursue.

3) A more general interpretation of hobbies or interest is present with an added qualification relating to experimental work. The perception of such hobbies as dangerous in some responses provides an interesting qualifier.

4) This area has produced a number of responses which are noticeably different from the original concept. Although pupils do perceive the characteristics noted, their concern is also with their scientist's mode of working and the possible social implications. A rewording of the item initially may have directed responses in to commenting more succinctly on the characteristics of a scientist. However the responses would indicate that a reworking of the initial construct is necessary perhaps in conjunction with latter constructs.

5) A certain match with the original construct is evident here on the items specifying particular intellectual difficulties. Practical difficulties are not seen as prominent problems nor are time commitments.

(6) These areas again produce definite responses within the original (7) classification although, as has been noted, the categories of response to both items are invariably the same and not necessarily divided between the general society view and the individual. Recognition of the involvement of an individual in science is not noted amongst the responses.

(8) (9) (10) The last three areas produce examples of responses which are very much governed by the item content. The original concepts are reflected in the item responses in so much as the pupils identify with the characters in the situation rather than develop their own responses. In the case of (8) and (9) this is less successful than with (10). It is unlikely that these constructs would form part of the perceptions of pupils. A presentation of the key words of title of the construct, without the situation would have produced little, it would appear, in terms of a structured response.

Stage 2 Comparative analysis of the Free Response Questionnaire with the Fixed Response Questionnaire.

The fixed response questionnaire reflects the pupils own perception of the items presented. The free response questionnaires have allowed the pupils to respond openly to similar areas of investigation. The extent to which the free response questionnaire reflects the scales derived from fixed response questionnaire adds further to our view of the fields of assessment that are reliable for future investigation.

In terms of the free response questionnaire, the analysis in the previous stage, represent in table 8.4.2. indicates certain clear areas of pupil response. Areas (1), (2), (3), (5), (6) and (7) are incorporated although each requires some minor modifications on terms of original concept. Evidence also exists for the incorporation of both personal and work characteristics of the scientists in relation to (4). The latter items (8), (9), (10) tend not to encourage response but could perhaps form a new method of assessment if developed further. In terms of the fixed response questionnaires the results form the derived scales,are presented in section 8.3. Here a threefold attitudinal domain seemed to emerge with difficulty as an additional but related facet. The derived analysis also showed that the conception of a scientist could well be divided into two aspects relating to personal and work characteristics. The personal characteristics forming one facet of a scientist factor whilst the work characteristics formed a close factorial relation with the social implications facet (table.8.3.8.). There are striking similarities between these two aspects of questionnaire analyses. The open response supports the overall findings from the fixed response questionnaire in terms of the areas each of the techniques identifies as important. Although it could be expected, as both rely on the same population, it is encouraging because it reinforces the detailed statistical analysis carried out to refine the scales of the fixed response questionnaires. In other words both methods of identifying constructs are producing similar, supportive results. The nature of these areas also identifies well with a number of the initial constructs defined in the attitude dimensions.

One area which provides further enlightenment through the open response questionnaire is the one relating to the scientist. The open response item produced a mixture of responses which detailed personal and work characteristic together with the social implication of the scientists work. This mixed perception is evident in the fixed response data both in the existence of two separate scales on the free response technique and in the relationships displayed on the combined analyses. The comparitive information here will provide a sound base for improvements to this particular scale. As with others in more minor areas. The responses to the open ended questionnaire are often to be criticised because they, like a comprehension exercise, repeat the question or the text. However the pupil does make a conscious choice of what to relate. The pupils open choices here appear to support and clarify the nature of the attitudinal domain identified earlier.

Table 8.4.1. FREE RESPONSE QUESTIONNAIRE - PERCENTAGE ITEM RESPONSES

| ITEM AREA | DESCRIPTION (Values) | % Response Total | per category |
|---|---|---|---|
| (1)CONSCI | | | |
| ao | Enjoyment of school science (5 to 1) | 99.0 | 23.5;23.5;19.6;16.7; 15.7; |
| a1 | practical (1, 0) | 54.9 | all + |
| a2 | theoretical (1,0) | 0 | |
| a3 | written (1, 0) | 17.7 | 2.0; 15.7; |
| a4 | homework (1, 0) | 2.9 | all 0 |
| bo | difficulty (1, 0) | 13. | 10.8; 2.9 |
| co | teacher (1, 0) | 3.9 | 2.9; 1.0; |
| (2)SCIOCP | | | |
| ao | Becoming a scientist (5 to 1) | 99.0 | 16.7;8.8;4.9;8.8;57.8 |
| a1 | activity (1, 0) | 26.5 | 11.8; 14.7; |
| a2 | challenger (1, 0) | 1.0 | all 1 |
| a3 | demands (1, 0) | 23.5 | all 1 |
| a4 | difficulty (1, 0) | 2.0 | all 1 |
| (3)SCIINT | | | |
| ao | Interest in science as a hobby(5tol) | 98.0 | 25.5;20.6;7.8;8.8;35.3 |
| a1 | experimental work (1, 0) | 24.5 | all 1 |
| a2 | solving problems (1) | 1.0 | |
| a3 | collecting things (1) | 1.0 | |
| a4 | learning (1) | 6.9 | |
| a5 | danger (1,0) | 11.8 | all 1 |
| (4)SCITS | | | |
| ao | scientists and their work (1) | 73.5 | |
| a11 | intelligence (1) | 5.9 | |
| a12 | hard working (1) | 17.6 | |
| a13 | interesting people (1,0) | 4.9 | 3.9; 1.0; |
| a14 | open secretive (1,0) | 2.0 | shared |
| a2 | mode of working (3.2.1 ) | 43.1 | 13.7; 23.5; 5.9 |

Table 8.4.1. contd

| | | | |
|---|---|---|---|
| bo | Impact of scientist's work on society (5 to 1) | 31.4 | 22.5;4.9;2.0;0;2.0; |
| b11 | beneficial - general (1) | 19.6 | |
| b12 | knowledge (1) | 0 | |
| b13 | mechanisation (1) | 1.0 | |
| b14 | communications (1) | 1.0 | |
| b21 | harmful - general (1) | 2.0 | |
| b22 | weapons (1) | 2.9 | |
| b23 | pollution (1) | 2.0 | |
| b24 | resource waste (1) | 1.0 | |
| (5)SCIDIF | | | |
| ao | difficulty with science (5 to 1) | 92.2 | 58.8;14.7;2.9;11.8; 3.9; |
| a1 | intellectual (1) | 23.5 | |
| a21 | linguistic - comprehension | 40.2 | |
| a22 | linguistic - symbols (1) | 24.5 | |
| a31 | mathematical calculations (1) | 18.6 | |
| a32 | mathematical symbolism (1) | 2.9 | |
| bo | time - work ratio (1) | 4.9 | |
| co | interest - concentration (1) | 1.0 | |
| do | teaching skills (1, 0) | 4.9 | shared |
| (6)SCISOC | | | |
| ao | science - impact on society(5 to 1) | 97.1 | 41.2;18.6;21.6;5.9;9.8 |
| a11 | beneficial general (1) | 69.6 | |
| a12 | knowledge (1) | 2.0 | |
| a13 | mechanisation (1) | 12.7 | |
| a14 | communications (1) | 7.8 | |
| a21 | harmful - general (1) | 13.7 | |
| a22 | arms/weapons (1) | 15.7 | |
| a23 | pollution (1) | 12.7 | |
| a24 | resource waste (1) | 17.6 | |

Table 8.4.1. contd

| | | | |
|---|---|---|---|
| (7)SCIINV | | | |
| ao | science individual within society (5 to 1) | 86.3 | 20.6; 14.7; 32.4; 7.8; 10.8; |
| a11 | beneficial general (1) | 52.9 | |
| a12 | knowledge (1) | 0 | |
| a13 | mechanisation (1) | 12.7 | |
| a14 | communications (1) | 23.5 | |
| a21 | harmful general (1) | 12.7 | |
| a22 | arms/weapons (1) | 3.9 | |
| a23 | pollution (1) | 52.9 | |
| a24 | resource waste (1) | 0 | |
| (8)THRLAW | | | |
| ao | scientific theories and laws(5 to 1) | 41.2 | 6.9;8.8;7.8;10.8;6.9; |
| | do not understand (0) | 26.5 | |
| bo | interest response (1, 0) | 2.9 | |
| co | interpretation (1) | 1.0 | |
| (9)SCIMET | | | |
| ao | scientific method (1,2,3,) | 56.8 | 48.0;5.9;2.9; |
| | do not understand 0 | 5.9 | |
| (10) AIMSCI | | | |
| ao | aims of science (1,2,3,) | 78.4 | 33.3; 28.4; 16.7; |
| | do not understand 0 | 1.0 | |

Table 8.4.2.

Comparison Table of Free Response Areas and Original Construct

| ATTITUDE DIMENSIONS<br>ORIGINAL CONSTRUCT AREA | FREE RESPONSE AREAS | ADDITIONAL COMMENTS |
|---|---|---|
| (1) Commitment to Science | | |
| A. School science in the curriculum | | |
| (i) view of school science | Positive response | |
| (ii) comparison with other subjects | No response | |
| B. School sciences learning activities | | |
| (i) practical | Positive response | Written Work |
| C. Science in general | | |
| (i) view of science | No response | |
| (2) Scientific Occupation | | |
| A. Desire to take up a scientific occupation | | |
| (i) unspecified | Positive response | |
| (ii) specified | No response | |
| B. Difficulties associated with pursuing career | Weak response | |
| (3) Scientific Interest | | Dangerous activity |
| A. Interest in active pastimes | Positive response | Overall or general response rather than specific hobby. |
| B. Interest in passive pastimes | Weak response | |

| | | |
|---|---|---|
| (4) <u>Characteristics of the Scientist</u> | | |
| A. Personal and social characteristics | Weak response to some areas, e.g. intelligence | Mode of working as a scientist. |
| B. Professional characteristics | Positive response to some areas e.g. hard working | Social impact of a scientist's work |
| (5) <u>Difficulty with school science</u> | | |
| A. Intellectual Difficulty | | |
| (i) conceptual | Positive response | |
| (ii) mathematical | Positive response | |
| (iii) linguistic | Positive response | |
| B. Practical Difficulties | No response | |
| C. Time commitment | Weak response | |
| (6) <u>Science and Society</u> | | |
| A. General View | Positive Response | Improved clarification of the benefits and Illeffect. |
| B. Benefits and Illeffects | Positive response | |
| C. Scientific Expenditure | Positive response | |
| (7) <u>Science and the Individual</u> | | |
| A. Benefits & Illeffects | Positive response | |
| B. Individual's involvement in science | No response | |
| (8) <u>Scientific Theories & Laws</u> | | |
| A. Flexibility<br>B. Incorporating all knowledge<br>C. Predictive | Positive response but classified as a bi-polar scale | Presentation produces response |

(9) Scientific Method

| | |
|---|---|
| A. Observation<br>B. Criticism<br>C. Self criticism and co-operation | Positive response but classified as a bipolar scale |

(10) Aims of Science

| | |
|---|---|
| A. Utilitarian activity<br>B. Philosophical | Positive response but classified as a bipolar scale. |

## Section 5 Analysis of the Pupil Rating Schedule

In the initial analysis of the Pupil Rating Schedule (P.R.S.) a number of characteristics were selected for further investigation. These characteristics represented the three major dimensions, identified as representing the major areas of teacher assessment and the key areas with respect to this present study.

| Scale | Abbreviation | *Teacher Assessment Area |
|---|---|---|
| Ability in Science | (ABILITY) | 2 |
| Personal Application | (PERSAPPL) | 1 |
| Personality | (PERSON) | 3 |
| Science Attitude | (ATTITUDE) | 1 and 3 |
| Science Interest | (INTEREST) | 1 and 3 |
| Classroom Behaviour | (CLASBEH) | 1 |

*Key

1. Pupil's performance in science
2. Pupil's ability in science
3. Pupil's personality

In the first stage of the analysis the relationship between these characteristics is reexamined in the light of more extensive data from the full empirical study. The second stage considers the P.R.S. assessment and it's relation to the pupil self report techniques.

### STAGE 1 Analysis of the Restricted Pupil Rating Schedule

The factor analyses of the six characteristics on the restricted schedule are presented in table 8.5.1. In these analyses two clear factors appeared using Kaiser's criterion and represented 84% of the variance. Both rotations (table 5.1.1.) produce similar results in this instance. Classroom behaviour and personal application are the items with the highest loading on factor one. Attitude, Interest and Ability have their highest loading here also but have minor loadings associated with personality on factor two. A brief examination of the correlation matrix for these analyses indicates that the two scales of Classroom Behaviour and Personality do not have a relationship of any statistical significance. (see table 8.5.1c).

Table 8.5.1.(a) Pupil Rating Schedule - Restricted Characteristics (Varimax Rotations to Kaisers Criterion) Total Variance = 84.0%

| | FACTOR 1 | FACTOR 2 |
|---|---|---|
| Attitude | 82 | 41 |
| Persappl | 90 | |
| Clasbeh | 88 | |
| Interest | 79 | 49 |
| Ability | 60 | 47 |
| Person | | 67 |

Table 8.5.1. (b) Pupil Rating Schedule - Restricted Characteristics (Oblique Rotation to Kaisers Criterion) Total Variance = 84.0%

| | FACTOR 1 | FACTOR 2 |
|---|---|---|
| Attitude | 83 | 30 |
| Persappl | 91 | |
| Clasbeh | 88 | |
| Interest | 79 | 35 |
| Ability | 64 | 32 |
| Person | | 69 |

n.b. The decimal points are omitted from these results.

Table 8.5.1. (c) Pupil Rating Schedule - Restricted Characteristics

Correlation Coefficients

| | ATTITUDE | PERSAPPL | CLASBEH | INTEREST | ABILITY | PERSON |
|---|---|---|---|---|---|---|
| ATTITUDE | - | 82 | 71 | 84 | 70 | 35 |
| PERSAPPL | - | - | 78 | 85 | 65 | 23 |
| CLASBEH | - | - | - | 68 | 50 | - |
| INTEREST | - | - | - | - | 70 | 40 |
| ABILITY | | | | | | 36 |
| PERSON | | | | | | - |

n.b. All values 1% significance.

The decimal point has been omitted from these values.

Thus the teachers rating the pupils seem to make only one clear point, that is the rating of a pupils classroom behaviour in terms of being a help or hindrance to the lesson does not depend on the type of personality displayed by the pupil. Attitude and interest are seen as clearly related to classroom behaviour but they are also seen as being related to personality perhaps by definite outward expressions by the more extroverted pupils. The ability construct, independent to an extent on the previous analyses of the full schedule incorporates both aspects although perhaps considering the factor loadings the more co-operative pupils in terms of classroom behaviour are generally given higher assessments.

It is difficult to pronounce clearly on this data. The analyses serve to indicate possible routes to explaining how the teacher perceives and then assess the pupils on this instrument. It is undoubtably difficult for a teacher to assess characteristics which would have underlying relationships in the general view. The phenomenon of co-judgement easily occurs. A pupil who is able in a subject invariable shows interest and displays a good attitude.

After judging a pupil's ability or similarly, positive classroom behaviour, it is usually to infer a commensurate level of interest and attitude toward the subject. Within the constructs of teaching situation and in the absence, generally, of the necessity to assess different characteristics regularly, it is difficult to imagine the assessments changing. The value of a teacher based assessment is considered in the next stage.

## STAGE 2 Analyses of the Restricted Pupil Rating Schedule and the Pupil Self Report Techniques

A problem raised early in the thesis was related to the suitability of teacher assessment in relation to pupil's attitudes. One could see the teacher being ideally placed to assess attitudes and in some studies teacher rating has been used as a validation of questionnaires. Having considered the domain of teacher assessment of attitude related characteristics, how are such assessments actually related to the pupils own report of their characteristics?

In table 8,5.2. the major areas of teacher assessment are considered with the finalised scales of pupil self assessment. These scales have been considered to be both reliable and valid and represent the spectrum of attitudinal variables identified within this study. The table presents the oblique rotation of six factors which accounted for 81.3% of the total variance. The table presents a clearer picture of the results than in the straightforward varimax rotation. Although there are no major differences in the distribution of significant loadings. The first factor contains the majority of variables relating to the pupil rating schedule. They seem to represent the largest, cohesive body of variables and there are no other representations of these on other factors. This would suggest that the teacher based assessment relates primarily to itself. However this does not completely remove inter-relationships between the teacher and the pupil assessment instruments. If the correlation matrix of the factor analysis is examined a number of relationships do appear significant. Consider the scale ATTITUDE as representative of the teacher assessment instruments first five categories, the following statistically significant correlations are recorded in the correlation matrix:

| | ATTITUDE |
|---|---|
| COMSCIL3 | 46 |
| SCIOCPL3 | 27 |
| SCIINTL3 | 16 |
| SCIENTL3 | 18 |
| SCIDIFL3 | 44 |
| SCIVALL3 | 32 |
| SCIDANL3 | 37 |
| SCIOCPSD2 | 21 |
| SCIINSSD2 | 39 |
| SCIDIFSD2 | 32 |
| SCITSSD2 | 14 |
| VALUESD2 | 34 |
| DANGERSD2 | - |
| INTFR | 18 |
| SCIPERFR | 13 |
| SCISOCFR | 16 |
| SCIWRKFR | - |

n.b. the decimal points are omitted here.

With the high relationship between attitude and the other characteristics from the teacher assessment on factor one the other characteristics produce a similar pattern. Thus if each characteristic is taken in isolation, there is displayed some degree of correspondence between teacher and pupil assessments; of particular interest here is how the teacher's assessment of pupil attitude has the highest relation with the pupil's expression of enjoyment of science on the Likert questionnaire (COMSCIL3). However the prime point is that the internal relationships between the characteristics of the teacher assessment instrument override, in magnitude, the relationships with other variables in the factor analysis.

The next four factors (factors 2, 3, 4 and 5 table 8.5.2.) present a similar picture to the analyses of the combined pupil instruments is section three (see table 8.3.9.) This would be expected and detailed analyses of these factors is not considered here.

The final factor contains reference to two variables, (see factor 6, table 8.5.2.) The highest loading variable is the personality assessment from the pupil rating schedule. This has frequently appeared on a factor separate from the other P.R.S. assessments but usually with some interelation which is absent here. The other variable loading on this factor relates to a Likert scale of difficulty with science. As this is a negative loading it is tempting to infer that the more extrovert pupils are the higher the lowest level of difficulty they are willing to subscribe too. With the difficulty concept being spread across a number of factors and with it being a weak scale overall, it is however unwise to draw any conclusions from this apparent association.

Finally a weak association is noted on factor two between the teacher assessed characteristic of personality and a factor which generally reflects the pupils personal attitudes and interests. Again it is tempting to contemplate that the more extrovert the pupil the more noticeable that particular pupil's display of attitude or interest in the subject would be. However the size of the loading mitigates in any serious considerations of this.

Overall the lack of a strong degree of association on the same factor for teacher and pupil assessments must lead to the conclusion that the two forms of assessment are not providing a complete common measure. Whilst a level of correlation appears to exist between the teacher assessment and the pupil's self report it would be unwise to credit this association with anymore than a general indication, by the teacher, of the pupil's attitudinal state.

Table 8.5.2. Pupil Rating Schedules and Derived Construct Scales

(Oblique Rotation to Kaiser's Criterion)

Total Variance = 81.3%)

| INSTRUMENT | SCALE | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| LIKERT | COMMSCIL3 | | 74 | | | | |
| | SCIOCPL3 | | 76 | | | | |
| | SCIINTL3 | | 96 | | | | |
| | SCIENTL3 | | | 77 | | | |
| | SCIDIFL3 | | 39 | -30 | 34 | 50 | -55 |
| | SCIVALL3 | | | 42 | | 49 | |
| | SCIDANL3 | | | | | 51 | |
| SEMANTIC | SCIOCSD2 | | 48 | | -59 | | |
| DIFFERENTIAL | SCIINSD2 | | 37 | 35 | -50 | | |
| | SCIDIFSD2 | | 59 | -42 | | | |
| | SCITSSD2 | | | 82 | | | |
| | VALUESD2 | | | | -46 | | |
| | DANGERSD2 | | | | -87 | | |
| FREE | INTFR | | 78 | | | | |
| RESPONSE | SCIPERFR | | | 52 | 46 | | |
| | SCISOCFR | | | | | 60 | |
| | SCIWRKFR | | | | | 72 | |
| PUPIL | ATTITUDE | 99 | | | | | |
| RATING | PERSAPPL | 96 | | | | | |
| SCHEDULE | CLASBEH | 89 | | | | | |
| | INTEREST | 98 | | | | | |
| | ABILITY | 94 | | | | | |
| | PERSON | | 30 | | | | 87 |

# CHAPTER NINE CONCLUSIONS

In drawing conclusions the areas of concern highlighted in the first introductory chapter are considered once again in the light of the findings detailed in this research study.

The first major concern related to the divergence of views and opinions that seemed to exist over the nature of attitudes in the context of science education. In the second chapter a wide range of attitude constructs were identified as being operational in measurement instruments employed to ascertain attitudes towards science. The majority of the instruments considered used a number of constructs relating to attitude and frequently failed to specify the particular nature of the constructs the instruments were designed to measure. As any measurement instrument should have a clear construct base if it is to be of any real value, both in ascertaining a measure of attitude and in comparing this measure with other variables, this approach was soundly criticised. The review also identified difficulties which appeared even in instruments which purported to have a sound construct base. Through an initial examination of the items on identified scales it was found that even providing a theoretical base for an attitude construct did not ensure that operationally the items reflected this construct. In the light of these problems the conceptual, item based analysis of attitude measurement instruments was undertaken in chapter three.
This analysis identified clearly ten attitude related domains which reflected the majority of the constructs employed, either directly or indirectly on the measurement instruments. These were as follows:

1. Commitment and Enjoyment of Science
2. Scientific Occupations
3. Scientific Interests and Pastimes
4. Characteristics of the Scientist
5. Difficulties with Science as a School Subject
6. Science and Society

7. Science and the Individual
8. The Scientific Method
9. Scientific Theories and Laws
10. The Aims of Science

A full specification of these dimensions is to be found in table 3.2. . This type of analysis is in itself an important contribution into the field of attitude measurement in the science context. Initially it seems to highlight the range of constructs that have been employed, on particular instruments, to ascertain measures of an attitude to science. Virtually every instrument considered employed a different range of constructs and each construct was often only represented by a few items. A particular instrument therefore reflected a particular perception of attitudes to science. Although certain constructs were common to many instruments the relative importance of the construct, as indicated by the number of items representing it, could vary from instrument to instrument. This must seriously question the results from comparative studies with such instruments. What confidence can be placed in a review of studies which show a relationship between various measurements of attitude to science and a common variable, such as intelligence, if the different measures of attitude to science reflect somewhat different measurement constructs?

The research work undertaken to assess pupil's attitudes to science has involved the use of a number of different measuring techniques. The second major concern of the study was to examine the suitability of available measuring techniques. These were examined with the operational constructs identified from the attitude questionnaire analysis in mind. Initially a review of the types of measurement instrument was undertaken as part of the literature review in chapter two. A more critical consideration of the suitability of the various techniques was undertaken in chapter four. The results of this prescribed a number of techniques for further investigation, these were as follows:

Fixed Response Techniques:

(a) Likert Questionnaire

(b) Semantic Differential Questionnaire

(c) A combined Forced-Choice and Free Response Questionnaire

(d) A structured - Situation Type Questionnaire

Open Response Techniques

A Situation Type Questionnaire

These particular questionnaires represented the breadth of possible measurement techniques available. The details of their construction was considered in chapter five.

The measurement of pupils attitudes to science has been largely undertaken through the use of pupil self report techniques. A concern of this study was to broaden the range of measurement techniques available to incorporate a teacher based assessment. The development and construction of this instrument, the Pupil Rating Schedule, was considered in chapter six. This development produced a view of teacher assessment which centred around three main areas. These are:-

(1) the pupil's academic ability or capability;

(2) the pupil's performance or actual achievement and

(3) the pupil's personality

These areas represented the underlying dimensions from an analysis of twenty one assessment characteristics which were elicited using a repertory grid technique. A selection of six of these characteristics were used in the major field study to ascertain the relationships between pupils self report techniques and teacher assessment. This instrument represents an important departure from traditional assessment methods. The detailed specification of the areas of teacher assessment form a particularly important addition to the knowledge at present available. The complete or restricted rating schedules are well researched instruments which could see application in a number of fields where a distinct pupil rating was required.

The development and construction of the range of measurement techniques detailed so far was to facilitate an extensive comparison of attitude constructs and attitude measurement techniques. The numbers prescribed to enable the various questionnaires to undergo reliability and validity examinations, as well as provide sufficient comparative data, resulted in a test population of nearly 1200 pupils. These were drawn from the second year of secondary schools in the Staffordshire area. The specific details of the sample were considered in chapter seven.

The analysis of these questionnaires presented in chapter eight addressed itself to certain particular issues. It was important at the outset to carefully note that the relationship between the reliability and validity of the operational constructs used should be regarded as a function of the instrument itself as well as the construct used. The response of a pupil to a questionnaire is dependent upon not only the particular item, and it's associated underlying construct, but also on the nature of the questionnaire or measuring instrument used to prompt the response. The analysis therefore not only examined the individual questionnaires for their reliability and validity, as would normally be expected, but also examined the relationship between similar constructs appearing on different techniques. The use of this comparative analysis was to answer the question as to whether with the numerous instruments available to assess attitudes were in fact assessing common constructs.

Each particular questionnaire initially underwent an individual examination. Here it's capability to assess the critical attitude constructs, prescribed by the earlier conceptual analysis of the attitude measurement instruments, was assessed. The analysis of these questionnaires followed a distinct strategy carefully detailed in the introduction to chapter This is an important prescription. Future studies in this field may find it particularly useful to help clarify the aims and objectives of the vast variety of statistical procedures that are now available. This is especially so in the light of modern computer based data processing.

The performance of each questionnaire has been considered in detail in chapter eight certain important overall points which have emerged are now considered.

In the separate analyses of the Likert, Semantic Differential and Free Response questionnaires each analysis indicated certain constructs which appeared to have both face and operational validity. These constructs are seen to represent four areas:

(a) personal attitudes and interests in science, science hobbies and scientific careers;

(b) the personal characteristics of a scientist;

(c) difficulties associated with science and

(d) the social implications of science.

Within each of the questionnaires certain of these areas are represented better than others. It is fair to conclude that the areas, (a), (b) and (d) however are common areas of assessment to all of the questionnaires. Conspicuous by their absence from these areas are the constructs which initially related to the aims of science, the scientific method and scientific theories and laws. Of the two questionnaires which attempted their measurement, Likert and Free Response, neither produced supportive evidence of their clear, independent presence in the pupil's perceptions. It has been noted that this may be because they reflect knowledge based areas of which the pupils may have a poor understanding. Essentially these areas are seen to represent a primarily cognitive aspect of the attitude domain. It was appreciated after the initial conceptual analysis of the attitude questionnaires that the dimensions identified could be subdivided into two groups which reflected the affective and cognitive areas of the attitude domain. In terms of the areas identified as representing the cognitive domain the areas concerned with the nature and functioning of science, (the scientific method, scientific theories and laws and the aims of science), certainly belonged to this cognitive area.

It is also the case that the constructs relating to the areas identified in the groups above, (b) and (d) could be part of this domain as well. In their case there obviously existed some level of understanding to allow response in these areas. Overall it was important that all of the attitude constructs identified from the conceptual analysis were examined. The non appearance following detailed analyses of the questionnaires of the aspects concerning the nature and functioning of science establishes that they are difficult areas to assess and reasoning that this is because of their largely difficult cognitive nature is acceptable. Their presence on future attitude instruments should be considered with extreme caution.

In the combined analysis of the fixed response questionnaires a number of important points emerged. Initially a comparison was undertaken which used the initial constructs defined from the attitude dimensions. Whether these were arranged as single scales or combined to make tetrad groups of four construct areas the questionnaire technique seemed to be as important in determining the response pattern as the nature of the constructs themselves. The pattern from the analysis of the fixed response questionnaires indicated that for all constructs, other than those connected with the personal domain, that the overall response pattern was particular to the technique employed. Thus with different questionnaires, based upon theoretical constructs, it is possible to obtain different measurements. The theoretical constructs relating to the personal domain were the only exception. In their case the different questionnaires seemed to produce a more consistent assessment with each other.

The analysis of the derived construct scales produced a much more useful overall conclusion. Here the constructs used possessed both reliability and validity as a result of the item analyses of the response to each separate questionnaire. A comparative analysis of the responses to these scales indicated three underlying areas of pupil perception.

These were as follows:

(a) A personal attitude towards science and interest in science related hobbies and scientific careers.

(b) A perception of the personal characteristics of the scientist.

(c) A perception of the implication of the work of science on society.

The responses to the constructs representing each of these areas on all the questionnaires considered displayed some degree of commonality. The presence of clearly defined and validated scales of measurement tends to overcome the effects due to the particular nature of the questionnaire. Such that there are common assessments of identical constructs. This is particularly true of the Likert and Free Responses questionnaires. There is an area of doubt still concerning the Semantic Differential questionnaire. Despite the construct scales following the pattern just indicated there is still a degree of internal relationship between its own construct scales which is greater than the relationship between identical constructs on different questionnaires.

Of the two questionnaires, Likert and Free Response both demonstrate that they can assess the three main areas. The Free Response questionnaire provides a greater degree of discrimination it seems between the areas but the Likert questionnaire provides a far better representation of the three areas overall in terms of the number of scales available. It is encouraging to see that the most popular of the attitude assessment techniques does overall provide the most appropriate questionnaire on this occasion. Undoubtedly the Free Response questionnaire is capable of further development and may provide a further alternative in future use.

The development of the Free Response questionnaire was carried out in conjunction with a similar Forced Choice instrument. This has produced a number of points which could be important for future work.

Due to the ipsative nature of the forced choice scores only a limited amount of statistical analysis was possible. Overall this indicated that the two techniques taken together were not producing vastly different results. This appeared to be the case when considering either prescribed constructs or derived constructs extracted from further analysis of the Free Response questionnaire. In future the use of a Forced Choice questionnaire may make a useful addition to the range of measurement techniques. It could be particularly useful in assessing specific aspects of the constructs already identified. In assessing the strengths of different aspects of the personal domain perhaps what is more important however has been the effect of the forced choice format upon the response pattern of the Free Response questionnaire. In all the comparative analyses performed this technique has displayed the most noticeable evidence of discrimination between the constructs employed. Following a forced choice format of arranging the items in groups of four representing four different constructs and making each of the items statements non controversial, the Free Response questionnaire has taken on some of the characteristics normally associated with the forced choice technique alone. Even with a free vote the questionnaire responses after analysis indicate a fairly clear separation between the constructs assessed. The Free Response questionnaire has certain potential for development in the light of the initial results from it's use in this study.

The Open Response Situations Type questionnaire produced initial information, in the form of words, phrases and sentences, distinctly different in nature from the other questionnaires. The development of an assessment procedure for this type of questionnaire response was an important step in establishing that pupils open responses could be quantified and analysed to provide important information. In this study the analysis of the frequency of pupil responses in certain areas confirmed to a large extent the importance of the underlying attitudinal domains arrived at through an analysis of the fixed response questionnaires.

This type of information was all that was initially looked for on this questionnaire. The extent to which these areas are referred to by the pupil on the open response format now adds further to the view that these areas are the fields of assessment that will produce reliable, future assessments. The technique will also be valuable in providing additional items for further questionnaires as past use has shown. In its own right it can be used to provide a global assessment of the overall pupil responses. The main response category is coded, usually on a five point scale, to provide such an assessment. The responses could then be analysed using statistical procedures to establish further relationships. The extent to which this measurement technique could be used in providing further, improved assessments of pupil's attitudes is obviously also an area for further work.

A structural form of this situation type questionnaire was also used in the main study. The important point to emerge from the analysis of the item responses was that the questionnaire produced an assessment of similar underlying nature to the main, large item questionnaires. In a comparative analysis with these questionnaires the personal aspects, from this questionnaire related to the underlying factor which comprised the personal aspects of all the main fixed response questionnaires. The main advantage of the questionnaire was that it was easy to administer. It seems to produce clear assessments and may again be worthy of further work.

The Pupil Rating Schedule formed an integral part of the comparative analysis of different assessment techniques. The restricted number of characteristics used reflected the major aspects of teacher assessment and particularly of science attitude and interest. It appears that the underlying factor which corresponds to the pupil's own perception of their attitude and interests does not correspond well with the underlying assessment of the pupil by the teacher on these characteristics. The teacher based assessments overall tend to be of a similar nature in that there is a considerable degree of associated judgement from one characteristic to the next. In this study for the majority of teachers assessments no external relationships with the pupil assessments are greater than these internal associations. Essentially this means that the use of teacher based assessments in this area will not provide a suitable accurate measure of pupil attitude or interest.

The research work presented here has proceded to analyse the nature of attitude assessment, with respect to science and to compare the performance of certain different techniques of attitude assessment. Through an extensive empirical study it has been possible to establish certain clear constructs of attitude assessment which have reliability and validity across a range of attitude assessment techniques. The comparison of the capabilities of the different techniques has indicated that the Likert questionnaire presents the most suitable technique to assess the range of attitude constructs identified. The introduction in this thesis of certain approaches to measurement and the analysis of attitude test instruments are strongly recommended for future work undertaken in this area. Finally the further development of techniques such as the Free Response and the Situation Type questionnaires are to be recommended as potentially useful attitude assessment techniques.

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# COMPARATIVE EVALUATION OF DIFFERENT METHODS FOR THE ASSESSMENT OF ATTITUDES TO SCIENCE

## APPENDIX

The appendix contains copies of the following assessment instruments

1. Likert Questionnaire (A Science Survey)
2. Semantic Differential Questionnaire (A Science Survey)
3. Forced Choice Questionnaire (A Science Survey)
4. Free Response Questionnaire (A Science Survey)
5. Situations Type - Structured Response Questionnaire (Reactions to Science Situations)
6. Situations Type - Open Response Questionnaire (Reactions to Science Situations)
7. Pupil Rating Schedule - FORMAT A
8. Pupil Rating Schedule - FORMAT B

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University of Keele

Department of Education

## A SCIENCE SURVEY

Please complete the following :

Your Name _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Class or Form _ _ _ _ _ _ _ _

This is a survey which is designed to find out how you feel about science. This is not a test and so there are no right or wrong answers.

The survey contains a number of statements and you are asked to indicate how much you agree or disagree with each of the statements. You record your opinion by drawing a circle around the symbol next to the statement which most closely reflects your own feelings.

EXAMPLE

99. Learning about scientific discoveries is interesting. AA A N D DD

Draw a circle around AA if you completely agree with the statement
A if you mildly or partly agree
N if you are undecided or neutral about the issue
D if you mildly or partly disagree
DD if you totally disagree with the statement.

A person who would find learning about scientific discoveries totally uninteresting would mark this statement

AA A N D (DD)

Another person who is only slightly interested in learning about scientific discoveries would mark this statement

AA (A) N D DD.

NOTE : Read each statement carefully, then draw a circle around the symbol which most closely reflects your feelings, using a pencil.

If you should change your mind about an answer you have already marked, use a rubber to erase the first answer.

Do not spend too much time thinking about your answers. Always try to give the answer which comes naturally first to your mind.

It is important that you should give an answer to every statement.

This will not be shown to anybody else.

Key: AA - complete agreement
A - mild or partial agreement
N - undecided or neutral
D - mild or partial disagreement
DD - total disagreement

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | The world is a better place to live in with science. | AA | A | N | D | DD |
| 2. | Scientific theories and laws help us predict the future. | AA | A | N | D | DD |
| 3. | Laws and theories in science can be changed if new facts emerge. | AA | A | N | D | DD |
| 4. | A scientist just guesses at the reasons behind why things happen in the world.. | AA | A | N | D | DD |
| 5. | Too much work is crammed into too little time in science lessons at school. | AA | A | N | D | DD |
| 6. | Scientists often use their imagination to think up new ideas. | AA | A | N | D | DD |
| 7. | I enjoy science as a hobby at home. | AA | A | N | D | DD |
| 8. | The government should aid science by giving more scientists jobs and building more labs. | AA | A | N | D | DD |
| 9. | When putting forward new theories scientists throw the old ones away. | AA | A | N | D | DD |
| 10. | I think science is interesting. | AA | A | N | D | DD |
| 11. | Leisure toys such as the T.V. and radio have been provided for us by science. | AA | A | N | D | DD |
| 12. | Scientists are dedicated to their work. | AA | A | N | D | DD |
| 13. | I find it hard to see what the results from our science practical work means. | AA | A | N | D | DD |
| 14. | Scientists often work together on problems and share their their information. | AA | A | N | D | DD |
| 15. | A scientist obtains most of his information through reading and not experimenting. | AA | A | N | D | DD |
| 16. | When scientists carry out experiments they only need to consider one set of results. | AA | A | N | D | DD |
| 17. | I would help form a science hobbies club after school. | AA | A | N | D | DD |
| 18. | Science aims to serve mankind. | AA | A | N | D | DD |
| 19. | The importance of science is not in the ideas but what the ideas can be used for. | AA | A | N | D | DD |
| 20. | I do not find it hard to understand the ideas we are taught in science lessons. | AA | A | N | D | DD |

Key: AA - complete agreement
A - mild or partial agreement
N - undecided or neutral
D - mild or partial disagreement
DD - total disagreement

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

| | | | | | | |
|---|---|---|---|---|---|---|
| 21. | A scientist works in a well planned orderly way. | AA | A | N | D | DD |
| 22. | Science is for dreaming up new ideas. | AA | A | N | D | DD |
| 23. | Scientists should check and recheck all the results of their experiments. | AA | A | N | D | DD |
| 24. | I am always glad when school science lessons are over. | AA | A | N | D | DD |
| 25. | Scientific ideas are based on observations. | AA | A | N | D | DD |
| 26. | There is too much noise in our everyday lives because of science. | AA | A | N | D | DD |
| 27. | Science is fascinating. | AA | A | N | D | DD |
| 28. | When at home scientists lead a happy family life. | AA | A | N | D | DD |
| 29. | We should all be involved in science in this day and age. | AA | A | N | D | DD |
| 30. | Scientific discoveries are worthwhile even if they have no practical use at all. | AA | A | N | D | DD |
| 31. | There is just too much science to learn in school time. | AA | A | N | D | DD |
| 32. | Scientific theories and laws are fixed for all time. | AA | A | N | D | DD |
| 33. | A scientist should report exactly what he sees even if it does not seem right to him at the time. | AA | A | N | D | DD |
| 34. | I look forward to doing science experiments in science lessons. | AA | A | N | D | DD |
| 35. | A useful thing about theories and laws in science is that they help tell us what might happen next. | AA | A | N | D | DD |
| 36. | I should like to experiment with breeding fish to see how different kinds are produced. | AA | A | N | D | DD |
| 37. | As a scientist, I know that my experiments will always give me the right answers. | AA | A | N | D | DD |
| 38. | The results of the practical work in science really help you to understand science. | AA | A | N | D | DD |
| 39. | Money spent on scientific projects is wasted. | AA | A | N | D | DD |
| 40. | A scientific job is the job for me when I leave school. | AA | A | N | D | DD |

Key: AA - complete agreement
A - mild or partial agreement
N - undecided or neutral
D - mild or partial disagreement
DD - total disagreement

---

| | | | | | | |
|---|---|---|---|---|---|---|
| 41. | Ideas are the important products of science. | AA | A | N | D | DD |
| 42. | Science has given us the ability to talk and see people all over the world. | AA | A | N | D | DD |
| 43. | Science does more harm than good in society. | AA | A | N | D | DD |
| 44. | There is too much practical work in the job of a scientist to interest me. | AA | A | N | D | DD |
| 45. | Science provides energy for our needs. | AA | A | N | D | DD |
| 46. | Scientists are really boring people. | AA | A | N | D | DD |
| 47. | Science is about explaining and describing how things happen in the world. | AA | A | N | D | DD |
| 48. | Even if a theory has been put forward by a great scientist it may be proved wrong by an unknown scientist. | AA | A | N | D | DD |
| 49. | Finding a use for a newly discovered substance is more important than finding out what it is made of. | AA | A | N | D | DD |
| 50. | I would have to stay at school too long to become a scientist. | AA | A | N | D | DD |
| 51. | Even though a scientific law has been stated this does not mean that it may never need changing. | AA | A | N | D | DD |
| 52. | One has to be very intelligent to become a scientist. | AA | A | N | D | DD |
| 53. | If I was helping with the school play I would like to help with wiring the lighting. | AA | A | N | D | DD |
| 54. | I am interested about learning science at home. | AA | A | N | D | DD |
| 55. | Science discoveries that do not have a practical use are a waste of time. | AA | A | N | D | DD |
| 56. | Science has provided many helpful devices at home to make our lives easier. | AA | A | N | D | DD |
| 57. | I would rather do any subject than science at school. | AA | A | N | D | DD |
| 58. | Science creates more problems than it solves in society. | AA | A | N | D | DD |
| 59. | In general I do not like science. | AA | A | N | D | DD |
| 60. | Scientists are scatterbrained. | AA | A | N | D | DD |

Key : AA - complete agreement
A - mild or partial agreement
N - undecided or neutral
D - mild or partial disagreement
DD - total disagreement

| | | | | | |
|---|---|---|---|---|---|
| 1. I would like to work in a science laboratory. | AA | A | N | D | DD |
| 2. A scientist is willing for others to try out his theories. | AA | A | N | D | DD |
| 3. Everybody needs to learn and understand science today. | AA | A | N | D | DD |
| 4. I would rather be a scientist than a newspaper reporter. | AA | A | N | D | DD |
| 5. Science is valuable because it helps solve practical problems. | AA | A | N | D | DD |
| 6. Science has provided many labour saving devices for industry. | AA | A | N | D | DD |
| 7. Science is my favourite subject at school. | AA | A | N | D | DD |
| 8. Scientific theories and laws do not tell us anything new. | AA | A | N | D | DD |
| 9. I can travel all over the place easily thanks to science. | AA | A | N | D | DD |
| 10. Working in an office would be better for me than working in a laboratory. | AA | A | N | D | DD |
| 11. Science helps mankind. | AA | A | N | D | DD |
| 12. Explaining the way of nature is more important than finding out how to use nature. | AA | A | N | D | DD |
| 13. I would not like to become a science teacher. | AA | A | N | D | DD |
| 14. If someone gave me some money I would like to buy a chemistry set to do all sorts of experiments at home. | AA | A | N | D | DD |
| 15. Science has provided medicines to keep us healthy. | AA | A | N | D | DD |
| 16. The theories and laws of science today are stepping stones for the future. | AA | A | N | D | DD |
| 17. If I could only see what all the special words and and names meant in science it would be easy to do. | AA | A | N | D | DD |
| 18. When trying to answer a difficult problem a scientist will keep on trying until it is solved. | AA | A | N | D | DD |
| 19. There is too much hard work involved in becoming a scientist. | AA | A | N | D | DD |
| 20. Science produces too many dangerous weapons which could destroy mankind. | AA | A | N | D | DD |

Key : AA - complete agreement
A - mild or partial agreement
N - undecided or neutral
D - mild or partial disagreement
DD - total disagreement

| | | | | | |
|---|---|---|---|---|---|
| 21. One has to be good at maths to do well at science in school. | AA | A | N | D | DD |
| 22. I would not be happy just being taught science without the practical work. | AA | A | N | D | DD |
| 23. I am no good at science because I cannot set science experiments up right. | AA | A | N | D | DD |
| 24. Scientists should be paid as much as 'pop stars'. | AA | A | N | D | DD |
| 25. Science should be left to scientists as it does not concern me. | AA | A | N | D | DD |
| 26. I enjoy school science lessons. | AA | A | N | D | DD |
| 27. A scientist will consider all the different ways of explaining a discovery before choosing the best one to use. | AA | A | N | D | DD |
| 28. Science is just for dreaming up new ideas. | AA | A | N | D | DD |
| 29. New theories and laws in science are based on the old ones. | AA | A | N | D | DD |
| 30. I would like to build my own radio. | AA | A | N | D | DD |
| 31. When with other people scientists tend to be shy and withdrawn. | AA | A | N | D | DD |
| 32. It would be fun to visit a science museum. | AA | A | N | D | DD |
| 33. The main aim of science today is to develop new products for man. | AA | A | N | D | DD |
| 34. Being a scientist is the last job I would like. | AA | A | N | D | DD |
| 35. Scientific theories and laws only tell us what we know already. | AA | A | N | D | DD |
| 36. I take books on science subjects out of the library. | AA | A | N | D | DD |
| 37. Scientific theories and laws are true beyond any doubt. | AA | A | N | D | DD |
| 38. The scientific method is based on careful observation. | AA | A | N | D | DD |
| 39. One needs to learn science 'off by heart' as it is difficult to understand. | AA | A | N | D | DD |
| 40. The clean and peaceful countryside has been spoilt for us by science. | AA | A | N | D | DD |

Key : AA - complete agreement
A - mild or partial agreement
N - undecided or neutral
D - mild or partial disagreement
DD - total disagreement

| | | | | | | |
|---|---|---|---|---|---|---|
| 41. | Science lessons contain to many special words that I find hard to understand. | AA | A | N | D | DD |
| 42. | I would rather read a book than do experiments in the science lessons. | AA | A | N | D | DD |
| 43. | Science programes on T.V. like ' Tomorrow's World ' are great to watch. | AA | A | N | D | DD |
| 44. | I would rather join the policeforce than become a scientist. | AA | A | N | D | DD |
| 45. | Scientists tell the truth about their work. | AA | A | N | D | DD |
| 46. | Science is not worth bothering about. | AA | A | N | D | DD |
| 47. | If a famous scientist and an unknown scientist disagree we accept the opinion of the famous scientist. | AA | A | N | D | DD |
| 48. | I would not like to become an engineer when I leave school. | AA | A | N | D | DD |
| 49. | Practical work in science lessons is easy to do. | AA | A | N | D | DD |
| 50. | I like listening to science talks on the radio. | AA | A | N | D | DD |
| 51. | Scientists should not criticise each other's work. | AA | A | N | D | DD |
| 52. | I would join a school science club. | AA | A | N | D | DD |
| 53. | We all need to learn science to survive in this day and age. | AA | A | N | D | DD |
| 54. | Thanks to science our houses are very comfortable compared with years ago. | AA | A | N | D | DD |
| 55. | A scientific theory or law can just be set up without bothering about what went before. | AA | A | N | D | DD |
| 56. | Science lessons in which we do experiments are boring. | AA | A | N | D | DD |
| 57. | I should like to become a scientist when I leave school. | AA | A | N | D | DD |
| 58. | It is all the maths in science lessons that makes them so hard. | AA | A | N | D | DD |
| 59. | The money spent on science could be better spent elsewhere. | AA | A | N | D | DD |
| 60. | Science has provided us with plenty of food to eat. | AA | A | N | D | DD |

University of Keele

Department of Education

# A SCIENCE SURVEY

Please complete  Your Name _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _  Your Form _ _ _ _ _ _ _ _ _ _ _ _

This is asurvey designed to find out how you feel about different subjects related to science and to science learning.

The survey consists of a number of items. Each item is made up of an expression and a rating scale. The rating scale is made up of descriptive, opposite word pairs or phrases between which there is a seven-point scale

You are asked to indicate how you feel about the expression by placing a cross (X) on the rating scale at the position which most closely reflects your own feelings.

**EXAMPLE**

Suppose you are indicating how you feel about 'Scientific Experiments' on a rating scale 'difficult - easy'. A cross (X) in each position shown below is briefly explained on the right-hand side:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| difficult | X | | | | | | | easy | means VERY difficult |
| | | | | | | | X | | " VERY easy |
| | | X | | | | | | | " QUITE difficult |
| | | | | | | X | | | " QUITE easy |
| | | | X | | | | | | " SLIGHTLY difficult |
| | | | | | X | | | | " SLIGHTLY easy |
| | | | | X | | | | | " NEUTRAL |

**NOTE:** Read each item carefully. Then place your cross in the position on the rating scale which most closely reflects your own feelings.

Work QUICKLY, giving your immediate and truthful response. It is important that you should give an answer to every item.

<u>Your answers will not be shown to anybody else in your school</u>.

| | | | |
|---|---|---|---|
| Science in our society | useful | __:__:__:__:__:__ | useless |
| Practical work in science | helps my understanding of science | __:__:__:__:__:__ | does not help my understanding of science |
| Scientists in their work | easily diverted | __:__:__:__:__:__ | persevering |
| Building a radio | boring | __:__:__:__:__:__ | interesting |
| Science in our society | destructive | __:__:__:__:__:__ | constructive |
| Science in our world | dull | __:__:__:__:__:__ | exciting |
| Science in relation to my health | helpful | __:__:__:__:__:__ | harmful |
| Scientists | boring | __:__:__:__:__:__ | interesting |
| Practical work in science | confused | __:__:__:__:__:__ | clear |
| A scientist's family life | unhappy | __:__:__:__:__:__ | happy |
| Taking up a scientific hobby | stimulating | __:__:__:__:__:__ | dull |
| Scientific ideas | easy | __:__:__:__:__:__ | hard |
| Scientists in their work | organised | __:__:__:__:__:__ | disorganised |
| Science lessons | enjoyable | __:__:__:__:__:__ | not enjoyable |
| Science in relation to me | dangerous | __:__:__:__:__:__ | safe |
| Science in our world | interesting | __:__:__:__:__:__ | boring |
| Scientists | unimaginative | __:__:__:__:__:__ | imaginative |
| Learning about science | unimportant | __:__:__:__:__:__ | important |
| Practical work in science | straightforward | __:__:__:__:__:__ | difficult |
| A visit to a science museum | pleasant | __:__:__:__:__:__ | unpleasant |
| Practical work in science | dull | __:__:__:__:__:__ | exciting |

| | | | |
|---|---|---|---|
| Science in our society | worthless | __:__:__:__:__:__ | valuable |
| Science lessons | interesting | __:__:__:__:__:__ | boring |
| Science in relation to me | helpful | __:__:__:__:__:__ | harmful |
| Becoming a scientist | difficult | __:__:__:__:__:__ | straightforward |
| Science in our society | unimportant | __:__:__:__:__:__ | important |
| Scientific work | enjoyable | __:__:__:__:__:__ | not enjoyable |
| Running a science club | tedious | __:__:__:__:__:__ | exciting |
| Science in relation to me | worthless | __:__:__:__:__:__ | valuable |
| Scientific terms and names | difficult | __:__:__:__:__:__ | simple |
| Scientists in their work | unco-operative | __:__:__:__:__:__ | co-operative |
| Working in a science laboratory | tedious | __:__:__:__:__:__ | stimulating |
| Science in our society | safe | __:__:__:__:__:__ | dangerous |
| Science lessons involving maths | simple | __:__:__:__:__:__ | hard |
| Practical work in science | tedious | __:__:__:__:__:__ | stimulating |
| The amount of work in science lessons | too much | __:__:__:__:__:__ | too little |
| Money spent on science | well spent | __:__:__:__:__:__ | wasted |
| Science in my home | useless | __:__:__:__:__:__ | useful |
| Science lessons | unpleasant | __:__:__:__:__:__ | pleasant |
| Scientists in their work | open-minded | __:__:__:__:__:__ | narrow-minded |
| Watching programmes on science on television | exciting | __:__:__:__:__:__ | dull |
| Scientists | honest | __:__:__:__:__:__ | dishonest |
| Studying the stars and planets | enjoyable | __:__:__:__:__:__ | not enjoyable |

| | | | |
|---|---|---|---|
| A job as a scientist | exciting | __:__:__:__:__:__ | dull |
| Collecting fossils and rocks | boring | __:__:__:__:__:__ | interesting |
| Scientific ideas | complex | __:__:__:__:__:__ | simple |
| Science in relation to me | comforting | __:__:__:__:__:__ | threatening |
| Scientific terms and names | easy | __:__:__:__:__:__ | hard |
| Practical work in science | interesting | __:__:__:__:__:__ | boring |
| Collecting and studying plants | dull | __:__:__:__:__:__ | exciting |
| Becoming a scientist | complex | __:__:__:__:__:__ | simple |
| Scientists in their work | indifferent | __:__:__:__:__:__ | dedicated |
| Science in our world | stimulating | __:__:__:__:__:__ | monotonous |
| Ascientific career | monotonous | __:__:__:__:__:__ | stimulating |
| The pace of work in science lessons | rushed | __:__:__:__:__:__ | slow |
| Reading a science fiction book | entertaining | __:__:__:__:__:__ | dull |
| Studying the weather | stimulating | __:__:__:__:__:__ | monotonous |
| Learning about science | wise | __:__:__:__:__:__ | foolish |
| Science in relation to me | unimportant | __:__:__:__:__:__ | important |
| Practical work in science | not enjoyable | __:__:__:__:__:__ | enjoyable |
| A job as a scientist | boring | __:__:__:__:__:__ | interesting |
| Science lessons involving maths | difficult | __:__:__:__:__:__ | easy |
| Science in our society | chaotic | __:__:__:__:__:__ | orderly |
| Science in relation to me | productive | __:__:__:__:__:__ | wasteful |

| | | | |
|---|---|---|---|
| Practical work in science | difficult to perform | __:__:__:__:__:__:__ | easy to peform |
| Money spent on science | excessive | __:__:__:__:__:__:__ | too little |
| A scientific career | interesting | __:__:__:__:__:__:__ | boring |
| Science in our society | threatening | __:__:__:__:__:__:__ | comforting |
| Becoming a scientist | easy | __:__:__:__:__:__:__ | hard |
| Science in our society | harmful | __:__:__:__:__:__:__ | helpful |
| Scientists | sociable | __:__:__:__:__:__:__ | unsociable |
| Working as an engineer | interesting | __:__:__:__:__:__:__ | boring |
| Science in our society | productive | __:__:__:__:__:__:__ | wasteful |
| Scientists | clever | __:__:__:__:__:__:__ | dull |
| Working with a chemistry set | not enjoyable | __:__:__:__:__:__:__ | enjoyable |
| Taking science books out of the library | interesting | __:__:__:__:__:__:__ | boring |
| Science in relation to me | useless | __:__:__:__:__:__:__ | useful |
| Science lessons | stimulating | __:__:__:__:__:__:__ | monotonous |
| Science in our society | good | __:__:__:__:__:__:__ | bad |
| Science in our world | pleasant | __:__:__:__:__:__:__ | unpleasant |
| Scientists | scatterbrained | __:__:__:__:__:__:__ | thoughtful |
| Scientific work | boring | __:__:__:__:__:__:__ | exciting |
| Learning about science | useful | __:__:__:__:__:__:__ | useless |
| Scientific work | hard | __:__:__:__:__:__:__ | easy |

# University of Keele

## Department of Education

## A SCIENCE SURVEY

In the following you will find a number of items. Each item is made up of four statements. You are asked to give votes to each of these statements. For each item you are asked to give,

4 votes to the statement which you think is the most important,
3 votes to the statement which you think is next to most important,
2 votes to the next,
1 vote to the statement which you think is the least important.

So that the statements are placed in order of your personal choice.

You record your votes in the spaces provided on your answer sheet.

Please note the items are designed to find out your personal choice of the importance of the statements. There are NO right or wrong answers.

In assessing the importance of the statements all the statements are to be accepted as true.

EXAMPLE

99. (a) School science lessons are usually enjoyable.
    (b) Scientists are generally intelligent people.
    (c) Science itself cannot be blamed for pollution.
    (d) Scientific ideas must always be based on careful observation.

| | (a) | (b) | (c) | (d) |
|---|---|---|---|---|
| 99. | 2 | 3 | 4 | 1 |

A person who responded in this way would have decided that statement (c) was the most important, then statement (b), then (a) and that statement (d) was the least important.

NOTE: Read each item carefully.

Record your votes for each statement on your answer sheet in the order of their importance to you.

It is important that you give an answer to every item.

Your answers will not be shown to anyone else in your school.

1. (a) Science lessons contain many specialised words which can be difficult to understand.
   (b) Generally scientists are not shy and lonely individuals.
   (c) Money spent on scientific projects is usually money well spent.
   (d) Scientific theories and laws usually have to be changed as time goes by.

2. (a) Scientists usually find their work stimulating and challenging.
   (b) One cannot learn much school science in school time.
   (c) A scientific theory is only as good as are the observations on which it is based.
   (d) Science itself cannot be blamed for pollution.

3. (a) Our life is effected by the inventions of science.
   (b) Even if a famous scientist claims a theory is true, this does not mean that everyone will accept it.
   (c) Building a radio can be an interesting thing to do.
   (d) Scientists, like others, are concerned about the welfare of people.

4. (a) Laws and theories in science are changed if and when new facts emerge.
   (b) The government should aid science by financing research and building labs.
   (c) Scientists do not 'show-off' any more than other people.
   (d) Science programs on the T.V. are usually interesting to watch.

5. (a) One can learn much about science from library books.
   (b) Scientists are no less friendly and sociable than are other people.
   (c) The work of science in our society is usually worth rewarding.
   (d) Scientific ideas must always be based on careful observation.

6. (a) Scientists are usually serious people, dedicated to their work.
   (b) It could be enjoyable to own a chemistry set to do home experiments.
   (c) Theories and experiments suggested by one scientist are always checked by others before being accepted.
   (d) Because of the inventions of science, homes are now more comfortable than they used to be.

7. (a) Science itself cannot be blamed for changing the countryside.

(b) Most of the information a scientist obtains on the world is through experimentation.

(c) Collecting fossils and rocks can be an interesting hobby.

(d) Scientists live a normal life at home just like anyone else.

8. (a) It is always possible for an unknown scientist to prove the theories of a famous scientist wrong.

(b) Leisure toys such as the T.V. and radio have been provided for us by science.

(c) In their view of life scientists are generally broad minded.

(d) The experimental work in science lessons is usually interesting.

9. (a) Science is amongst the most popular subjects at school.

(b) Generally scientists are dedicated to their work.

(c) Some of the problems of society have been eased by the inventions of science.

(d) When events happen in the world science tries carefully to reason out why.

10. (a) In their approach to work scientists are usually thoughtful and precise.

(b) Compared to other school subjects, science is generally one of the most interesting.

(c) When a scientific law is stated it may need to be changed in the future.

(d) The inventions of science themselves cannot be blamed for societies problems.

11. (a) One can help solve some of the problems in our society by using the works of science.

(b) The basis of the scientific method is always careful observation.

(c) School science is usually interesting.

(d) To become a scientist one has to stay at school and college a long time.

12. (a) New theories and laws put forward in science include the old theories and laws.

(b) The problems of our society cannot just be put down to the presence of science.

(c) Scientists are no more absent minded than are other people.

(d) Some of the ideas we are taught in science lessons are difficult to understand.

13. (a) One usually needs to learn science 'off by heart' as it is difficult to understand.

(b) Just like other people scientists can be interesting to talk and listen to.

(c) Our lives have been made easier at home because of the inventions of science.

(d) New scientific theories and laws are based on the old versions of the theories and laws.

14. (a) The scientist is usually thoughtful about his actions.

(b) It can be important for everyone to learn about science today.

(c) Scientific theories and laws do not tell us just what we know already.

(d) The inventions of science have provided many labour saving devices for industry.

15. (a) The cause of the worlds troubles cannot just be put down to the work of science.

(b) Theories and laws in science today are forming stepping stones for the future.

(c) The school science lessons are usually worth looking forward to.

(d) All scientists, it seems, have to do well at school and college.

16. (a) We can use scientific theories and laws to predict future events.

(b) Although weapons are produced by science, it is not the aim of science to use these weapons to destroy man.

(c) Scientists are generally intelligent people.

(d) The science lessons are amongst the most enjoyable in the school.

17. (a) In general everyone needs to learn and understand science today.

(b) A scientist usually works out all possible ways to answer a problem before choosing the best.

(c) The presence of science in our society is generally beneficial.

(d) Scientific theories and laws may change with time.

18. (a) To become a scientist a lot of hard work at school and college is required.

(b) A science hobbies club could provide a good after school activity.

(c) The checking and rechecking of the results from experiments is important in the scientific method.

(d) Science can allow us to talk and see people all over the world.

19. (a) The inventions of science can be used to help mankind.
(b) The meaning of the results from experiments are always considered carefully in science.
(c) Experiments in science lessons are generally difficult to set up.
(d) A scientist tends to work in a well planned orderly way.

20. (a) When carrying out experiments in science a large number of results are always taken.
(b) The wasting of our natural resources cannot just be put down to the work of science.
(c) A scientist usually keeps an open mind when looking at a new problem.
(d) It is usual to find practical work in science difficult to do.

21. (a) It is the maths in science lessons that usually makes them so hard.
(b) Scientists may often work together and share their findings.
(c) The medicines which keep us healthy have been provided by science.
(d) Scientific theories and laws help us to predict the future.

22. (a) Scientists are just as creative as other people.
(b) Doing experimental work in science is usually enjoyable.
(c) As our knowledge of science grows our scientific theories and laws may change.
(d) In general the benefite of science to society are greater than any illeffects.

23. (a) It is noy just the fault of science that there is noise in our everyday lives.
(b) Everyone working in the field of science allows their work to be criticised by others.
(c) In general science is an important subject to learn in this day and age.
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24. (a) A useful thing about scientific theories and laws is that they may tell us what might happen next.
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University of Keele

Department of Education

## A SCIENCE SURVEY

In the following you will find a number of items. Each item is made up of four statements. You are asked to give votes to each of these statements. For each item you are asked to give

4 votes to the statements with which you agree very strongly

3 votes to the statements with which you partly agree

2 votes to the statements with which you agree least

1 vote to the statements with which you do not agree at all.

You can use 4,3,2 or 1 as often as you like in the voting.

You record your votes in the spaces provided on your answer sheet.

Please note the items are designed to find out your personal opinion. There are NO right or wrong answers.

EXAMPLE

99. (a) School science lessons are usually enjoyable.
    (b) Scientists are generally intelligent people.
    (c) Science itself cannot be blamed for pollution.
    (d) Scientific ideas must always be based on careful observation.

| | (a) | (b) | (c) | (d) |
|---|---|---|---|---|
| 99. | 3 | 4 | 3 | 1 |

A person who responded in this way would strongly agree with (b), partly agree with (a) and (c) and not agree at all with statement (d).

NOTE: Read each item carefully.

Record your votes for each statement on your answer sheet according to your own personal opinion.

It is important that you give an answer to every item.

**Your answers will not be shown to anyone else in your school.**

1. (a) Science lessons contain many specialised words which can be difficult to understand.
   (b) Generally scientists are not shy and lonely individuals.
   (c) Money spent on scientific projects is usually money well spent.
   (d) Scientific theories and laws usually have to be changed as time goes by.

2. (a) Scientists usually find their work stimulating and challenging.
   (b) One cannot learn much school science in school time.
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**University of Keele**

**Department of Education**

**A SCIENCE SURVEY ANSWER SHEET**

Please complete the following:

Your Full Name ________________ Your Form ________

| | (a) | (b) | (c) | (d) | | (a) | (b) | (c) | (d) |
|---|---|---|---|---|---|---|---|---|---|
| 1. | ____ | ____ | ____ | ____ | 13 | ____ | ____ | ____ | ____ |
| 2. | ____ | ____ | ____ | ____ | 14. | ____ | ____ | ____ | ____ |
| 3. | ____ | ____ | ____ | ____ | 15. | ____ | ____ | ____ | ____ |
| 4. | ____ | ____ | ____ | ____ | 16. | ____ | ____ | ____ | ____ |
| 5. | ____ | ____ | ____ | ____ | 17. | ____ | ____ | ____ | ____ |
| 6. | ____ | ____ | ____ | ____ | 18. | ____ | ____ | ____ | ____ |
| 7. | ____ | ____ | ____ | ____ | 19. | ____ | ____ | ____ | ____ |
| 8. | ____ | ____ | ____ | ____ | 20. | ____ | ____ | ____ | ____ |
| 9. | ____ | ____ | ____ | ____ | 21. | ____ | ____ | ____ | ____ |
| 10. | ____ | ____ | ____ | ____ | 22. | ____ | ____ | ____ | ____ |
| 11. | ____ | ____ | ____ | ____ | 23. | ____ | ____ | ____ | ____ |
| 12. | ____ | ____ | ____ | ____ | 24. | ____ | ____ | ____ | ____ |

University of Keele

Department of Education

# REACTIONS TO SCIENCE SITUATIONS

In the following, you will find a number of short stories, each describing a certain situation. The situations relate to science and to science learning.

We should like to have your reactions to each of these situations.

Read each short story and the question that follows the story carefully.

Choose from the list of statements the statement which most closely reflects your own feelings in answer to the question.

Record your choice on your answer sheet by drawing a circle around the letter of your choice for that question.

**EXAMPLE**

99. Keith and Jean were planning a day out during the holidays.
Keith said: "I would really like to visit the science museum, there are plenty of interesting things to see there!"
Jean replied: "Well, I don't want to go there. I would much rather visit the art gallery."

Question: If Keith and Jean asked you to choose where you wanted to go, would you

(a) Definitely visit the science museum, like Keith?

(b) Probably visit the science museum?

(c) Definitely visit the art gallery, like Jean?

(d) Probably visit the art gallery?

(e) Be undecided about where you would prefer to go?

A person who would definitely prefer to visit the science museum would record their choice by drawing a circle around choice 'a' on the answer sheet as follows:-

99. (a) b c d e

Another person who would probably prefer to visit the art gallery would respond as follows:-

99. a b c (d) e

Please note the items are designed to find out how you feel about the various situatons. There are NO right or wrong answers.

Your answers will not be shown to anybody else in your school.

University of Keele

Department of Education

## REACTIONS TO SCIENCE SITUATIONS

In the following, you will find a number of short stories, each describing a certain situation. The situations relate to science and to science learning.

We should like to have your reactions to each of these situations.

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EXAMPLE

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Question: If Keith and Jean asked you to choose where you wanted to go, would you

(a) Definitely visit the science museum, like Keith?

(b) Probably visit the science museum?

(c) Definitely visit the art gallery, like Jean?

(d) Probably visit the art gallery?

(e) Be undecided about where you would prefer to go?

A person who would definitely prefer to visit the science museum would record their choice by drawing a circle around choice 'a' on the answer sheet as follows:-

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Another person who would probably prefer to visit the art gallery would respond as follows:-

99. a b c (d) e

Please note the items are designed to find out how you feel about the various situatons. There are NO right or wrong answers.

Your answers will not be shown to anybody else in your school.

(1) Roger and Paul were on their way to their next lesson. "It's science next",said Paul. "I always enjoy science lessons." Roger replied: "That's allright for you, but I am always glad when science lessons are over. I don't enjoy them at all."

<u>Question</u>: If you were walking alongside Roger and Paul and they turned and asked you what you thought about science lessons, would you

(a) Strongly agree with Paul about science lessons?

(b) Mildly agree with Paul about science lessons?

(c) Strongly agree with Roger about science lessons?

(d) Mildly agree with Roger about science lessons?

(e) Neither agree or disagree with Roger or Paul?

(2) Going home on the school bus one day, Alan and Mike were discussing what school subjects they would do if they could pick for themselves. Alan said that science was his favourite subject and that he would choose to do science first out of all his subjects. Mike replied that he could not stand science and that there were lots of other subjects in school that he would put before science.

<u>Question</u>: If you could choose your school subjects, would you

(a) Be just like Alan and pick science as your favourite?

(b) Put science near the top of a list of your favourite subjects?

(c) Be just like Mike and pick another subject as your favourite?

(d) Put science near the bottom of a list of your favourite subjects?

(e) Not be bothered as all subjects are the same to you?

(3) Joy and Tracey had just sat down at their bench in the laboratory, when they heard the teacher say: "In this lesson we are going to do some practical work." Joy immediately turned to Tracey and said: "Great! I always like practical work; let's get started!" Tracey replied: "Well, I don't like doing practical work and I shall be glad when it's over."

<u>Question</u>: If you had been with Joy and Tracey, what would have been your view?

(a) I agree with Joy. I always like doing practical work in science lessons.

(b) I enjoy practical work in science lessons most of the time.

(c) I agree with Tracey. I don't like doing practical work in science lessons.

(d) I rarely enjoy doing practical work in science lessons.

(e) I have never really thought about whether or not I like practical work in science lessons.

(4) Brian had just arrived home from school one day when he overheard his brother, Mark, and his sister, Judith, talking.
Mark was saying how he was very interested in science and always enjoyed watching television programmes and reading newspaper reports on science.
Judith replied that she had no interest in science at all and always avoided anything to do with science on the television or in newspapers.
When they saw that Brian was listening they asked him what his view was.

Question: If you were Brian what would your view be?

(a) Like Mark. I am very interested in science.

(b) I am interested in science now and then.

(c) Like Judith, I am not interested in science at all.

(d) I am very rarely interested in science.

(e) I am undecided about whether I am interested in science or not.

(5) Bill was reading a book called "How to become a scientist".
John came up to him and said:"What are you reading that for?
You are not thinking of becoming a scientist when you leave school are you?"
Bill replied: "I certainly am. There are plenty of jobs which involve science that really interest me."
John responded by saying that he would never think of becoming a scientist, he was not interested at all.

Question: If you were discussing taking a scientific job on leaving school, with Bill and John, what would your view be?

(a) Like Bill. I would be very interested in taking a scientific job.

(b) I would be mildly interested in taking a scientific job.

(c) Like John. I would not be interested at all in taking a scientific job.

(d) I am not really interested in taking a scientific job.

(e) I am undecided about whether or not I would be interested in taking a scientific job.

(6) David was trying to make up his mind about what he would do when he left school. He was interested in science and so he asked his teacher about training to be a scientist. His teacher had told him that he would have to stay at school and work for a lot of exams before he could become a scientist.

Question: If you wanted to become a scientist, like David, how would what the teacher said affect you?

(a) It would not make any difference at all to my interest in becoming a scientist.

(b) I would probably still be interested in becoming a scientist.

(c) I would definitely give up any interest I had in becoming a scientist.

(d) I would probably not be interested in becoming a scientist.

(e) I am uncertain as to whether it would affect my interest or not.

(7) One afternoon Andrew was at home trying out an experiment with his science kit that he had been given as a Christmas present. Ralph, his friend, called to see him and, seeing what Andrew was doing, said: "I cannot understand why you are so interested in playing around with that science stuff. I can think of lots of things I would rather do in my spare time than take up science as a hobby."

Question: How do you feel about science as a hobby?

(a) Just like Andrew. I am very interested in scientific hobbies.

(b) I am sometimes interested in carrying out scientific hobbies.

(c) Just like Ralph. I am not interested at all in scientific hobbies.

(d) I am not usually interested in carrying out scientific hobbies.

(e) I am undecided or neutral about carrying out scientific hobbies.

(8) Gillian and Mary were looking at books in their school library. Gillian had picked out some books on science to read at home and she showed them to Mary and said: "These look really interesting. I will enjoy reading these at home."
Mary replied: "They would be the last thing that I would read in my spare time. I've taken out much more interesting books that have nothing to do with science."

Question: When selecting books from the school library, would you

(a) Always look for a book on science?

(b) Usually look for a book on science?

(c) Never look for a book on science?

(d) Occasionally look for a book on science?

(e) Not be bothered about what books you took out?

(9) Peter and Steven were both looking through their daily paper to see what was on television that evening.
Peter said: "This show looks interesting. They are interviewing a famous scientist."
Steven said: "I don't think that will be very good. All scientists are dull people who don't lead very interesting lives."
Peter replied: "Well, I think it will be good. Scientists are not dull at all and usually have very interesting things to say about their lives."

Question: What is your view about scientists?

(a) I agree strongly with Peter.

(b) I agree mildly with Peter.

(c) I agree strongly with Steven.

(d) I agree mildly with Steven.

(e) I neither agree nor disagree with Peter or Steven.

(10) Anne and Margaret were sitting watching a film on television. Part of the film was about a scientist who spent his time working alone on experiments in his laboratory.
Anne said: "That's just like a scientist! Scientists are always by themselves and doing nothing but work all the time!"
Margaret replied: "No, that is just the film!" Scientists often spend time with other people; they might work like that sometimes but only if something important needs to be done."

<u>Question</u>: If you were watching the film with Anne and Margaret and they asked you what you thought about scientists and their work, would you

(a) Agree <u>strongly</u> with Anne?

(b) Agree <u>mildly</u> with Anne?

(c) Agree <u>strongly</u> with Margaret?

(d) Agree <u>mildly</u> with Margaret?

(e) Neither agree or disagree with Anne or Margaret?

(11) Tim and Phil were coming out of their science lesson.
Tim said to Phil: "All this maths that we do in science lessons really puzzles me. I think that I could understand what was going on if we didn't have to keep doing maths as well."
Phil replied: "I find that it's all the long words that bother me. I just do not understand them."

<u>Question</u>: How do you feel about these problems in your science lesson?

(a) I agree with both Tim and Phil.

(b) I agree with Tim but disagree with Phil.

(c) I agree with Phil but disagree with Tim.

(d) I disagree with both Tim and Phil.

(e) I neither agree or disagree with Tim or Phil.

(12) Janet and Michelle were talking about the problems they had with their science lessons.
Janet said: "My problem is that I cannot understand the ideas behind what we are taught in science. They just don't make any sense to me."
Michelle said: "My problem is with the practical work in science. I just cannot set experiments up and get sensible results."

<u>Question</u>: How do you feel about these problems in your science lessons?

(a) I agree with both Janet and Michelle.

(b) I agree with Janet but disagree with Michelle.

(c) I agree with Michelle but disagree with Janet.

(d) I disagree with both Janet and Michelle.

(e) I neither agree or disagree with Janet or Michelle.

(13) Dawn was talking to Mary about science lessons in their school. Dawn said: "I find that ther is always too much to do in our science lessons and so I have to do a lot of work in my spare time to keep up and to understand what is going on."

<u>Question</u>: If you were Mary and Dawn was talking about science lessons in your school, would you

(a) Agree with Dawn, that there is always too much to do in your science lessons?

(b) Agree that there is sometimes too much to do in your science lessons?

(c) Disagree with D wn, and say that there is always too little to do in your science lessons?

(d) Disagree and say that there is sometimes too little to do in your science lessons?

(e) Neither agree or disagree with Dawn?

(14) Jane and Mike were watching the news on the television when it was announced that a large sum of money had been given to a new science project.
Jane said; "I think that it is wrong to give science so much money. All science does is cause trouble and make a mess in our world."
Mike had a different view and said: "Well I think that science should have as much money as it needs. Science helps us to solve all our problems today."

<u>Question:</u> If you were watching the television with Jane and Mike, would you

(a) Agree <u>strongly</u> with Jane?

(b) Agree <u>mildly</u> with Jane?

(c) Agree <u>strongly</u> with Mike?

(d) Agree <u>mildly</u> with Mike?

(e) Neither agree nor disagree with Jane or Mike?

(15) One afternoon Jenny and Sheila were listening to records in Jenny's house.
Jenny said: "You know if it were not for science we would not be able to listen to these records."
Sheila, looking puzzled, asked: "What do you mean?"
Jenny replied: "Well scientists discovered all the things that go together to make a record and a record player, you see. Science does a lot for us."
Sheila then said: "You could be right there but science has also spoilt the peace and beauty of some of our countryside, through all the discoveries science has made in helping industry."

<u>Question</u>: How do you feel about science and your everyday life?

(a) I agree with both Jenny and Sheila.

(b) I agree with Jenny but disagree with Sheila.

(c) I agree with Sheila but disagree with Jenny.

(d) I disagree with both Jenny and Sheila.

(e) I neither agree nor disagree with Jenny or Sheila.

(16) John and Ian were sitting at their bench in the science laboratory. when they heard the teacher say: "Today we are going to look at some famous theories and laws in science."
John whispered to Ian: "What does he mean by theories and laws in science?"
Ian replied: "I think they are a way of making a summary of what we know in science and helping us say what might happen next. They change as time goes on as more things are discovered."
John then said: "Oh! I thought they were certain true facts in science that never changed."

Question: If John and Ian asked you to decide which of their views was closest to your own, would you

(a) Agree strongly with John?

(b) Agree mildly with John?

(c) Agree strongly with Ian?

(d) Agree mildly with Ian?

(e) Neither agree nor disagree with John or Ian?

(17) At the end of a science experiment, the teacher had collected all the observations made by the class on the board. He then asked everyone to examine these observations carefully and to explain what had happened in the experiment.
Gary said to Nigel: "This is the way science works. First you observe what goes on and then you try to make sense of it."
Nigel replied: "I thought that science worked by scientists just thinking about the world and then deciding what was right."

Question: If Gary and Nigel asked you how you thought science worked, what would you say?

(a) I would be in total agreement with Gary.

(b) I would mildly agree with Gary.

(c) I would be in total agreement with Nigel.

(d) I would mildly agree with Nigel.

(e) I would neither agree nor disagree with Gary or Nigel.

(18) Carol was writing down in her book a list of different types of materials which the teacher had written up on the blackboard.
Susan, her friend said: "I'm fed up of doing this. Why can't we do something useful? After all that is what science is about, namely, being useful to people."
Carol replied: "Well I think that science is really for collecting together facts about the world and putting them down in order."

Question: What do you think science is about? Would you

(a) Agree with both Carol and Susan?

(b) Agree with Carol but disagree with Susan?

(c) Agree with Susan but disagree with Carol?

(d) Disagree with both Carol and Susan?

(e) Neither agree nor disagree with Carol or Susan?

University of Keele

Department of Education

# REACTIONS TO SCIENCE SITUATIONS

## ANSWER SHEET

Please complete

Your Name ____________________ Your Form __________

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University of Keele

Department of Education

# REACTIONS TO SCIENCE SITUATIONS

Please complete:

Your Name _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Your Form _ _ _ _ _ _ _ _

In the following, you will find a number of short stories, each describing a certain situation. These situations relate to science and to science learning.

We should like to have your reaction to each of these situations.

Read each item carefully. Then respond to the question at the end of the item in your own words, in the space provided.

Write as clearly as you can, but do not worry too much about your spelling and punctuation.

Write as much as you need to express your reaction to the situation. You do not have to fill all the space provided.

The items are designed to find out how you feel about the various situations.

There are NO right or wrong answers.

Your answers will not be shown to anybody else in your school.

(1) Roger and Paul were on their way to their next lesson. "It's science next",said Paul. "I always enjoy science lessons." Roger replied: "That's alright for you, but I am always glad when science lessons are over. I don't enjoy them at all."

__Question__: Suppose that Roger and Paul asked what __you__ thought about science lessons. Write down below what you would say to them.

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(2) Bill was reading a book called 'How to become a scientist'. John came up to him and said: "What are you reading that for? You are not thinking of becoming a scientist when you leave school are you?"
Bill replied: "I certainly am. There are plenty of jobs which involve science that really interest me."
John responded by saying that he would never think of becoming a scientist because it would take too much hard work.

__Question__: What do you think about becoming a scientist after leaving school? Write your answer in the space below.

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(3) One afternoon Andrew was at home trying out an experiment with his science kit that he had been given as a Christmas present. David, his friend, called to see him and, seeing what Andrew was doing, said: "I cannot understand why you are so interested in playing around with that science stuff. I can think of lots of things I would rather do in my spare time than take up science as a hobby."

<u>Question</u>: How do you feel about science as a hobby?

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(4) Anne and Margaret were sitting watching a film on television. Part of the film was about a scientist who spent his time working alone on experiments in his laboratory.

Anne said: "That's just like a scientist! Scientists are always by themselves and doing nothing but work all the time!"

Margaret replied: "No, that is just the film! Scientists often spend time with other people; they might work like that sometimes but only if something important needs to be done."

<u>Question:</u> What are your thoughts about scientists and their work?

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(5) Tim and Phil were coming out of their science lesson.
Tim said to Phil: "All this maths that we do in science lessons really puzzles me. I think that I could understand what was going on if we didn't have to keep doing maths as well."
Phil replied: "I find that it's all the long words that bother me. I just do not understand them."

<u>Question:</u> What problems do <u>you</u> have with school science?

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(6) Jane and Mike were watching the news on the television when it was announced that a large sum of money had been given to a new science project.
Jane said to Mike: "I think that it is wrong to give science so much money. All science does is cause trouble and make a mess in our world."
Mike had a different view and said: "Well I think that science should have as much money as it needs. Science helps us to solve all our problems today."

<u>Question:</u> What do you think about science in our world?

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(7) One afternoon Jenny and Sheila were listening to records in Jenny's house.
Jenny said: "You know if it were not for science we would not be able to listen to these records."
Sheila, looking puzzled, asked: "What do you mean?"
Jenny replied: "Well scientists discovered all the things that go together to make a record and a record player,you see. Science does a lot for us."
Sheila then said:"You could be right there but science has also spoilt the peace and beauty of some of our countryside, through all the discoveries science has made in helping industry."

<u>Question:</u> What do you think about science and yourself?

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(8) John and Ian were sitting at their bench in the science laboratory when they heard the teacher say: "Today we are going to look at some famous theories and laws in science."
John whispered to Ian: "What does he mean by theories and laws in science?"
Ian replied: "I think they are a way of making a summary of what we know in science and helping us say what might happen in the future. They change as time goes on as more things are discovered."
John then said: "Oh! I thought they were certain true facts in science that never changed."

<u>Question:</u> Suppose John asked you what <u>you</u> thought about theories and laws in science. Write down below what you would say to him.

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(9) Gary and Nigel had just finished doing an experiment in their science lesson. Their teacher then told everyone to carefully examine the results from their observations and then to use their results and everyone else's to explain as a class,what had happened in the experiment.
Gary said to Nigel: "This is the way that science works. First of all you observe what goes on and then you try and make sense of it."
Nigel replied: "I thought that the way science worked was by scientists just thinking about the world and deciding what they thought was right."

Question: How do you think that science works?

(10) Carol was writing down in her book a list of different types of materials which the teacher had written up on the blackboard.
Susan, her friend, said: "I'm fed up of doing this. Why can't we do something useful? After all that is what science is about, namely, being useful to people."
Carol replied: "I do not think that is true. I think that science is really for collecting together facts about the world."

Question: What do you think that science is about?

UNIVERSITY OF KEELE

DEPARTMENT OF EDUCATION

# A Pupil-Rating Schedule

## DIRECTIONS

### General

On the following pages you will find listed a number of characateristics which are frequently used by teachers to describe or rate their pupils.

We should like you to rate the pupils in your form according to each of the characteristics listed.

The rating is to be done using 'bi-polar' scales each of which gives two or more 'stimulus' words describing the extremes of the scale.

Rate each pupil with respect to each characteristic and indicate his/her position on the scale by placing an 'X' where appropriate. The following example is designed to illustrate the use of the bi-polar scale.

### Example

Assume that the neatness and legibility of a pupil's written work is to be rated on the following scale,

neat, readable __:__:__:__:__:__:__ untidy, illegible

For a pupil whose work is consistently neat and readable, the rating could be

neat, readable X:__:__:__:__:__:__ untidy, illegible

Likewise, for a pupil whose work is consistently untidy and difficult to read, the other extreme of the scale would be appropriate

neat, readable __:__:__:__:__:__:X untidy, illegible

Different degrees of the characteristic may be indicated using the intermediate points of the scale.

### How to use this Schedule

1) Please fill in the information requested below.
2) Read the descriptions of the characteristics that follow. Use these descriptions for reference, as necessary, throughout the rating procedure by matching the reference numbers of the characteristic with their corresponding number on the rating sheets.
3) Please enter the name of the pupil to be rated in the space provided on the rating sheet.
4) Rate the pupil with reference to characteristics listed. Please record your 'first impression' and try not to 'cross reference' between different characteristics or pupils.
5) Repeat the rating procedure for each of the pupils in your form.

**Thank you for your co-operation**

Name : ____________________ Date : ____________

School : ____________________ Form : ____________

## Descriptions of the Characteristics to be Rated

1 General Ability - The general ability of the pupil to cope intellectually with 1
the academic rigour and demands of the school curriculum in general.

2 Ability in Science - The ability of the pupil to cope intellectually with the 2
academic rigour and demands of the science subject(s) studied.

3 Literacy - The ability of the pupil to comprehend written and oral communications 3
and skill in the use of language.

4 Numerical Ability - The competence of the pupil in performing mathematical 4
manipulations and calculations with acceptable speed and accuracy.

5 Manipulative Skills - The competence of the pupil in the careful and dexterous 5
handling and use of equipment in the orderly execution of practical tasks.

6 Observational Ability - The ability of the pupil to observe scientific phenomena 6
in a reliable manner and to take accurate measurements and readings.

7 Personal Application - The application of the pupil to his/her academic work in 7
the science subject(s) within the classroom.

8 Academic Performance - The achievement of the pupil in the science subject(s) 8
studied compared with his/her academic potential in the subject(s)

9 Trend in Achievement - The trend in achievement of the pupil in terms of whether 9
the pupil's achievement has improved or deteriorated over the last two terms.

10 Written Classwork - The neatness and legibility of the pupil's written work in 10
class.

11 Homework Punctuality - The punctual completion and submission by the pupil of 11
homework assignments.

12 Quality of Homework - The pupil's homework in terms of the quality and 12
organisation of its content.

13 Effort in Homework - The 'effort' made by the pupil in the preparation of his/her 13
homework as evidenced, for example, by the care and thoroughness taken over it.

14 Classroom Behaviour - The overt behaviour of the pupil in the classroom in terms 14
of his/her influence on the normal flow of the lesson.

15 Personality - The personality of the pupil in the classroom in terms of whether 15
he/she is lively and outgoing, as opposed to shy and withdrawn.

16 Maturity - The level of maturity displayed by the pupil in the classroom in terms 16
of whether the pupil's behaviour is mature and sensible, as opposed to immature
and childish for his/her age.

17 Interest in Science - The pupil's interest in the science subject(s) studied as 17
reflected by his/her eager involvment in all activities within the classroom.

18 Motivation toward School - The pupil's intrinsic drive towards learning and school 18
work in general.

19 Motivation toward Science - The pupil's intrinsic drive towards science work and 19
science learning activities.

20 Attitude toward School - The like or dislike and degree of commitment the pupil 20
has toward school.

21 Attitude toward Science - The like or dislike and degree of commitment the pupil 21
has toward the science subject(s) studied.

| | Pupil's Name : ____________ | | | | Pupil's Name : ____________ | | |
|---|---|---|---|---|---|---|---|
| 1 | high | __:__:__:__:__:__:__ | low | 1 | high | __:__:__:__:__:__:__ | low |
| 2 | high | __:__:__:__:__:__:__ | low | 2 | high | __:__:__:__:__:__:__ | low |
| 3 | high | __:__:__:__:__:__:__ | low | 3 | high | __:__:__:__:__:__:__ | low |
| 4 | high | __:__:__:__:__:__:__ | low | 4 | high | __:__:__:__:__:__:__ | low |
| 5 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless | 5 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless |
| 6 | high | __:__:__:__:__:__:__ | low | 6 | high | __:__:__:__:__:__:__ | low |
| 7 | tries hard | __:__:__:__:__:__:__ | makes little effort | 7 | tries hard | __:__:__:__:__:__:__ | makes little effort |
| 8 | works to full potential | __:__:__:__:__:__:__ | under-achieves | 8 | works to full potential | __:__:__:__:__:__:__ | under-achieves |
| 9 | performance improving | __:__:__:__:__:__:__ | performance deterior-ating | 9 | performance improving | __:__:__:__:__:__:__ | performance deterior-ating |
| 10 | neat, readable | __:__:__:__:__:__:__ | untidy, illegible | 10 | neat, readable | __:__:__:__:__:__:__ | untidy, illegible |
| 11 | always punctual | __:__:__:__:__:__:__ | always late | 11 | always punctual | __:__:__:__:__:__:__ | always late |
| 12 | high | __:__:__:__:__:__:__ | low | 12 | high | __:__:__:__:__:__:__ | low |
| 13 | tries hard | __:__:__:__:__:__:__ | makes little effort | 13 | tries hard | __:__:__:__:__:__:__ | makes little effort |
| 14 | co-oper-ative | __:__:__:__:__:__:__ | unco-oper-ative, disruptive | 14 | co-oper-ative | __:__:__:__:__:__:__ | unco-oper-ative, disruptive |
| 15 | outgoing, lively | __:__:__:__:__:__:__ | shy, withdrawn | 15 | outgoing, lively | __:__:__:__:__:__:__ | shy, withdrawn |
| 16 | mature, sensible | __:__:__:__:__:__:__ | immature, childish | 16 | mature, sensible | __:__:__:__:__:__:__ | immature, childish |
| 17 | keen, active | __:__:__:__:__:__:__ | disinter-ested, passive | 17 | keen, active | __:__:__:__:__:__:__ | disinter-ested, passive |
| 18 | eager, ambitious | __:__:__:__:__:__:__ | indifferent, unconcerned | 18 | eager, ambitious | __:__:__:__:__:__:__ | indifferent, unconcerned |
| 19 | eager, ambitious | __:__:__:__:__:__:__ | indifferent, unconcerned | 19 | eager, ambitious | __:__:__:__:__:__:__ | indifferent unconcerned |
| 20 | likes and is committed to school | __:__:__:__:__:__:__ | dislikes and is committed against school | 20 | likes and is committed to school | __:__:__:__:__:__:__ | dislikes and is committed against school |
| 21 | likes and is committed to science | __:__:__:__:__:__:__ | dislikes and is committed against science | 21 | likes and is committed to science | __:__:__:__:__:__:__ | dislikes and is committed against science |

UNIVERSITY OF KEELE

DEPARTMENT OF EDUCATION

# A Pupil Rating Schedule

Name : ____________________

School : ____________________

Form : ____________________

Date : ____________________

Names of Pupils

1 ____________________
2 ____________________
3 ____________________
4 ____________________
5 ____________________
6 ____________________
7 ____________________
8 ____________________
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11 ____________________
12 ____________________
13 ____________________
14 ____________________
15 ____________________
16 ____________________
17 ____________________
18 ____________________
19 ____________________
20 ____________________
21 ____________________
22 ____________________
23 ____________________
24 ____________________
25 ____________________
26 ____________________
27 ____________________
28 ____________________
29 ____________________
30 ____________________
31 ____________________
32 ____________________
33 ____________________
34 ____________________
35 ____________________
36 ____________________

## DIRECTIONS

### General

On the following pages you will find listed a number of characteristics which are frequently used by teachers to describe or rate their pupils. We should like you to rate the pupils in your form according to each of the characteristics listed.

The rating is to be done using 'bi-polar' scales each of which gives two or more 'stimulus' words describing the extremes of the scale.

Rate each pupil with respect to each characteristic and indicate his/her position on the scale by placing an 'X' where appropriate.

The following example is designed to illustrate the use of the bi-polar scale.

### Example

Assume that the neatness and legibility of a pupil's written work is to be rated on the following scale,

neat, readable __:__:__:__:__:__:__ untidy, illegible

For a pupil whose work is consistently neat and readable, the rating could be

neat, readable X:__:__:__:__:__:__ untidy, illegible

Likewise, for a pupil whose work is consistently untidy and difficult to read, the other extreme of the scale would be appropriate

neat, readable __:__:__:__:__:__:X untidy, illegible

Different degrees of the characteristic may be indicated using the intermediate points of the scale.

### How to use this Schedule

1) Please fill in the information requested on the front of this schedule.
2) Please enter the names of the pupils in your form in the space provided in the right hand margin on the front of this schedule.
3) Place the front page against the rating forms provided so that the numbers of the pupils on the front page match the numbers on the rating forms.
4) Rate all the pupils with reference to the characteristic listed. Please record your 'first impression' and try not to 'cross reference' between different pupils or characteristics.
5) Repeat the rating procedure for each of the characteristics listed.

Thank you for your co-operation

| PUPILS | Manipulative Skills | | | PUPILS | Observational Ability | | |
|---|---|---|---|---|---|---|---|
| | The competence of the pupil in the careful and dexterous handling and use of equipment in the orderly execution of practical tasks. | | | | The ability of the pupil to observe scientific phenomena in a reliable manner and to take accurate measurments and readings. | | |
| 1 | | __:__:__:__:__:__:__ | | 1 | | __:__:__:__:__:__:__ | |
| 2 | | __:__:__:__:__:__:__ | | 2 | | __:__:__:__:__:__:__ | |
| 3 | | __:__:__:__:__:__:__ | | 3 | | __:__:__:__:__:__:__ | |
| 4 | | __:__:__:__:__:__:__ | | 4 | | __:__:__:__:__:__:__ | |
| 5 | | __:__:__:__:__:__:__ | | 5 | | __:__:__:__:__:__:__ | |
| 6 | | __:__:__:__:__:__:__ | | 6 | | __:__:__:__:__:__:__ | |
| 7 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless | 7 | high | __:__:__:__:__:__:__ | low |
| 8 | | __:__:__:__:__:__:__ | | 8 | | __:__:__:__:__:__:__ | |
| 9 | | __:__:__:__:__:__:__ | | 9 | | __:__:__:__:__:__:__ | |
| 10 | | __:__:__:__:__:__:__ | | 10 | | __:__:__:__:__:__:__ | |
| 11 | | __:__:__:__:__:__:__ | | 11 | | __:__:__:__:__:__:__ | |
| 12 | | __:__:__:__:__:__:__ | | 12 | | __:__:__:__:__:__:__ | |
| 13 | | __:__:__:__:__:__:__ | | 13 | | __:__:__:__:__:__:__ | |
| 14 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless | 14 | high | __:__:__:__:__:__:__ | low |
| 15 | | __:__:__:__:__:__:__ | | 15 | | __:__:__:__:__:__:__ | |
| 16 | | __:__:__:__:__:__:__ | | 16 | | __:__:__:__:__:__:__ | |
| 17 | | __:__:__:__:__:__:__ | | 17 | | __:__:__:__:__:__:__ | |
| 18 | | __:__:__:__:__:__:__ | | 18 | | __:__:__:__:__:__:__ | |
| 19 | | __:__:__:__:__:__:__ | | 19 | | __:__:__:__:__:__:__ | |
| 20 | | __:__:__:__:__:__:__ | | 20 | | __:__:__:__:__:__:__ | |
| 21 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless | 21 | high | __:__:__:__:__:__:__ | low |
| 22 | | __:__:__:__:__:__:__ | | 22 | | __:__:__:__:__:__:__ | |
| 23 | | __:__:__:__:__:__:__ | | 23 | | __:__:__:__:__:__:__ | |
| 24 | | __:__:__:__:__:__:__ | | 24 | | __:__:__:__:__:__:__ | |
| 25 | | __:__:__:__:__:__:__ | | 25 | | __:__:__:__:__:__:__ | |
| 26 | | __:__:__:__:__:__:__ | | 26 | | __:__:__:__:__:__:__ | |
| 27 | | __:__:__:__:__:__:__ | | 27 | | __:__:__:__:__:__:__ | |
| 28 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless | 28 | high | __:__:__:__:__:__:__ | low |
| 29 | | __:__:__:__:__:__:__ | | 29 | | __:__:__:__:__:__:__ | |
| 30 | | __:__:__:__:__:__:__ | | 30 | | __:__:__:__:__:__:__ | |
| 31 | | __:__:__:__:__:__:__ | | 31 | | __:__:__:__:__:__:__ | |
| 32 | | __:__:__:__:__:__:__ | | 32 | | __:__:__:__:__:__:__ | |
| 33 | | __:__:__:__:__:__:__ | | 33 | | __:__:__:__:__:__:__ | |
| 34 | | __:__:__:__:__:__:__ | | 34 | | __:__:__:__:__:__:__ | |
| 35 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless | 35 | | __:__:__:__:__:__:__ | low |
| 36 | | __:__:__:__:__:__:__ | | 36 | high | __:__:__:__:__:__:__ | |

PUPILS

## Manipulative Skills

The competence of the pupil in the careful and dexterous handling and use of equipment in the orderly execution of practical tasks.

| Pupil | | | |
|---|---|---|---|
| 1 | | __:__:__:__:__:__:__ | |
| 2 | | __:__:__:__:__:__:__ | |
| 3 | | __:__:__:__:__:__:__ | |
| 4 | | __:__:__:__:__:__:__ | |
| 5 | | __:__:__:__:__:__:__ | |
| 6 | | __:__:__:__:__:__:__ | |
| 7 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless |
| 8 | | __:__:__:__:__:__:__ | |
| 9 | | __:__:__:__:__:__:__ | |
| 10 | | __:__:__:__:__:__:__ | |
| 11 | | __:__:__:__:__:__:__ | |
| 12 | | __:__:__:__:__:__:__ | |
| 13 | | __:__:__:__:__:__:__ | |
| 14 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless |
| 15 | | __:__:__:__:__:__:__ | |
| 16 | | __:__:__:__:__:__:__ | |
| 17 | | __:__:__:__:__:__:__ | |
| 18 | | __:__:__:__:__:__:__ | |
| 19 | | __:__:__:__:__:__:__ | |
| 20 | | __:__:__:__:__:__:__ | |
| 21 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless |
| 22 | | __:__:__:__:__:__:__ | |
| 23 | | __:__:__:__:__:__:__ | |
| 24 | | __:__:__:__:__:__:__ | |
| 25 | | __:__:__:__:__:__:__ | |
| 26 | | __:__:__:__:__:__:__ | |
| 27 | | __:__:__:__:__:__:__ | |
| 28 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless |
| 29 | | __:__:__:__:__:__:__ | |
| 30 | | __:__:__:__:__:__:__ | |
| 31 | | __:__:__:__:__:__:__ | |
| 32 | | __:__:__:__:__:__:__ | |
| 33 | | __:__:__:__:__:__:__ | |
| 34 | | __:__:__:__:__:__:__ | |
| 35 | dexterous, careful | __:__:__:__:__:__:__ | ham-handed, careless |
| 36 | | __:__:__:__:__:__:__ | |

PUPILS

## Observational Ability

The ability of the pupil to observe scientific phenomena in a reliable manner and to take accurate measurments and readings.

| Pupil | | | |
|---|---|---|---|
| 1 | | __:__:__:__:__:__:__ | |
| 2 | | __:__:__:__:__:__:__ | |
| 3 | | __:__:__:__:__:__:__ | |
| 4 | | __:__:__:__:__:__:__ | |
| 5 | | __:__:__:__:__:__:__ | |
| 6 | | __:__:__:__:__:__:__ | |
| 7 | high | __:__:__:__:__:__:__ | low |
| 8 | | __:__:__:__:__:__:__ | |
| 9 | | __:__:__:__:__:__:__ | |
| 10 | | __:__:__:__:__:__:__ | |
| 11 | | __:__:__:__:__:__:__ | |
| 12 | | __:__:__:__:__:__:__ | |
| 13 | | __:__:__:__:__:__:__ | |
| 14 | high | __:__:__:__:__:__:__ | low |
| 15 | | __:__:__:__:__:__:__ | |
| 16 | | __:__:__:__:__:__:__ | |
| 17 | | __:__:__:__:__:__:__ | |
| 18 | | __:__:__:__:__:__:__ | |
| 19 | | __:__:__:__:__:__:__ | |
| 20 | | __:__:__:__:__:__:__ | |
| 21 | high | __:__:__:__:__:__:__ | low |
| 22 | | __:__:__:__:__:__:__ | |
| 23 | | __:__:__:__:__:__:__ | |
| 24 | | __:__:__:__:__:__:__ | |
| 25 | | __:__:__:__:__:__:__ | |
| 26 | | __:__:__:__:__:__:__ | |
| 27 | | __:__:__:__:__:__:__ | |
| 28 | high | __:__:__:__:__:__:__ | low |
| 29 | | __:__:__:__:__:__:__ | |
| 30 | | __:__:__:__:__:__:__ | |
| 31 | | __:__:__:__:__:__:__ | |
| 32 | | __:__:__:__:__:__:__ | |
| 33 | | __:__:__:__:__:__:__ | |
| 34 | | __:__:__:__:__:__:__ | |
| 35 | high | __:__:__:__:__:__:__ | low |
| 36 | | __:__:__:__:__:__:__ | |