A Study of Affective Objectives in the Teaching of Chemistry

by

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SUMMARY

The difficulties existing for many pupils in the areas of formulae and equations and the belief that many of these problems were due to maturity barriers, led to the inauguration of this study in 1970.

A preliminary survey was made of the situation extant in 1970 concerning these topics. This revealed a very confused picture with wide variation of teacher approach. The most obvious problem was one of over-complexity in formulae and equations. Teachers were teaching with little or no regard for the developmental ideas of Piaget et al.

This problem was investigated at school level by a test based on a Gagne net for the writing of formulae and by a questionnaire. This test was examined in depth and confirmed the indications gathered in the preliminary survey. Pupils did not appear to reason logically when writing formulae but rather committed certain common formulae to memory, and failure at one step in the thought process did not appear to affect performance in the next. The very high number of pupils unable to handle proportion (71%) calculations from equations (97%) was disturbing, (the problem may be purely mathematical), and many pupils showed a lack of understanding of even the most basic principles e.g. nomenclature, formation of ions. Pupils seemed able to cope with individual steps in, e.g. formula writing, but could not handle all the material "en bloc" when it was presented in a very short time (2 - 3 months). This meant that overall performance was very poor (28% correct). A re-run of part of this test confirmed these results.

The questionnaire revealed that pupils tended to underestimate the difficulty of many topics and that many teachers were more consistent than them in their estimates of difficutly.

The teaching order of the '0' grade course in Chemistry was then examined /

examined in the light of the degree of complexity in formulae and equations needed for each section. A revised teaching order, which was basically 'organic first' was drawn up using the principal of gradual revelation of these topics.

To evaluate this revised order a maturity study was set up, having both experimental and control groups. The progress of the groups was monitored by a series of short tests, the results of which, and the 1973 'O' grade examination in Chemistry were analysed. No significant differences were found, but following the revised order did not disadvantage pupils over those following the standard orders. In fact, there was some evidence to show that the revised order had achieved for these pupils, a higher level of understanding on the more difficult topics, especially calculations from equations and the mole. They also were more consistent in their level of performance on writing formulae.

A detailed analysis of the last test (an overall revision of the work) was carried out and showed the same problems as were evident in the Gagne study, e.g. interpretation of nomenclature such as the difference between - IDE and - ITE compounds. Some topics appeared to be still beyond the majority of pupils e.g. (i) extrapolation from Na_2CO_3 to Na_2SiO_3 (12%); (ii) writing balanced equations (20%); (iii) calculations from equations (20%).

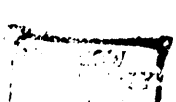
However, pupils did seem to grasp the mathematical rules for formulae writing reasonably competently.

A similar questionnaire to that used in the first investigation revealed that in general the revised group found the course easier than the control groups and that pupils now overestimated the difficulty of those topics previously underestimated.

A final survey in 1974 showed a situation on the one hand eased by the removal of a recall barrier in formula writing and on the other worsened by the choice of the correct level of complexity of formulae to be used in any questions /

questions being left to the pupil.

Recommendations were made for lessening the amount of conceptually difficult material (Piaget Stage 3) in the '0' grade syllabus and its replacement by work involving lower order skills, including purely practical ones.



Contents

Abstract

An examination of certain proposed affective objectives of Chemistry education has been carried out, particularly with the intention of determining whether these objectives are being attained by Scottish pupils following S.C.E. courses in Chemistry at Secondary Schools.

A critical survey of Attitude concept and theory has been made, together with an account of measurement procedures which have been devised for attitude assessment and which have been reported in the literature. Results of research have also been reported, particularly in the area of the affective component of attitude to science education.

Current opinions on the formulation of desirable affective objectives in education have been included, and critical comment on those proposed for current science syllabuses in Scotland has been made.

Questionnaires have been devised employing various attitude measurement techniques in an attempt to measure the attitudes of both pupils and teachers to education in Chemistry. A pre-test has been done in a small number of schools and, after modification, the questionnaires have been circulated to over thirty schools throughout the country. Twenty eight schools cooperated and over thirteen hundred pupils and one hundred science teachers completed questionnaires. A computer programme was prepared to process the data which emerged and to apply statistical analysis procedures.

The results from various categories of pupils have been compared and findings have been reported. Pupils who had not included science subjects in their course were used as control groups. A comparison of results obtained by three distinct methods of analysing the data has been carried out, and an attempt to demonstrate that one of these is clearly more appropriate in assessing attitudes has been made.

Results from individual schools have been discussed, and a detailed survey of five schools has been made in an attempt to relate the results from pupils in these schools to the attitudes of their teachers and to their school environment.

Suggestions for further work in this field have been proposed which are considered not only to be relevant to the teaching of Chemistry, but essential if Chemistry is to make its fullest contribution to the educational process.

Introduction

The thought and the utterances of the great educators through the ages have been influenced by the widely held belief that not only is it important to educate the intellect, but it is at least equally important to educate also the non-intellectual component of the personality.

Twenty five centuries ago, the Greek educators saw education as a growth process concerned with all sides of man's nature, and Plato wrote of the importance of the formation of character and of educating the emotions which he described as involving attitudes, morality and beliefs. The coming of Christianity with its inherent respect for the individual and the emphasis placed on the soul saw the Christian Fathers moving education onto the spiritual plane. Clement wrote that the aim of education was: "... not to teach, but to improve the soul, to train it to a virtuous, not to an intellectual life ...". Some remnants of these rather extreme views survived the Dark Ages, and with the Renaissance, the rediscovery of the richness of Greek and Roman educational thought reinforced the values placed on the non-intellectual fruits of education, and the writings of Erasmus, Rabelais and Montaigne in this period are, in a sense, preoccupied with this theme.

The history of education is, however, an account of an ebb and flow between times of enlightenment and times of sterility, and in the nineteenth century the need for

increased literacy to further the ends of industrialism and to make possible universal franchise, saw a shift of emphasis away from the education of the 'whole man' and towards more mundane outcomes of education such as literacy and numeracy. The reaction against this rather pragmatic era in education was not long delayed however, and writers such as Charles Dickens and, more locally, David Stow helped to create a new climate of thought on the ultimate aims of education. Stow wrote that education is "... that system which cultivates the whole nature of the child, instead of the mere head - the affections and habits, as well as the intellect".

In the twentieth century, as in other eras, education reflects current values and beliefs which predominate in society, and among these appears to be the worship of the intellect. Critics of modern education claim that it has been largely concerned with distilling off brains, processing them in the most efficient manner and leaving the residue to the mercy of thoughtless educators of the 'non-academic'. But in fairly recent years the scientific influence on the twentieth century has contributed a new line of thought and a new impetus to educational theory viz., the findings and postulates of psychology. It is now widely accepted that education must take account of the inner forces within the personality of the child, and interest in this new method of child study has been explosive. Theories, speculation and hypotheses have appeared rapidly, new concepts have been defined and

neologisms have appeared. Changes in educational objectives, curricula content and teaching methods have resulted. In the scale of time in which the evolution of educational thought has been considered, it may be that these changes have taken place so rapidly and accepted so enthusiastically as panaceae for everything that ails education, that not enough consideration has been given to one property that schemes based on these new concepts must possess i.e. empirical verifiability.

In the area of the classical non-intellectual component of the educational process, a theory of attitudes has defined three major components: cognitive, affective and action. The affective component has been postulated as that aspect of attitude which involves what are commonly referred to as 'feelings'. A taxonomy of educational objectives in the affective domain has also been produced and is a device which makes it possible to think with a higher degree of operational specificity and, for this reason, has been welcomed by both curriculum planners and educational researchers. The taxonomy has been applied to several subjects in the school curriculum and attitudinal (i.e. affective) objectives which the content of the subject should inculcate have been listed. In view of what has been said above on the subject of empirical verifiability it was considered that a fruitful area of research would be that into the claims made (or perhaps they are pious expressions of hope) for one subject viz., Chemistry and the underlying concepts and theory on which they are based.

Consequently, it is the purpose of this investigation to carry out:-

(a) a critical survey of attitude concept and theory, measurement procedures which have been devised and results of research, particularly in the area of the affective component of attitude to science education,

(b) an examination of certain desirable affective objectives of chemistry education, together with an attempt to measure whether these objectives are being attained by Scottish schoolchildren following S.C.E. courses in Chemistry.

The investigation is, therefore, of an area of psychology applied to education which has aroused a great deal of interest in recent years. Perhaps it is more, in that it is an affirmation by one practicing teacher of the need for a great deal of research into current educational theory which must be undertaken by those working at the grass roots as well as by others. This research is seen as being a continuous process as new theories are evolved and as the needs of children change. It is also considered that it will provide an essential moderating effect on proposed educational changes for, as Einstein, speaking of his Theory of Relativity said: "... a thousand experiments can never prove me right; a single experiment can prove me wrong".

Chapter 1

The Concept, Theory, Organisation and Measurement of Attitudes: A Critical Survey

1.1 The Concept of Attitude

G.W. Allport, a leading figure in the study of attitudes for over thirty years has claimed that attitude research was:

"... the primary building stone in the edifice of social psychology" (1)

He has traced the origins of the concept from the writings of Herbert Spencer in 1862 through the study of the Polish peasant by Thomas and Znaniecki in 1918 to his own definition of an attitude in 1935:

"An attitude is a mental and neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related". (1)

Psychologists have placed attitudes in a sequence of events which results in the production of actions which originate in a hierarchy of motives which, in turn, govern the order of attractiveness of goals presented to the individual. A distinction is drawn, however, between a general disposition to act in a certain way and the action produced in a particular situation, and the apparent disparity between these two is the reason why the concept of attitude has been defined in so many ways and has been

the subject of long debates. Attitude is seen by some as implying the probability of behaviour and by others as acting as a latent mediating process inherent in the individual's personality which ultimately determines what response is made. Additional conceptual refinements have been proposed both before, and since Allport's definition. Faris[2] in 1925 distinguished between conscious and unconscious attitudes, between mental and motor attitudes, between individual and group attitudes, and between latent and kinetic attitudes. It is sufficient to say that Allport's influential definition has survived the test of time and the concept embodied in it has survived all attempts by learning theorists to dislodge it from the field of social psychology.

1.2 Attitude Theory

An important implication of Allport's definition of attitudes is that attitudes are learned predispositions. Perhaps it is no coincidence that only a few years earlier than Allport's definition, Jean Piaget's[3] research on the Moral Judgement of the Child was published (1932). His theory is one of moral attitude development in stages emanating from the child's play and asserts that the child's notion of fairness and justice are independent of adult precept and influence, and is retributive and equalitarian in nature. This is gradually replaced by more rational and objective considerations as the child matures. It must be said, however, that serious criticism of Piaget's work has been made on the basis of inadequate sampling,

lack of controls and imprecise presentation. A more serious objection lies in his unacceptance of the part played by cultural and class factors.

Also arising from Allport's definition is the implication that attitudes can only be inferred from overt behaviour. However, the few empirical studies of the relationship between attitudes and behaviour which have been carried out, suggest that a knowledge of verbally expressed attitudes cannot be assumed to be predictive of behavioural consequences in a given situation. Findings on this subject are quoted later under attitude measurement.

In 1959, Katz and Stotland[4] recognised that attitudes are complex and defined three major components: the cognitive, the affective and the action components. The cognitive component was defined as that aspect of attitude that is related to knowledge whereas the affective component is related to "feelings", and the action component represents the extent to which the attitude has habits of action associated with it. At about the same time Heider[5] postulated a concept which soon attained a prominent position in the theory of attitude change. This theory was that beliefs, attitudes and behaviour were in a state of balance and that they will always adjust themselves to maintain consistency for an individual. If, for any reason, balance is removed, tension occurs and changes in the attitude components will take place to restore it. Festinger and Newcomb have carried out investigations which lend weight to these concepts.

1.3 The Organisation of Attitudes

Eysenck[6] has suggested that attitudes are organised in a hierarchy. At the lowest point in the hierarchy are opinions expressed on any one occasion on any topic. More specific attitudes or "habitual opinions" are on the level above these, and above these are more general attitudes. On the top of the hierarchy are placed ideologies or "super attitudes". The importance of this concept in the field of attitude research is that, depending on where an attitude is located on this edifice, it has received contributions in its formation from many parts of the personality (in the case of the highest level) or from very few, perhaps only one (in the case of the lowest level). The terms multidimensional and unidimensional have been used to describe attitudes at these levels. In the school situation, unidimensional attitudes would be those related to individual subjects, teachers or classes whereas attitudes to all teachers and other pupils would be on a higher level. Above them would be found attitudes to school in general and at the top of the hierarchy, motives and values. A consequence of this application for the educational researcher is that unidimensional attitudes e.g. to a certain subject can, it is claimed, be measured with a greater degree of validity than attitudes further up in the structure. Empirical evidence is, in fact, contradictory in this area, and it would seem that a major difficulty lies in the correct positioning of any attitude under investigation into a structure of this nature.

1.4 Measurement of Attitudes

1.4.1 Principles of measurement of attitudes

The basis on which techniques for measuring attitudes rests can be described as follows: attitude towards an object determines the responses made to a measuring instrument, and from the characteristics of the responses the nature of the attitude can be inferred. Five groups of techniques have been described by Cook and Selltiz[7]:-

(a) measures in which inferences are drawn from material which consists of self reports, beliefs, feelings, behaviour etc., towards an object;

(b) measures in which inferences are drawn from observed overt behaviour towards the object;

(c) measures in which inferences are drawn from reactions to partially structured material relevant to the object;

(d) measures in which inferences are drawn from performance on objective tasks where the performance is influenced by disposition towards the object;

(e) measures in which inferences are drawn from physiological reactions to the object.

The merits and demerits of the above methods have been the subject of extended debate. Self report measures are susceptible to distortion in that the implication of answers are obvious and the responses are therefore controlled. Assurances of anonymity and the use of 'distractors' within the items posed to the subject have

been suggested as has been the use of forced-choice tests. Large discrepancies between overt verbal responses and overt non-verbal behaviour has been reported. A. Anastasi[8] has reported a correlation coefficient as low as 0.02. A.L. Edwards[9] has pointed out one advantage of the questionnaire type self report. This is that this rapid and convenient method provides large numbers of responses which enable an attitude scale to be constructed from which the degree of affect can be found and not merely whether the attitude is positive or negative. More will be said on attitude scales later.

As with self report procedures, the reservations expressed on the use of overt behaviour is that there may not be a simple correspondence between the nature of the behaviour and the nature of the underlying attitude. Because of these reservations and because of the difficulty of devising suitable situations, these measures have not been widely used and there is a paucity of information about the validity of such measures. It could be said, however, that individual interviews fall into this category and L.F. Lowery[10] has incorporated this technique in an investigation into the attitudes of students towards changes in the science curriculum in a Californian High School. Lowery in another enquiry[11] into the development of an attitude measuring instrument has used a picture projective technique which is an example of a partially structured stimulus, where the informant supplies a meaning for and interpretation of the stimulus. The

stimulus may also be verbal rather than pictorial, and in the same enquiry Lowery has used word association and sentence completion tests.

An interesting study by Hammond[12] in 1948 is an example of inferences drawn from objective tasks. In the method developed by Hammond, at least some of the items included, which referred to an attitudinal object, had either no correct answers or the subject-matter was chosen so that few, if any, of the respondents would know any correct answers supplied. The assumption made is that when forced into a choice of errors the respondent is likely to choose the alternative most consistent with his own attitudinal disposition. A search for any application of this device in attitudes towards science was unsuccessful, so it will be mentioned here rather than the following section, that Hammond claims support for his method on the basis of empirical evidence obtained in the study of labour-management studies in the U.S.A. The use of objective tasks has been applied as a test of logical reasoning, where syllogisms or other logical forms are presented and the subject asked which conclusions can be drawn. Again, no application of this to enquiries into science could be found in the literature, but this method and some elements of Hammond's method have been used in one of the questionnaires from which information was acquired in the present study. It should be mentioned that Nedelsky[13] has suggested that the method of errors should have the effect of polarising attitudes to science in a

sample composed of those pro and anti science, so that pupils who are pro-science will consistently choose wrong answers with a scientific content (assuming no correct answers have been included). The method of inferences from physiological reactions has been included in the above list for academic interest, since reactions such as galvanic skin response or vascular constriction, which have been used, would not seem to be generally appropriate.

1.4.2 Measurement of Interest

Two methods widely used for the measurement of interest have been described fully by A. Anastasi[8]. The first is Strong's Vocational Interest Bank which had its origins in 1920 and has undergone continuing revision. Responses to 400 items are graded 'Like', 'Indifferent' and 'Dislike' and are in eight sections including occupations, subjects, amusements, actions, comparison of interest in pairs and a rating of the subjects abilities. It is claimed that the results can be used as a predictor of suitable occupations and a different marking key is available for each occupation. These have been derived by sampling large numbers of individuals of specified occupations. It is interesting to note that correlations relating to the subject's eventual occupation over intervals of about 20 years are of the order of 0.70. The second measurement of interest is the Kuder Preference Record which has also been used widely for vocational purposes, and which tests interests in a small number of broad areas.

It is of a forced triad type where activities are listed and the most and least preferred are indicated. Correlations of 0.90 have been recorded. H.J. Butcher[14] employed a Kuder Preference Record to determine the potential of schoolchildren as future University Science students. The results showed a high degree of variance with a High School Personality Questionnaire. D. Vitrogan[15] and D.C. Wynn and J.C. Bledsoe[16] used Kuder Preference Records in determinations of generalised attitudes to science and of factors related to gain and loss of interest in science by High School pupils in the U.S.A. The results of these are reported later (Chapter 2.2).

1.4.3 Construction of Attitude Scales

The quantitative scaling of attitudes is achieved by the preparation of a set of items to which a response must be made. Two criteria in selecting items commonly used are that:

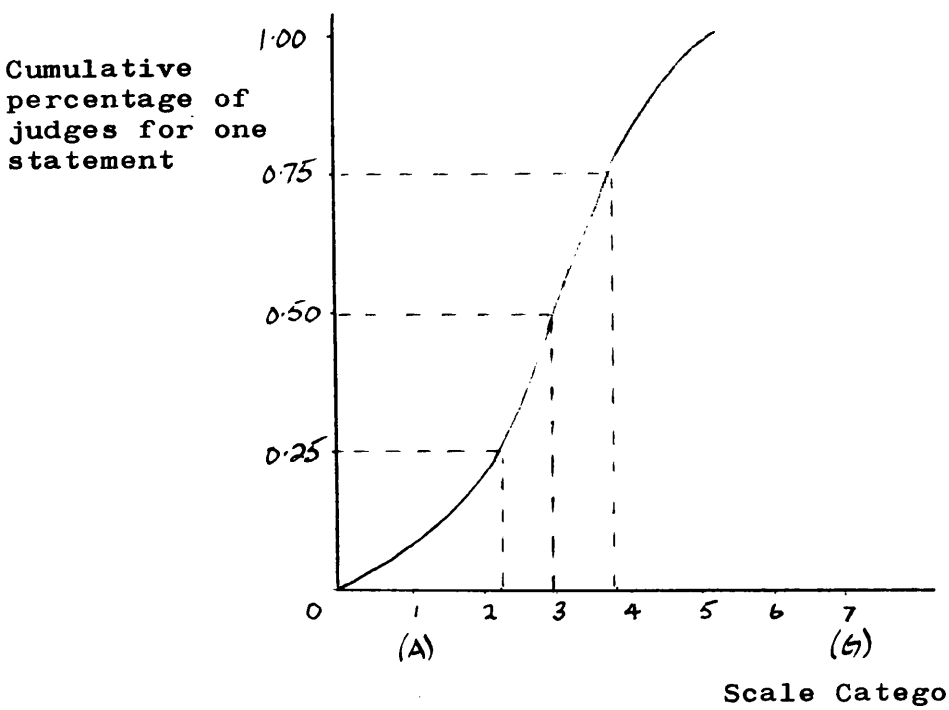
(a) the items must elicit responses that are psychologically related to the attitudes being measured;

(b) the scale should be capable of differentiating among individuals who are at different points along the dimension being measured and not merely between opposite extremes in attitude.

Most attitude scales that have so far been devised fall into three main categories:

(a) Differential Scales

In these the items form a gradation so that the individual agrees with only a few and disagrees with statements on either side of those with which he has agreed. The Thurstone scale[8] has been widely used and is a differential scale consisting of about 130 edited short statements whose position on the scale had been determined by about 300 'judges' who gave ratings from A to K (A: most favourable, F: neutral, K: unfavourable). Various methods of judging scale positions have been used i.e. the methods of 'paired comparisons', 'successive intervals' and 'equal appearing intervals'. The latter method will be described briefly.



Scale categories of 1 to 11 were used for A to K. The percentage of judges placing a statement in one of these categories was plotted as shown. The 50th percentile or

median position was taken as the statement's scale value i.e. 3 in the above example. Scale values for all of the statements were found in this way and statements were selected for general use whose scale values were equally spaced along the attitude continuum. An 'index of variability' (Q) for each statement was used and is the distance in scale value between the 25th and 75th percentiles. In the above example Q = 1.6 and indicates low variability. Statements with high Q values were eliminated.

Two criticisms that have been made about Thurstone scales are:

i) the procedure is cumbersome and tedious. A.L. Edwards[9] has refuted this by comparing the time required to construct such a scale with other methods such as summated scales.

ii) since an individual's final score is taken as the mean or median of the scale values of several items to which he has agreed different <u>patterns</u> of attitudes may be expressed by the same score. This appears to be valid criticism but one that no attitude scale can escape.

iii) scale values are influenced by the attitudes of the judges. Further refinements of the procedure can, however, eliminate judges with extreme attitudes. In the field of attitudes to science M.B. Ormerod[17] and W.H. Dutton and L. Stephens[18] have used Thurstone techniques.

(b) Summated Scales

Here the individual indicates agreement or disagreement with each item and subscores for each item are added. In Likert-type scales a graded response is made possible and scores of 6 to 1 are assigned to six responses graded from 'strongly agree' to 'strongly disagree'. The score is the sum of items interpreted in terms of empirically established norms. Validity coefficients of 0.46 - 0.60 have been reported e.g. by the Minnesota Teachers' Attitude Inventory by cross validation methods. M.B. Ormerod[17] used a Likert technique in conjunction with the Thurstone procedure in the reference already made and more recently, S.A. Brown and T.N. Davis[19] used a Likert technique to construct five sub-scales each relating to an attitudinal objective laid down for pupils in the first two years of secondary education in Scotland. A sample of 3,000 children was tested and items for the scale were collected from audio tape recordings of conversations with small groups of such pupils. The principle of obtaining items from statements made by the children for whom scales are intended follows closely that inherent in Joan Barker Lunn's study[20] of English school children's attitudes in streamed and unstreamed Primary schools. The subject matter of this study is not germane to this present survey, but the study is worthy of mention because of the impressive design of the measuring instrument and the incisiveness of the enquiry.

(c) Cumulative Scales

A brief mention will be made of these scales which are set up so that items form a cumulative series. In theory an individual whose attitude is at a certain point on the dimension being measured will give a favourable answer to items on one side of that point and an unfavourable response to others. Higher scores are allocated to one end of the scale than the other so that the total positions the individual on the attitude dimension being measured.

1.4.4 Measurement of Concept Connotation.

In addition to the above scales the Semantic Differential Technique has been used as a tool for personality assessment. Originally designed for research in the psychology of meaning, it measures connotations of any given concept for an individual. Word pairs such as 'valuable/ worthless' are joined by a seven point scale from +3 to -3 including zero. It has been found that as age increases subjects tend to agree more closely in connotation of common objects. Responses can be analysed in several ways:

(a) the over-all similarity of any two concepts for an individual or group can be found by their positions on all scales;

(b) three main factors which, it is claimed, the technique can meausre viz., 'evaluative', 'potency' and 'activity' can be determined by separate analysis of word pairs which manifest these factors;

(c) 3D models can be constructed for an individual with axes reflecting responses to e.g. 'good', 'active' and 'weak' and points which represent where different concepts are found relative to these axes are plotted. Several concepts, when plotted give a pattern for an individual or group which, when compared with patterns developed by other individuals or groups, or at different times for the same individuals or groups, can show differences and changes in attitudes.

No application of this technique could be found in the literature for the measurement of attitudes to science, but the technique has been used in the work at present under consideration. It is worthy of note here that recommendations in the literature that scales such as +3 to -3 should be used in measurement techniques is considered, in the light of the present work, to be a basic fault in such techniques. It will be shown later that the use of negative numbers has the effect of shielding a great deal of information which could otherwise be brought to light by statistical analysis.

Chapter 2

Results of Measurement of Attitudes to Science: A Literature Survey

2.1 Pre- 1960 Research

Although the theories on attitude measurement had been published as early as the 1920's, it was not until forty years later that attempts were made to apply these theories and new techniques to science education. No record of any published work has been found until 1960. It is not the purpose of this work to indulge in speculation as to the initial paucity of interest in this direction followed by a sudden upsurge of interest, but the observation that during these forty years the Age of Technology was reached is certainly relevant.

In 1941 however, C. Mitchell[21] approached the theories of attitude measurement with very proper scientific scepticism and devoted a paper to answering the question: "Do sclaes for measuring attitudes have any significance?". The attitudes he measured were those of pupils towards education, school and school practices and his main purpose was to test validity and reliability. It is consoling to note that over thirty years ago Mitchell appeared satisfied in both respects and reported coefficients of 0.73 and coefficients of reliability of 0.71. On testing validity he concluded that:

"... it would seem that these pupils either put their attitudes into action or their actions produced the attitudes that were checked on the scales .... To this degree, it is only reasonable to assume that these scales give some index of the pupils' beliefs or attitudes .... and measure to some degree what they intend to measure".

He also found that 77% of a group expressed the same attitudes to two scales used at a three monthly interval.

Four years later the Gestalt psychologist Duncker[22] suggested that a child's interest in science can be stimulated by experimental work. Piaget's writings[23] on the growth of logical thinking in 1958 seems to provide an extension of Duncker's reasoning. As has often been the case in education, Piaget's work has been invaluable in defining problems and his ideas of the development of concepts, interests and reasoning as the mental age increases stimulated a great deal of research in following decades.

2.2 Research in the Sixties

In 1960, J. Wrigley and J.F. Kerr[24] made a study of attitudes and aims in science teaching in schools in Northern Ireland. Three main attitudes were found: grammar schools treated science mainly as a mental discipline, technical schools treated it as a necessary tool, and secondary modern schools used science as a help in developing an inquiring interest in life. There is, unfortunately, no record of the attitudes which may have been

inculcated in the pupils by the above teachers' attitudes.

In the following year, G.R. Meyer and D.M. Penfold[25] found correlations of the order of 0.40 between interest tests and achievements in science examinations. This was part of the total study which involved 150 pupils and where statistical relationships were sought between interest in science and each of forty-seven variables representing factors in school and home which might affect interest in science. An important conclusion reached was that a pupil whose home was secure and whose parents had a genuine interest in education would be more likely to acquire an interest in science (and presumably other subjects) than a less fortunate pupil in this regard. Unfortunately, this is one variable which it would be very difficult for the teacher to modify.

W.H. Dutton and L. Stephens[18] carried out research two years later into the attitudes of prospective teachers towards science. A sample of 226 prospective teachers was used and the attitude scale devised was found to have a coefficient of reliability of 0.93 after test and retest. The sample was restricted to women only and ages varied from 20 to 24. Most of the student teachers were destined to teach in elementary schools in the U.S.A. The general attitude of the vast majority of these prospective teachers towards science was found to be quite high. The mean for the distribution of scores is quoted as 8.03 with a standard deviation of 0.53. In free-response statements, favourable feelings towards experiments, field trips and creative work

were expressed. Aspects of science disliked were lack of participation and work with insects, reptiles and dead animals. 90% of the sample expressed favourable feelings towards field trips, nature study and pupil participation.

In 1964 D.G. Lewis[26] carried out research into the existence of a group factor of scientific ability which is of some relevance to the development of interest in science since, if abilities in each science discipline are mutually dependent, interest in science as a whole should be both present for some pupils and absent for others. Lewis's findings were, in fact, that attainment in physics, chemistry and biology was linked by a group factor as distinct from the general factor of intelligence and contradicted earlier opinions that no such factor would be shown to exist. As will be seen later, these findings are relevant to the sample used in the present work where pupils were following science courses which included chemistry and/or physics and/or biology.

Also in 1964 K.J. Jones[27] conducted a study of interest in science in Massachusetts over two weeks on 52 senior High School students. A Likert-type word preference inventory drawn from a pool of 1478 verbal behaviours was used and Jones tentatively claims in his report that he was able to assess each student's preference for a science or non-science activity and obtain a measure of the students' scientific interest. More important, his results seem to suggest that the measurement of interest can be used to predict achievement in science. Jones does not, however,

claim that this will necessarily be reflected in classroom achievement nor in subsequent entrance into scientific careers. Achievement in science is here represented by a Science Vocabulary Test.

L.F. Lowery's paper in 1966[11] on developing an attitude measuring instrument was followed in 1967 by a report on attitudes of Fifth Grade students towards science.[10] Similarities of attitudes were held in common between experimental and control groups, the sexes and socio-economic areas. These included a fear for human life in space exploration, confusion between science and technology, images of making precious elements such as gold, fear of dangers in experiments and a feeling that new inventions or ideas contained an element of chance. The experimental vs control findings showed that the notion of chance in obtaining new inventions or ideas lessened in the course of time for the experimental groups only. In the Socio-Economic areas all attitudes increased in a positive direction during a period of time, the lowest socio-economic areas gaining most. Control groups in all socio-economic areas showed no significant gains in attitude during the same time. In boys vs girls groups it was found that at the start of the study girls held significantly more positive attitudes to science than boys. By the end of the study the experimental boys' gains were generally greater than the girls'. It was also found that both experimental boys and girls decreased their number of images pertaining to destructive forces in science, but the boys' images decreased

more than the girls'. Both experimental and control girls retained the images they held which related science to the medical profession and which considered the importance of science to the welfare of mankind. Whereas boys in all area retained images of dangers in science as did girls in higher and middle socio-economic areas, girls in lower socio-economic areas lost these images. The period of time during which attitudes were tested was 7-8 weeks. A final conclusion from this interesting study was that knowledge gains in science and gains in attitudes to science do not go hand in hand e.g. experimental students who did poorly in general science tests in the pretest did not improve their performance in this respect although significant increase in positive attitudes to science were observed over the same period.

A method of determining a generalised attitude of High School students towards science was the aim of the research by D. Vitrogan[15] in 1967, and again, as is the case with much of the work being surveyed, was conducted in the United States. A sample of 205 pupils of both sexes and of ages 13-15 years old was used. All of the pupils had followed a course of general science and biology. Eight items taken from the ideas or writings of scientists, philosophers, science educators and researchers formed hypothetical criteria of a positive attitude towards science. The Kuder Preference Vocational Form, the Iowa Test of Educational Development, a Science Teacher's Rating and school marks in General Science were all used to evaluate

the pupils' motivational involvement with science. A Thurstone type attitude scale was also used and found to have almost zero correlation with the Kuder Form but correlations of the order of 0.70 with the other techniques. Vitrogan's report is concerned mainly with establishing validity and reliability of the measurement technique. It is, however, relevant to list some of the hypothetical criteria he used and which were favoured mainly by pupils with positive generalised attitudes towards science:

(a) controlled observation favoured rather than authoritative suggestions;

(b) flexible solutions to problems favoured rather than rigid solutions;

(c) controlled observation distinguished from casual observation;

(d) constant change stressed over non change;

(e) probability stressed over absolute orientation.

D.C. Wynn and J.C. Bledsoe's[16] research into factors related to gain and loss of scientific interest was also concerned with American pupils in the same year and invoked statements by three Presidents and members of the Congress that: "... survival of the nation may well depend upon its ability to compete successfully with other world powers in scientific research and development" as its 'raison d'être". It is therefore, perhaps, some measure of their scientific objectivity that the authors have to admit that: "... the extreme emphasis placed upon science education

during recent years has not resulted in greater interest in science among High school students". Further, they conclude that a greater interest stability (over a period of time) is present with such students than has been suggested by most investigators. They also find that interest cannot be expressed in terms of I.Q., achievements or socio-economic factors of the parents and sagely conclude: "... that if one desires to measure interests he must use interest measures".

There is little to report of similar researches in this country in 1967. The I.A.E. Study of Achievement in Mathematics[28] made some attempt to measure some of the affective outcomes of the mathematics courses in schools and found that coefficients of correlation between mathematics achievement and attitudes were small, except in the case of interests.

In 1968 there was a revival of interest of attitudes toward science in this country, and the Education (Research) Committee of the Association for Science Education initiated an enquiry into the attitudes of pupils in schools toward science as a subject and toward scientists. Tape recordings of 12 to 13 year old pupils talking about science and scientists were made in a variety of schools. C. Selmes[29] reported the findings in 1969 as indicating a great deal of interest in these topics. The amount of time spent in these recordings discussing various aspects of science or scientists and the use of recurring phrases were expressed as a percentage of the whole time for each topic. A

favourable picture of Chemistry emerged although fewer comments were made about Chemistry than physics or biology. Examples are: enjoyable practical work (24%); discovering things (12%); easy to understand a lot of it (12%) especially when the teacher does not use big words; difficult to understand (15%) when the teacher does not explain the practical. A similar analysis on scientists' comments are: messing about with chemicals (8%); they invent good things like new drugs but also some bad things like H-bombs (18%); they are usually men ... ladies are not wanted (8%); very brainy (7%); mad or eccentric (7%); they devote their whole life to it (7%). Selmes also reported little realisation that science is a method of investigation. The sample number is not recorded in Selmes's report but the fact that some 50 hours of recordings were collected suggests a satisfactory survey. Reservations are made by Selmes on the method of collecting information which was to seek freedom of expression during recording sessions by asking teachers to withdraw and leaving a senior pupil in charge. As an alternative, a competent interviewer was suggested by Selmes in hindsight. The report, however, reflects very clearly a most significant and incisive contribution in this field.

At about the same time and acting on their own initiative B. Ashton and H.M. Meredith[30] carried out an enquiry into the attitudes of pupils in the sixth form. The method used was to examine the arguments produced by the pupils to account for the swing away from science

subjects by students going to Universities. The question had been posed in a General Studies G.C.E. A-level paper as one of eight choices which also included topics such as 'Vietnam' and 'Moral Standards'. Of the 12821 candidates who took the examination, about 2000 chose the science option and about 200 of these papers were examined for common views on the topic and recurring arguments. The most common arguments advanced to account for the swing were: time-table too full i.e. hard work; high level of intelligence required; little scope for self expression; impersonality, inhumanity and misuse; lack of practical work; late introduction to science; early decision for arts or science; desire to help the community directly; poor image of the personality and job of scientists. The above arguments were advanced more often by girls except in the case of: high level of intelligence; little scope for self expression; poor image of scientist, but in these cases the differences were marginal. Many candidates, however, thought that, in time, as idealism recedes, a future swing would favour science.

H.J. Butcher[14] in the same year published a report concerned with a sample of 1000 Scottish schoolchildren to determine at an early age and before they were required to specialise in school subjects, which pupils were potential University scientists. His results show that the influence of both home and school in subject choice is very considerable and he reports that five indicators of orientation towards science were found to have importance

in the following order: rating of science as a school subject; rating of maths as a school subject; composite rating of the careers of research chemist, physicist and science teacher; rating of the career of research chemist and the Kuder scientific interest test.

2.3 Research in the Seventies

In May 1970 Laughton and Wilkinson[31] conducted a 'Science Opinion Poll' consisting of a Likert-type attitude scale measuring pupils' attitudes towards science. Higher scores on the attitude scale were obtained by pupils who intended to opt for science subjects. Also in 1970 Flynn and Munro[32] attempted to evaluate the Nuffield science course and found that genuine growth in the pupils' attainments of the stated objectives had taken place after one year of the course. Pupils in third forms in New Zealand schools were used for this purpose and the Nuffield course had been adapted for use in that country. Changes in pupils' interest in science and changes in teachers' behaviour were measured. Two groups of pupils were used: those who followed courses where experimental work predominated and those whose course was not biased in this way. No differences in the pupils' interest in 'out-of-school' science was found between these two groups but the experimental group gave science as a favourite school subject more often. Other attitudes measured were intellectual honesty, open-mindedness and critical-mindedness. Attitudes were scored tangentially from the written responses to cognitive test items but intercorrelations among different

markers proved to be low using this procedure. The research is, however, significant in that it is an attempt to evaluate whether or not stated objectives of a science course are being attained by science pupils. Too often research has been directed at the lesser-important question of differences in attitudes between arts and science pupils. Research by Povey (1970) and Hudson (1967) are examples of these. This distinction between norm-referenced attitudes and criterion-referenced attitudes will be mentioned in the next chapter when objectives are discussed.

Also in 1970, A.H. Johnstone and D.W.A. Sharp[33] reported their findings of enquiries among University students as to the factors governing giving up science subjects at school or continuing with them. The date of the decision was also sought. It was found that, of those students who had discontinued the study of science, 50% had done so between the ages of 11 and 13 and 90% between 11 to 16. It was suggested therefore that influence exerted at a later age is a waste of time and that good science teaching is important at an early age in order to influence pupils' attitudes. A distinction was drawn between those students who had taken 'traditional' science in schools and those who had been brought up on the revised or 'alternative' syllabus and it was found that 'alternative' students chose the course rather than the teaching as a source of interest in science whereas the reverse was true for 'traditional' students. Students who had given up science subjects were

asked to state their reasons for doing so and it is significant that some of the most popularly accepted reasons figured only slightly e.g. the revulsion against the materialistic aspects of science was not shown to be a major factor. Difficulty with mathematics and 'boring' science courses were two popular reasons for discontinuing science as was moderate examination results which were poorer than other optional subjects. 'Alternative' students were more concerned with this latter factor than 'traditional' students. A strong case is made, however, for scaling subject marks at school so that pupils can draw valid conclusions from comparisons between subject marks.

An investigation of social and subject factors in attitudes to science was conducted by M.B. Ormerod[17] and reported in 1973. A test was administered to whole year groups in 14 schools in various parts of England. 500 papers were selected to represent the third year pupils who took part from schools of various types at the time (1969-70). Pupils involved were in the upper half of the ability range i.e. C.S.E. or G.C.E. O-level candidates deemed likely to obtain passes. Ormerod found clear evidence that by the third year and, in the case of the most able pupils, the second year of secondary education, attitudes to the social implications of science have emerged and that these were related to subject choice for the most able girls. Ormerod recognises that relationship of this nature does not necessarily imply causation, and accepts that a third latent factor may be involved. He suggests that it is important,

especially for girls, to introduce topics concerned with social implications into science courses before the third year, but concedes that there is still no satisfactory explanation of the low number of girls opting for the sciences in Western democracies.

A pilot study into attitudes to science of Scottish schoolchildren of ages 11 to 14 was reported in 1973 by S.A. Brown and T.N. Davis.[19] The authors emphasise that only tentative conclusions have been drawn from this pilot study of 323 pupils, the main purpose of the work being the development of a suitable attitude scale which would then be applied to 3000 pupils in 40 schools. Since this study has run parallel with the present work under consideration, it is considered that even tentative conclusions may be found to be relevant and are summarised here. The scale used consists of five subscales each relating to an attitude objective laid down for all pupils in the first two years of secondary education in Scotland. Test reliability has been established. Boys scored significantly higher than girls on 'interest and enjoyment in science' and 'awareness of the social and economic implications of science'. Pupils following an integrated science course had significantly higher scores than those who did not on 'awareness of the relationship of science to other aspects of the curriculum' and on 'objectivity in observation and in assessing observations'. Significant correlations were found between all subscale scores except the 'objectivity' and 'interest' scores. Correlation between attitude scores

and a group test of general intelligence which was also applied were, in general, low, the positive significant relationships being associated with attitude subscales of high cognitive content.

Comparison of the results which emerge from the work which is being carried out by S.A. Brown and T.N. Davis and the results of the present work should prove to be of interest, although it must be borne in mind that the present work will be concerned with pupils at least two years older and also, in general, of higher academic ability.

Chapter 3

Affective Objectives in Science Teaching

3.1 Lewis's Survey of Science Objectives

In 1965, D.G. Lewis[34] published a review of the literature on objectives in science teaching. This covered some of the major studies on this subject published during the previous 30 years, and was intended to clarify important objectives so that the dissatisfaction with traditional methods of assessment which was at that time in evidence, could be obviated. The review is relevant to this work for a different reason, however. It shows that no matter from what source desirable objectives in science education are obtained, considerable importance and emphasis has been placed on the non-cognitive outcomes, and that from this recognition has evolved the attitudinal objectives so much in evidence in the science syllabuses of today.

Lewis first reports on studies by V.H. Noll in 1933 in the United States which stressed the acquisition of sound thinking habits and which also gave examples of objective tests of the 'true/false' type which he claimed could be used to measure scientific thinking. Noll concluded that scientific attitude involved several fundamental habits of thought including:

a) accuracy in all operations;

b) intellectual honesty;

c) / over

c) open-mindedness;

d) suspended judgements;

e) looking for true cause and effect relationships;

f) criticism, including self criticism.

The Science Masters' Association report in 1938 on the teaching of science in British Grammar Schools was also concerned with non-cognitive outcomes which were described as 'scientific modes of thought' and included several closely related to the Noll study e.g.:

a) capacity to distinguish between facts and hypotheses;

b) isolation of relevant facts from a complex situation;

c) ability to apply generalisations to new problems.

An interesting category was also included viz., the application of scientific knowledge to socially desirable areas.

F.P. Frutchley and R.W. Tyler had stimulated the conclusions drawn by the S.M.A. in their study two years earlier and included some of their suggested desirable outcomes and also placed emphasis on the acquisition of 'an attitude of tolerance towards new ideas'. In 1945 O. Kesslar listed what he considered to be the elements of scientific method as a summary of science objectives. These had been derived from a literature survey and vetted by research scientists at the University of Michigan, and were aimed at the needs of University students. The headings were, in fact, essentially what had emerged from

the reports above. Heil, Kambly, Mainardi and Weisman were, however, more concerned with the understanding and use of facts in their study a year later and Burmester in 1952 placed emphasis mainly on the recognition of problems, hypotheses and the ability to interpret data. Dunning in 1954 countered this by stressing the importance of critical thinking.

The American Council on Education report in 1954 formulated seven science objectives which included:

a) to understand the point of view of a scientist;
b) to understand the role, importance and limitations of science in the modern world;
c) to change behaviour in the light of appropriate evidence;
d) the ability to recognise and formulate attitudes.

Perhaps the most important contribution at this time to the study of objectives was that provided by B.S. Bloom in 1956 in his Taxonomy of Educational Objectives in both the cognitive and affective domains. Bloom's work is without doubt prestigious and has certainly been influential in this area of educational thought and is surveyed critically in 3.2 below.

Lewis's review of objectives detects certain general trends. First is an increasing acknowledgement that science has become an essential part of our culture with consequent emphasis being placed on its social implications. Secondly it is a greater recognition of levels of development in

schoolchildren as relevant factors. Here the influence of Piaget is clearly evident. A third feature is the increasing emphasis on affective rather than cognitive objectives only. Lewis recognises that an argument can be advanced that since the acquisition of knowledge is basic to the fulfilment of all other objectives, it should have a pre-eminent position in any hierarchy of objectives, and that tests for knowledge are therefore tests of other objectives. As has been seen however in Chapter 2, correlations between factual knowledge and attitudinal objectives are very often low.

3.2 Bloom's Taxonomy of Affective Objectives

Many educators have been convinced that not only is it important to lay down broad educational objectives, but also, if possible, to break these down further into more specific objectives phrased in behavioural terms and arranged in a system of classification which would allow a greater degree of operational specificity. B.S. Bloom supplied this demand in the cognitive domain in 1956[35] and in the affective domain in 1964.[36] In both cases taxonomic models were formulated. The taxonomy applied to the cognitive domain has become prestigious and has been used extensively in the testing of cognitive objectives in many school subjects. An attempt to validate this taxonomy was made by R.P. Kropp, H.W. Stoker and W.L. Bastow[37] of Florida State University in 1966 with inconclusive results.

More relevant to the present work is the taxonomy of affective objectives which established categories which are intended to include all affective behaviours present in educational objectives. The categories comprise a hierarchy so that each category contains all of those that precede it, if properly ordered, and thus represent different positions on a continuum. The principle of this is one of 'internalisation' which Bloom defines as 'a process through which there is first an incomplete and tentative adoption of only the overt manifestations of the desired behaviour and later a more complete adoption'. The major categories in ascending order of their degree of internalisation are:

a) RECEIVING: sensitivity to the existence and willingness to receive certain phenomena and stimuli.

b) RESPONDING: implies active attending; doing something with or about the phenomena, not merely perceiving them.

c) VALUING: implies perceiving phenomena as having worth; revealing consistency in behaviour related to these phenomena.

d) ORGANISATION: conceptualisation of values and use of concepts to determine interrelationship among values.

e) CHARACTERISATION: organisation of values, beliefs, ideas and attitudes into an internally consistent system; organisation of values into a total philosophy.

Only one major study of the affective taxonomy could be found in the literature. A Lewy[38] attempted empirical validification of the taxonomy in mathematics, music and reading. 80 items at the taxonomic levels of Receiving, Responding, Valuing and Organisation were constructed using affective objectives common to several published curricula for each subject. They were categorised in the four taxonomic levels (the fifth was not employed) by three 'experts' or 'raters' who had experience in constructing affective test items and who were familiar with the taxonomy. Lewy reports that the experts agreed on the allocation of 74% of the items and that 25% were allocated to adjacent categories. The items which were forced-choice questions were then presented to some 300 high school students and their responses were compared with: a) a Thurstone attitude score for Mathematics; (b) the number of musical programmes students listened to in a given period and (c) the number of books students had read in a given period in order to establish concurrent validity. Coefficients of 0.82 for Mathematics, 0.60 for Music and 0.47 for Reading were found and a correction for attenuation suggested that these might be higher. Reliability coefficients tested by the Kuder-Richardson Formula 20 were found to be between 0.93 and 0.95 suggesting high internal consistency.

In the study, Lewy claimed that empirical referents for the constructs of the Affective Taxonomy could be both directly observed in human behaviour and defined in terms

of a particular category of the model. Two hypotheses were advanced and verification attempted:

1) the possibility of obtaining inter-rater agreement in the allocation of affective behaviours to taxonomic categories;
2) the emergence of factors (as determined by factor analysis) which can be identified with the constructs of the model.

Dynamic validity was also studied i.e. whether or not the relationship described in or postulated by the schema are, in fact, displayed by their empirical referents. This aspect of validity was studied in connection with two of the taxonomy's alleged properties viz. hierarchical structure and interfield generalisability.

The general results reported by Lewy are that, from the data, the constructs of the model have empirical referents among affective educational objectives and that the hierarchical structure of these referents corresponds to that claimed by the model. He suggests that his procedure is not the only one that could be used, nor the best, but that it illustrates how such reasoning may provide an opportunity to verify empirically the relationships which, it has been claimed, exist between abstract psychological concepts. No claim is made that the model is an efficient describer of higher levels i.e. Characterisation and Organisation. Lewy further says:

"Unlike the cognitive taxonomy which rests on a

technical vocabulary common to logic and philosophy, the Affective Taxonomy employs a set of terms and constructs rather different from those familiar to educational theory and practice. As a result, a reader trained in this (cognitive) field fails to respond intuitively and immediately to the vocabulary of the model and hence tends to doubt whether processes described by these new terms are really relevant to educational practice".

In the face of this apologia, it should be said that space has been given to the above study because it is an attempt (the only one found) to verify empirically an area of educational theory which is not only relevant to the present work, but which, after a period of gestation, may give premature birth to standard and accepted teaching practices - as has happened in the case of the cognitive taxonomy and the learning theories of Gagné and Ausubel. Despite inherent imperfections (and brief criticism is made below) it at once illustrates the complexity and paucity of such attempts at verification. As will be seen later, however (Chapter 3.4) there seems, as yet, to be little evidence of the influence of the Affective Taxonomy on those affective or attitudinal objectives defined as 'desirable' for the curriculum in which the present work is concerned.

It must be said, in conclusion, that the above test of hierarchical structure appears to rely on a Guttman postulation that hierarchically ordered variables will yield a correlation matrix which can be identified. It is,

perhaps, inevitable that notice will be taken that Lewy's conclusions rely on merely a postulation for their support. It must also be noted that reservations as to the procedure followed must result when the degree of subjectivity involved in categorising the items used in the test is considered.

3.3 Mager's Position on Objectives

Consideration will be given here to the views of R.F. Mager [39] on the preparation of objectives. Some criticism, which it is hoped will be both valid and constructive, will be made near the end of this Chapter concerning the manner in which affective objectives, which it is the purpose of this investigation to measure, have been stated. Support for this criticism is being sought from the criteria laid down by the above influential writer.

Mager recognises that a statement of instructional objectives describes educational intents and will communicate the intent to the degree to which the learner's behaviour, when demonstrating his achievement, has been described. To describe behaviour it is necessary to identify and name the overall behaviour act, define the important conditions under which the behaviour is to occur and the criterion of acceptable performance. A meaningfully stated objective is defined as one that succeeds in communicating the intent. The best statement is one that excludes the greatest number of possible alternatives. A

further criterion is put in the form of a question: "Can another competent person select successful learners in terms of the objective so that you, the objective writer, agree with the selections?"

Mager supplies a check list for writing objectives. Only a few examples will be noted here:

1. Formal questions:
   (a) Is the sentence structure clear, concise and straightforward?
   (b) Are all statements unambiguous?

2. Behaviour characteristic:
   (a) Does the statement clearly and precisely describe what the student will be doing when he demonstrates what he has learned?
   (b) Does the statement describe a complete action?

As will be appreciated, cognitive or 'performance' objectives can readily be related to the above criteria since an easily recognised response or behaviour will be a valid measurement of achievement. It is more difficult to embody in a statement of an affective objective a precise indication of what response or behaviour can be used to measure its attainment, but the least that the objective should communicate is that it is possible to measure it to some extent.

3.4 Affective Objectives of Current Syllabuses

In the Ministry of Education Pamphlet No. 38[40] published in 1960, a suggestion is made that science should find a central place in a liberal education since "our future community ..... will need more citizens capable of imaginative and creative thinking within the context of science". It is further suggested that scientific method should set the pace in education and the characteristics of this are listed as desirable aims viz : careful sifting of observations, designing experiments to test ideas and strict intellectual honesty. It is, however, recognised that "the ideals, methods and attitudes involved in the scientific approach will not spread automatically into a pupil's general outlook unless a conscious effort is made to broaden their application ...."

In 1966 the Nuffield Science Teaching Project[41] reappraised the place of science in education. The need for more people with scientific training and with a critical attitude of mind was recognised and one proposal to raise the general standard of science education is that: "pupils should gain an understanding that lasts throughout their lives of what it means to approach a problem scientifically". This approach is compared with the limitations of the "short-lived remembering of dictated information" and encouragement is given to teachers to emphasise the personal commitment of the scientist, the importance of the disciplined guess, the logical argument, the feeling of exploration and the readiness to make

'apparently unwarranted jumps" while knowing how to check their validity.

A report on a working party on Secondary School Science was made to the Consultative Committee on the Curriculum of the Scottish Education Department in 1969.[42] This report is more specific in stating affective objectives than those mentioned above, and this obviously manifests the increasing awareness of the importance of these objectives in modern education. They are, therefore, worthy of inclusion in full.

1. For pupils in the first two years of secondary education:
   (a) awareness of the inter-relationship of the different disciplines of science;
   (b) awareness of the relationship of science to other aspects of the curriculum;
   (c) awareness of the contribution of science to the economic and social life of the community;
   (d) interest and enjoyment in science;
   (e) an objectivity in observation and in assessing observations.

2. For pupils in years three and four of secondary education the objectives listed immediately above are included with the addition of:
   (a) an interest and a willingness to participate in science-related leisure pursuits;
   (b) willingness to conform to and an interest in propagating sensible rules for safety and good

health for the sake of the community, as well as of the individual;

(c) an interest in and a willingness to participate in conservation of the natural environment;

(d) an interest in gathering information about science through all the media of communication.

It is mentioned in the report that these objectives are arranged in a hierarchical structure. It is not made clear, however, if 1)a) above, for example, is at a higher or lower level than 1)e), and it must be said that there appears to be little resemblance to the best known hierarchical structure viz. Bloom's, no matter which objective is taken as the lowest. This can also be said of the list of objectives in 3.5 below.

In paragraphs 59, 80 and 81 of this report it is noted that attitude formation should be seen as one of the essential contributions of science to the general curriculum and an appeal is made that subject content and methods of teaching should reflect this contribution. Some suggestions are made in the report as to how attitudes can be assessed by teachers e.g. essays on interests and impressions. Brief mention is made of the existence of attitude assessment tests but it is accepted that little use has been made of these in schools and an appeal is made to Colleges of Education and University Education Departments for the development of suitable test instruments. Very little seems to have emerged during the past six years.

Some suggestions will be made under 'Suggestions for further research' at the end of this Thesis as to how these needs can be satisfied, but the following observations on the writing of affective objectives are made at this point:

a) It must be recognised that if it is considered to be essential to a satisfactory science education that affective outcomes are at least as important as cognitive outcomes (as the above Report states) then emphasis must be placed on training teachers in the meaning and inculcation of attitudes and their assessment.

b) Decisions as to what attitudes are 'desirable' at each stage in a pupil's education are major decisions which may require thorough reappraisal.

c) Rigorous criteria should be applied to the phrasing of such attitude statements. An application of Mager's criteria quoted above (Chapter 3.3) to the statements immediately above and below is worthy of consideration in this regard.

d) It would seem to be essential that affective objectives should only be included in any list of desirable objectives for any school subject after it has been verified empirically that such objectives are capable of being attained by those pupils for whom they are intended. Consequently, a great deal of research is required in this field and it is hoped that the present work may contribute something towards this end in the case of science education.

3.5 Affective Objectives selected for investigation in this work.

Recently, the consultative committee on the curriculum has been considering a new list of objectives for Chemistry at 'O' Grade of the Scottish Certificate of Education. It was thought most appropriate, considering the suggestion made in (d) above, that this present work should be concerned with the affective objectives included in these latest proposals. The full list of affective objectives is:

* 1) Awareness that Chemistry can form the basis for many satisfying careers.

* 2) Awareness of the contribution of Chemistry to the full development of the individual.

* 3) Awareness of the contribution of Chemistry to the economic and social welfare of the community.

* 4) Awareness that a number of variables can influence an experimental situation.

* 5) Interest and enjoyment in Chemistry.

6) Acceptance of the chemist's ability to produce new compounds.

7) Acceptance of the importance of observation in an experimental procedure.

* 8) Acceptance of the value of an experimental approach to problems.

9) Acceptance of the desirability of working and discussing in groups in appropriate situations.

10) Acceptance of responsibility for carrying out suitable safety procedures.

11) / over

11) Commitment to optimum precision of measurement.

12) Commitment to optimum precision of statement.

13) Commitment to cleanliness and neatness in experimentation.

14) Commitment to the systematic recording of experimental results and other data.

15) Commitment to objectivity in observation and assessment wherever possible.

* 16) Commitment to arriving at conclusions from the information, knowledge and understanding available.

* 17) Commitment to apply a scientific approach in other fields of experience.

The objectives marked with an asterisk were selected for testing on the grounds that they appeared to be the most important and generally accepted affective objectives - many appear in the survey by Lewis reported in Chapter 3.1 . In addition, it was not possible, because of limitations in time and in size of the questionnaire produced, to test all of the objectives listed. It must also be admitted that, in the case of some of the objectives omitted, concern was felt that a high degree of validity for test items designed could not be ensured.

It should be noted here that in determining whether or not the affective objectives of a curriculum have been met, the task is not so much concerned with collecting information about the attitudes and interests of the pupils and so

producing norms in the affective domain but rather whether or not a certain criterion has been met as a result of the curriculum. It is not relevant at this point, to discuss the relative merits of norm-referenced and criterion-referenced objectives. It is sufficient to note that it must be assumed, in the absence of information to the contrary, that all of the affective objectives listed above are criterion referenced.

Chapter 4

The Pretest

4.1 Design of the Pretest Questionnaire

It was decided to produce a series of Items which either asked questions, posed problems or described situations, and so design the Items that a response should manifest an attitude related to the affective objectives which had been chosen from the test (Chapter 3.5). As will be seen below, many of these Items are disguised attitude assessment tests, a technique which has not, as yet, figured prominently among the methods so far used. One advantage of this technique may be that the pupils for whom it was intended would possibly embark on the questionnaire without being aware of what was being tested and thereby enhance the possibility of genuine and germane responses. An attempt was also made to make the Items as interesting as possible so that application would be maintained at a high level throughout. The questionnaire was designed so that it could be answered in about one hour by Fourth and Fifth Year pupils following S.C.E. courses. Responses were translated to a scale of marks so that the application of statistical analysis would subsequently be possible.

Page 1 of the questionnaire (Appendix 4-1) elicited information as to whether the pupils included science in their group of 'O' Grade subjects and also whether the pupil was a girl or boy. Otherwise anonymity was preserved

and an indication was given that the paper was not a 'test' in the accepted sense of that word.

Item 1 (Appendix 4-2) was designed to test objective No. 1 (Chapter 3.5) and asked pupils to compare Chemistry with other subjects in its importance in preparing for 17 stated careers, many of which had no obvious scientific bias. A mark was awarded for a tick placed in any of the Chemistry boxes. Item 2 (Appendix 4-3) used the semantic differential technique to establish a general impression from pupils of a student of Chemistry i.e. objective No. 2. A Likert-type scale was used for scoring. A mark of +2 was awarded for a tick in a box in the column on the extreme left, and -2 for a tick in the column on the extreme right with +1, 0 and -1 awarded for the intermediate columns. A total of the whole Item was then taken. Items 3 and 4 (Appendices 4-4 and 4-5) were constructed so that attainment of objective Nos. 3 and 5 could be evaluated. Four achievements or personalities in each list have a definite scientific bias. A mark was awarded for a tick placed in any of these boxes. Totals of 'Importance', 'Free Book', 'Value' and 'Interest' were then made. It was hoped that reference between these tests would, in the main test, provide some indicationof test reliability and this is referred to in Chapter 5. Objective No. 4 viz. the pupils' ability to cope with several variables was tested in Item 5 (Appendix 4-6). It was considered that five variables in the problem would be sufficient to detect differing abilities. The only possible answers are the correct placing of 4

variables, 2 variables or 1 variable, and marks of that order were awarded in each case. Five sub-items in Item 6 (Appendix 4-7) were written to test objective No. 16 and a mark was awarded for the selection of the most logical or scientific answer. The six sub-items in Item 7 (Appendix 4-8) were written to achieve the same end but, in addition, a written explanation of why a response was chosen was requested. An additional mark was awarded for a logical explanation.

4.2 Organisation and Administration

It was decided to administer the pretest to pupils in three schools in a county in West Central Scotland. A letter was sent to the Director of Education giving information and requesting permission to contact the three Head Teachers. This was granted, and letters to Head Teachers, with accompanying letters to Principal Teachers of Chemistry, were sent outlining the nature and aims of the research project, assuring anonymity and requesting cooperation. This also was granted and about 40 questionnaires were despatched, with instructions, to each of the participating schools. In addition, a form for comments on the pretest (Appendix 4-9) was sent to the Principal Teacher of Chemistry. The conclusions reached from these comments are discussed in Chapters 4.4 and 5.1.

4.3 Pretest sample

Since the questionnaire was eventually to be administered to a large number of pupils from all types of schools, the

sample chosen in the pretest had to reflect, as far as possible, the schools and pupils for whom it was intended, so that difficulties in interpretation, phraseology and the time required to answer the questionnaire could be obviated. For this reason, of the three schools chosen, one was a 6-year comprehensive, one a Senior High School, and one a Junior High School. All were co-educational schools offering a wide range of S.C.E. subjects at 'O' Grade. Principal Teachers of Chemistry were asked to allow about 20 pupils who were following at least one science subject to answer the questionnaire and also the same number of non-Science pupils. An approximately equal number of girls and boys was requested as was the requirement that science and non-science pupils should be matched for I.Q. In all, 124 pupils completed a questionnaire. The pupils were chosen from an area where workers could be described as both 'blue and white collar', and who resided mainly in a large industrial town, although one school contained a large percentage of pupils from rural areas.

4.4 Results of the Pretest

The main purpose of the pretest was to obviate possible difficulties which might arise when a sample of approximately 10 times that used in the pretest was used. However, the inclusion of some statistical findings based on the relatively small sample used in the pretest is not irrelevant in that the methods used to produce the findings give some indication of the procedure to be followed in the analysis

of the main test findings in its earliest stages. It should be emphasised, however, that no great significance was placed on the pretest statistical findings unless they are confirmed and re-stated in the main test results.

Principal Teachers of Chemistry reported that pupils had no difficulty in completing the questionnaire and, in fact, most had completed it in 40 minutes. This prompted the inclusion of a further Item which will be described in Chapter 5.1 and appears in the Appendices to that Chapter. No difficulty was reported in interpretation of the instructions to each Item or of the method by which it had to be answered. All of these were considered to be important factors to eliminate since the administration of the questionnaires was carried out by posting them to the various schools and relying upon the staff at each school to deal with difficulties. The pretest did stimulate a re-appraisal of the format of some of the Items as well as the inclusion of a new one. The results of this re-appraisal are described in Chapter 5.1 in which the modified and extended questionnaire to be used in the main test is described.

Reference is now made to Appendix 4-10 which contains the statistical results of the pretest. For convenience, an abbreviation of the objective being tested is included. Mean scores ($\bar{X}$) and standard deviations (S) were calculated for male and female pupils in each science and non-science category. A mean score for all pupils doing science ($\bar{X}_2$) and a corresponding standard deviation was also calculated(S_2)

as was a mean score for all pupils not doing science ($\bar{X}_1$) and a corresponding standard deviation (S_1). From these results a 't' statistic was calculated from:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sigma\sqrt{\frac{1}{N_1} + \frac{1}{N_2}}} \qquad \text{where } \sigma = \sqrt{\frac{N_1 S_1^2 + N_2 S_2^2}{N_1 + N_2 - 2}}$$

N_1 and N_2 are the relevant number of scores in each case. The two categories compared here were those of science and non-science. It was not considered to be profitable, at this stage, to compare the sub-categories of boys vs girls or science boys vs non-science boys etc. This was, however, done in the main test and is reported in Chapter 5.

Using the 't' statistic, and from relevant tables at the 120 degrees of freedom level, the emergence of significant differences was examined. This is indicated in Appendix 4-10 by a value of $t \geq 1.98$ and it can be seen that in the case of the objectives designated by 'careers', 'value to community' and 'variables', there appears to be a significant difference between science and non-science pupils for these objectives. This difference is at the 5% level of significance i.e. there is only a 5 in 100 chance of these differences having been arrived at by chance. It should, however, be noted that, for the pretest, a test for normal distribution has not been carried out, and, as has been said above, conclusions will not be drawn from results in this work until the large sample is used and until further statistical refinements have been employed.

One major difficulty which the pretest threw into relief was that of the degree of discrimination which could be detected by the Items included. If differences in attitudes exist between science and non-science pupils it is clearly essential that any method produced which is designed to detect and measure such differences must be capable of doing so with as high a degree of sensitivity as possible. One cannot assume too much in the absence of evidence that differences between two categories of pupils exist. It could be that differences do not, in fact, exist. On the other hand the method used may not be sensitive enough to discriminate between categories where marginal differences do exist. In this case further effort must be made in order to increase the discriminating power of the techniques used. Chapter 5.1 describes the efforts that were made in this connection. Where no differences are found after these further efforts, it must be shown by some test of internal consistency that no matter what techniques have been employed to discriminate between attitudes of certain categories, they have been found to be capable of detection and measurement, or they have not, by all of the techniques used. Herein lies the difficulty experienced by the attitude tester who places objectivity above expediency in his procedures. For at what point can he state unequivocally that his findings are not to be questioned further, or his techniques no longer scrutinised in relation to their validity, reliability and discriminating power? In view of these difficulties it is not surprising that the literature survey has thrown up comparatively little

in the way of research of this nature, and that some of it, as has been shown, is contradictory. Nevertheless, it would seem to be essential that work of this kind be carried out no matter what risks of contradiction and derogation are run, for it is only by each successive researcher standing on the shoulders of his predecessors that the highest achievements can be made.

(1) THIS IS NOT A TEST.

(2) YOU ARE ASKED TO READ EACH ITEM ON THE FOLLOWING PAGES AND, IN EACH CASE, PUT YOUR ANSWER (WHICH, IN MANY CASES, IS SIMPLY YOUR OPINION) INTO THE EMPTY "BOXES" PROVIDED. PLEASE USE A BALL-POINT PEN.

(3) PLEASE WRITE YOUR CHRISTIAN NAME ONLY BELOW:-

- - - - - - - - - - - -

(4) PLEASE SCORE OUT "DO" OR "DO NOT" IN THE FOLLOWING SENTENCE SO THAT IT APPLIES TO YOU:-

I DO / DO NOT INCLUDE SCIENCE SUBJECTS IN MY GROUP OF 'O' GRADE SUBJECTS.

THANK YOU FOR TACKLING THESE ITEMS. YOUR EFFORT WILL PROVIDE INFORMATION THAT WOULD OTHERWISE HAVE BEEN IMPOSSIBLE TO OBTAIN.

Appendix 4-2

ITEM 1

Which of the following four subjects - Mathematics, Geography, Chemistry or Modern Studies - do you think would be the MOST important to study if you were preparing for the careers listed below. Place a tick in the box of the subject you think is most important in each case.

Career	Mathematics	Chemistry	Modern Studies	Geography
Farmer				
Accountant				
Banker				
Doctor				
Technical Representative				
Lawyer				
Oil Company Executive				
Architect				
Meteorologist				
Journalist				
Photographer				
Librarian				
House Builder				
Army Officer				
Car Mechanic				
Politician				
Social Worker				

Appendix 4-3

ITEM 2

How do you describe different things? If you had to describe "A Racing Car" you could do it like this:-

Quick	☑	☐	☐	☐	☐	Slow
Important	☐	☐	☑	☐	☐	Unimportant
Safe	☐	☐	☐	☑	☐	Dangerous

The positions of the ticks between the word pairs show that you describe it as very quick, neither important nor unimportant and rather more dangerous than safe.

Use the same method of ticking the box you think most appropriate to describe:-

"A Person studying Chemistry"

Serious	☐	☐	☐	☐	☐	Flippant
Careful	☐	☐	☐	☐	☐	Careless
Responsible	☐	☐	☐	☐	☐	Irresponsible
Kind-hearted	☐	☐	☐	☐	☐	Heartless
Generous	☐	☐	☐	☐	☐	Selfish
Articulate	☐	☐	☐	☐	☐	Inarticulate
Organised	☐	☐	☐	☐	☐	Messy
Exciting	☐	☐	☐	☐	☐	Boring
Friendly	☐	☐	☐	☐	☐	Stand-offish
Thoughtful	☐	☐	☐	☐	☐	Scatter-brained
Well educated	☐	☐	☐	☐	☐	Uncultured
Eccentric	☐	☐	☐	☐	☐	Conforming
Joyful	☐	☐	☐	☐	☐	Gloomy
Interesting	☐	☐	☐	☐	☐	Dull
Precise	☐	☐	☐	☐	☐	Woolly-minded

Appendix 4-4

ITEM 3

How important do you consider the following contributions to the benefit of the people of Britain over the past 100 years? Rate them on the following scale:-

+2 very important
+1 important
0 if you are undecided
-1 of little importance
-2 of very little importance

Put the number of your choice in the box marked "IMPORTANCE" after each subject.

	IMPORTANCE	FREE BOOK
The manufacture of man-made fibres, e.g. Terylene, Nylon		
The rise of the mass media (T.V., radio, Newspapers, cinema)		
The Education Act (1872), setting up State-controlled education		
The introduction of the Welfare State (1948)		
Labour-saving devices (washing machines, vacuum cleaners etc.)		
The growth of the plastics industry (polystyrene, PVC, polythene, etc.)		
The extension of the right to vote (1887, 1918, 1928, 1970)		
The discovery of penicillin		
Use of artificial fertilisers in farming		
Computers		

If, as an introductory FREE OFFER, a Book Club offered you four books on the subjects listed above, tick in the box marked "FREE BOOK" the four you would choose.

Appendix 4-5

ITEM 4

How valuable to the community do you consider the work of the people listed in the table below? Rate them on the following scale:-

+2	Very valuable
+1	Valuable
0	If you are undecided
-1	Of little value
-2	Of very little value

Put the number of your choice in the box marked "VALUE" after the person's name.

Put a tick in the box marked "INTEREST" opposite <u>four</u> of these people you would consider to be the most interesting to meet and to talk to about their work.

	VALUE	INTEREST
A playwright and poet		
Composer of electronic music		
Psychoanalyst		
Prime Minister of Britain		
A Mathematician who wrote a famous work on new fields in mathematics		
Biochemists who discovered the structure of the DNA molecule		
Painter of modern art		
Engineer and famous bridge-builder		
Doctor who did early work on vaccination		
A heart-transplant surgeon		

Appendix 4-6

ITEM 5

Six test runs were made on the same motor-cycle to find out the relative importance of four factors when economical performance is required, i.e. the best miles per gallon (m.p.g.). From the following results, place the four factors (Type of petrol, Average Speed, Town or Country Driving and the Experience of the Driver) in the order in which you think that they are important in giving the best m.p.g. Give the most important factor a letter A in the box provided, the second best a letter B, third C and fourth D.

Test Run No.	Type of Petrol (cost/gallon)	Average Speed on Journey (m.p.h.)	Town or Country Driving	Experienced or Learner Driver	m.p.g. obtained
1	38p	35	Mainly Country	Experienced	125
2	38p	60	Mainly Country	Learner	90
3	38p	60	Mainly Country	Experienced	95
4	38p	35	Mainly Country	Learner	120
5	38p	35	Mainly Town	Experienced	105
6	32p	35	Mainly Town	Experienced	105

Factor	Importance
Type of Petrol	
Average Speed	
Town/Country driving	
Experienced/Learner Driver	

Appendix 4-7

ITEM 6

(1) Natasha, the eminent astrologer, proclaims:- "Due to the alignment of the planets Jupiter and Mars, and the coming ascendency of Saturn, powerful forces will prevail over Sagittarians this month causing them to become moody and ill at ease".

Which course of action satisfied <u>your</u> acceptance or rejection of her proclamation?

(a) Dismiss her as a crank ☐

(b) See if her predictions were in agreement with the facts known about the current position of planets and the behaviour of Sagittarians that month ☐

(c) Accept her judgement as she is very knowledgeable in matters of this kind. ☐

(2) On the way back to Newtown Police Station, Sergeant Lynch remarked, "All the evidence points to Reilly as the burglar. His landlady says he was out all night on the night of the burglary, and three people have identified him as the man they saw running away from the burgled house. We've even found a jemmy back in his flat." "No, Bert," said Inspector Barlow, "it's definitely Anderson. I know we've nothing to pin on him at present, but when you've been in this business as long as I have, you get this feeling, call it 'copper's intuition' if you like. But I just <u>know</u> that Anderson's the burglar."

Of the two opinions about who committed the burglary, whose are you more inclined to accept?

(a) Inspector Barlow, because he's an experienced detective, and his hunches are shrewd? ☐

(b) Sergeant Lynch, because his explanation is based on the known facts of the crime? ☐

(c) Neither, because they are both equally convincing? ☐

(3) / over

(3) Twenty years ago Immanuel Velikovsky published a theory that during the fifteenth century B.C. the Earth was narrowly missed by a comet, and this comet eventually struck Mars to produce the planet Venus.

Which of the following satisfies you as the best method of deciding to approve or to reject Velikovsky's theory?

(a) See what facts of astronomy can be collected to support his theory ☐

(b) Accept the judgement of the thousands of famous scientists who disagree with him ☐

(c) Find out what his qualifications as a scientist are. ☐

(4) A famous atomic physicist has stated that a new radioactive element of atomic number 114 exists.

Which of the following would satisfy you as to the correctness of this?

(a) Believe him, since he is a famous physicist ☐

(b) Carry out experiments to detect this new radioactive element ☐

(c) Accept this, as a great many people have been saying this for fifty years ☐

(d) Believe him as his shrewd guesses have turned out to be correct in the past. ☐

(5) Your teacher has said that when we add 10 ml. of one liquid to 12 ml. of a different liquid, the resulting total volume will always be 22 ml.

Which of the following do you consider the most satisfactory way of deciding whether or not this is correct?

(a) Consult a textbook ☐

(b) Make a calculated guess ☐

(c) Ask another teacher of chemistry ☐

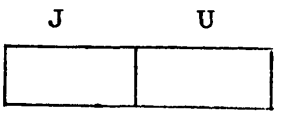
(d) Do experiments with volumes of several liquids. ☐

Appendix 4-8

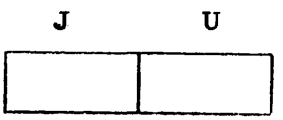
ITEM 7

Read through each of these passages, and then decide whether or not the conclusions that are being drawn in each case are justifiable. If you think that they are justifiable, put a tick in the box "J". If you think that they are not justifiable, put a tick in the box "U". Then explain why you think the conclusion is or is not justifiable in the space below each passage.

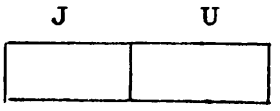
(1) Celtic's 6-1 victory over A.C. Milan last week raises hopes for their prospects in the forthcoming Scottish-Italian competition. If Celts can scrutge the scintillating soccer signors, who are, remember, the Italian champions, then Stein's stunners will steamroller their way over the weaker Italian teams in the tournament.



(2) If sensitive chemical tests cannot detect the presence of copper or zinc in a compound, we can conclude that copper or zinc are absent in that compound.

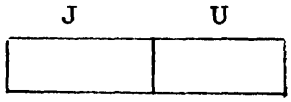


(3) "Of course, Paul, you realise that Raymond Chandler's detective novels are much better than anything Georges Simenon has written."
"Why? Who says so?"
"Oh ... eminent literary critics; they say so."
"And how would I recognise these 'eminent literary critics'?"
"Simple. They prefer Chandler's novels to Simenon's novels."

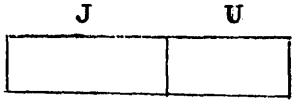


(4) / over

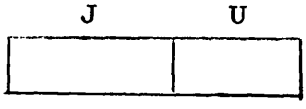
(4) The metal, Scotium, will displace hydrogen from acid. Since this reaction occurs for one metal - Scotium - it will occur for all other metals.



(5) Ghosts do not exist because no one has produced reliable enough evidence to support their existence.



(6) Film makers, responding to changes in the public's tastes, stepped up their emphasis on themes of violence. And what happened? As a result, figures for violent crime during that year showed a dramatic increase.



Appendix 4-9

COMMENTS ON THE PRE-TEST

(1) Did all of the pupils complete the questionnaire within 1 hour? YES/NO

(2) If your answer to (1) was NO, how many had finished within 1 hour?

QUARTER/HALF/THREE QUARTERS/ALMOST ALL

(3) Please underline any item which caused TWO or more questions to be asked about it.

ITEMS: 1, 2, 3, 4, 5, 6, 7

(4) An indication of the difficulties which prompted the questions in (3) would be most helpful.

Thank you for your co-operation with this questionnaire. The results from the large-scale survey will not be available for some time but these will be sent to you in due course.

		Item 1 Careers	Item 2 Chemistry Student	Item 3 Importance to Society	Item 3 Interest and Enjoyment	Item 4 Value to Community	Item 4 Interest and Enjoyment	Item 5 Variables	Item 6 Logical Conclusions	Item 7 Logical Conclusions
Science (girls)	$\bar{X}$	3·04	10·73	4·65	1·65	1·08	0·35	1·50	3·92	6·15
N = 26	S	1·45	4·49	2·22	0·92	0·68	0·48	1·42	0·87	2·25
Science (boys)	$\bar{X}$	2·98	9·02	4·84	1·76	0·67	0·20	1·57	3·24	5·33
N = 49	S	1·13	4·71	1·68	0·98	0·93	0·40	1·31	1·36	2·04
Science (both)	$\bar{X}_2$	3·00	9·61	4·77	1·72	0·81	0·25	1·55	3·48	5·61
N_2 = 75	S_2	1·24	4·68	1·87	0·96	0·88	0·44	1·34	1·28	2·16
Non-Science (girls)	$\bar{X}$	2·84	8·94	4·89	1·37	0·63	0·16	1·11	3·32	6·58
N = 19	S	1·53	2·89	1·33	0·87	0·93	0·36	1·25	1·26	1·96
Non-Science (boys)	$\bar{X}$	3·93	7·37	4·20	1·73	0·30	0·17	0·90	3·13	5·43
N = 30	S	1·31	5·57	1·94	0·81	1·10	0·38	1·14	1·48	2·43
Non-Science (both)	$\bar{X}_1$	3·51	7·98	4·47	1·59	0·43	0·17	0·98	3·20	5·88
N_1 = 49	S_1	1·48	4·81	1·79	0·86	1·06	0·37	1·19	1·41	2·38
t		2·10	1·90	0·90	0·78	2·20	1·05	2·46	1·16	0·66
Significant at 5% level? (Science v non-science means)		Yes	No	No	No	Yes	No	Yes	No	No

Chapter 5

The Main Test

5.1 Design of the Main Test Questionnaire

To ensure that no major difficulties would arise when the main sample of pupils were completing the questionnaire, the information acquired during the Pretest was used. In addition, further thought had been given to the manner in which some Items were scored, and this was taken into account.

Reference is made to the Appendices at the end of this Chapter and, for comparison, to those at the end of Chapter 4.

Appendix 5-1 contains a further assurance that the questionnaire should not be considered to be an 'examination'. Item 1 was modified (Appendix 5-2) so that a Likert-type scale replaced the previous method which was essentially a comparison of the value of chemistry as compared with other subjects. It was considered that a greater commitment would result by providing no alternative to the assessment of Chemistry by the pupils as a basis for the careers listed. In the same way, Item 2 (Appendix 5-3) had previously provided the opportunity to pupils of a 'neutral vote' by including a central column (Appendix 4-3). The inclusion of a sixth column would, it was considered, result in improved polarisation between each word-pair. A scale of +3 to -3 was accordingly introduced. The

Likert scale in Item 3 (Appendix 5-4) was extended to +3 to -3 for the same reason as was also the scale in Item 4 (Appendix 5-5). The descriptions of the people to be assessed in Item 4 were made more explicit and the instructions in the "Interest" test were placed below the list rather than above it where they had been previously placed (Appendix 4-5) since there had been some evidence in the Pretest that pupils had omitted this part, presumably due to the slight change in format from that used in the previous Item. Item 5 (Appendix 5-6) remained unchanged but is included for completeness.

In Item 6 (Appendix 5-7) a further distracter was included in each sub-Item, where possible, so that the number of choices was increased to four, except in one case. It was hoped that this would decrease the element of chance inherent in this Item. The answers to sub-Item (2) were modified to exclude information which would have suggested the correct response. The method of scoring in Item 7 (Appendix 5-8) was altered from a choice of justifiable/unjustifiable to a Likert scale since it had been found that the written explanations asked for in the Pretest (Appendix 4-8) indicated that the pupils were, in some cases, unsure of what the terms employed meant. In addition, it was considered that a scale of marks provides a refinement not given by what is virtually a yes/no response. The written explanation was discontinued since it was difficult to assess from the many replies in the Pretest the score which could validly be assigned to each

since the terminology used by the pupils varied greatly. In addition, the invitation to teenage pupils to write anonymously in a questionnaire had resulted in comments, in some cases, which could not be described as relevant to the enquiry. This occurred especially in the case of the sub-Item referring to a football team, where responses were obviously coloured by partisan loyalties. The sub-Item was subsequently re-worded to include a team which, it was hoped, would allow the pupils to deal with the Item objectively.

The Pretest had shown that the seven Items included in it could comfortably be answered in about 45 minutes. Since the questionnaire was intended to be answered during a double school period (60 to 80 minutes) it was considered that the inclusion of another Item in the main test would be possible, even allowing for the time required for instructions to pupils. The opportunity was taken, therefore, to include an Item which was designed to test the value that pupils placed in scientific method (i.e. objective no. 17 in Chapter 3.5). Item 8 (Appendix 5-9) describes an enquiry which included procedures which, in some cases exemplified accepted scientific method and in other cases were completely spurious. Some procedures were included which fell between these extremes. Again, a Likert-type scale of marks was employed, and initially, a total of the marks assigned to the procedures which would normally be described as 'scientific' was made so that a comparison between science and non-science pupils could be

made. This was followed later by a closer assessment of the importance placed on each procedure by science and non-science categories of pupils. This method of analysis of the results from certain items was widely employed, and is described in 5.4.5 below.

5.2 Organisation and Administration

Twenty six Education Authorities were selected to provide the sample which is described in 5.3 below. A letter was sent to each Director of Education giving information about the proposed test and requesting permission to approach certain Head Teachers. All but three Directors of Education replied to this letter and all who replied gave permission to contact schools. Fifty four schools had been chosen in the twenty six Authorities originally contacted and from the twenty three Authorities who became involved, forty two Head Teachers replied favourably to a letter requesting their cooperation. Of these, three were used in the Pretest. The Principal Teachers were then asked to specify the number of pupils who they could involve in completing questionnaires. Numbers of forty to one hundred were specified and these were despatched to schools with instructions to the supervising teachers. Of the thirty nine schools who had agreed to cooperate in the main test, twenty nine returned the completed questionnaires. Care had been taken that no demands were made on pupils at times when they were involved with preparation for S.C.E. or schedule examinations.

The questionnaires were then marked and the scores transferred to Data Processing Sheets. A punched computer card was then prepared for each pupil and these were then subjected to analysis by the computer programme which had been prepared. The computer programme is induced in the Appendices on Pages 183 to 186.

5.3 Main test sample

The twenty six Education Authorities originally contacted represented the major geographical areas in Scotland and included urban and rural areas, industrial areas and agricultural areas. Both large and small centres of population provided a variety of schools normally associated with such centres including six year Comprehensive, Senior High, Junior High, four year schools who were building towards a six year structure. Certain Grant Aided Schools were included. It is considered that the original fifty four schools would have provided a good representative sample of pupils both in number, and in the manner in which they were distributed among schools of different types. A constraint which is always present in research which is carried out using questionnaires which are not personally administered by the researcher, is that the sample which results is governed by factors over which he has only limited control. Nevertheless, the sample which finally emerged, and on which the main test was based is considered to have been a satisfactory representation from most geographical areas in Scotland and representing most types of communities and schools. Of the twenty nine

schools who returned questionnaires, twenty two were initially described as six year Comprehensives, four as Senior Highs, one as a Junior High, one as a 'Selective Comprehensive' School and one as a Comprehensive school together with a Senior High structure. It was, consequently, difficult to categorise the schools in the climate of changing structures which obtains in this country at present. Further information on the schools was elicited later (Chapter 5.4.7). In total, 1325 pupils completed a questionnaire of whom 721 were girls and 604 boys. All of these pupils were following courses leading to presentation in S.C.E. subjects. Most of the pupils were in the Fourth Year of their secondary education preparing for presentation at 'O' Grade, and the remainder were mainly S5 although some questionnaires were completed by pupils in S6. In each case, however, an approximately equal number of pupils had followed courses which had a science content as those who had not. In each school, Principal Teachers were again asked to match science and non-science pupils with regard to age, sex and I.Q. It must, however, be accepted that a major constraint which must always be taken into account when research of this nature is being carried out, which attempts to assess the contribution to a pupil's education being made by one subject in the curriculum, is that almost all pupils are studying several subjects, most of which are optional and have been chosen from several alternatives. A wide variety of combinations is possible in most schools, and it would be difficult to isolate and compare pupils whose

selection differed only by the inclusion of, for example, Chemistry. In the present work, a 'science pupil' has been defined as a pupil who includes at least one science subject in the group being followed. Nevertheless it is thought that one of these subjects will almost always have been Chemistry since the Principal Teachers of Chemistry involved pupils mainly in their own classes to constitute the science sample. A 'non-science pupil' is, accordingly, a pupil who has not studied a science subject since the S2 year. It would not have been possible to obtain a satisfactory sample of pupils who had never studied at any level, since the common course being followed by most pupils in Scotland contains elements of general science.

5.4 Results of the Main Test

5.4.1 Summary of the comparisons made

One of the stated aims of this work is that of determining whether or not certain affective objectives have been attained by pupils following S.C.E. Chemistry courses. As has been mentioned earlier (Chapter 3) a serious obstacle to this arises if specific criteria in defining and assessing such objectives have not been laid down, and as has been observed, affective objectives are peculiarly difficult to specify in this way, and reservations have been stated, in this connection, when considering the affective objectives now being examined. Recourse is therefore made to the more pragmatic method of relating the attainments, in these objectives, made by pupils

who have studied the science subject under consideration, with those of a control sample of pupils who have not studied the subject. Further comparisons will also be made between other categories of pupils according to differences in sex and in the type of school in which they have studied the subject. Further categories could, of course, be assembled according to, for example, age, geographical location or other subjects being studied but these have not been possible due to inevitable limitations in the scope of the work which must be imposed. It will be seen that the procedures adopted in making these comparisons changed as a result of statistical evidence which emerged, and these changes are briefly explained so that any future workers in this field may benefit not only from an indication of avenues which can be explored fruitfully, but also from an indication of routes which ultimately can prove to be sidetracks.

5.4.2 Comparison of means of various science and non-science categories

Reference is made to Tables 1, 2 and 3 on Pages 81, 85 and 86 where the comparisons of means and standard deviations have been made in Items 1 to 11 for the following categories: girls science vs girls non-science, boys science vs boys non-science, and all science pupils vs all non-science pupils. As has been seen in Chapters 4.1 and 5.1 the Items on the questionnaire in some cases gave rise to sub-Items. These are included in the eleven

TABLE 1

Item	Science Pupils Mean	Science Pupils Std Dvn	Non-Science Pupils Mean	Non-Science Pupils Std Dvn	Difference in Means	Error (1)	z_1	Error (2)	z_2
1	-0·99	11·03	-4·33	10·99	3·34	15·57	0·21	0·61	5·48
2	22·41	9·52	18·90	11·89	3·52	15·23	0·23	0·51	6·91
3	0·26	2·53	0·00	2·70	0·26	3·70	0·07	0·15	1·74
4	9·50	3·57	8·35	2·60	1·15	4·42	0·26	0·17	6·77
5	1·47	1·66	0·88	1·19	0·58	2·04	0·28	0·08	7·26
6	9·12	2·41	8·24	2·80	0·89	3·69	0·24	0·15	5·93
7	1·56	1·70	1·17	1·39	0·39	2·20	0·18	0·09	4·33
8	1·73	1·36	1·50	1·33	0·23	1·90	0·12	0·08	2·88
9	3·51	1·35	2·66	1·39	0·85	1·93	0·44	0·09	10·62
10	-2·02	3·47	-1·68	3·36	-0·35	4·83	-0·07	0·19	-1·84
11	7·12	4·64	6·33	4·39	0·80	6·38	0·13	0·25	3·21

Note:

a) Error (1) $= \sqrt{\sigma_1^2 + \sigma_2^2}$ $\qquad z_1 = \dfrac{\text{Difference in Means}}{\text{Error (1)}}$

b) Error (2) $= \sqrt{\dfrac{\sigma_1^2}{N_1} + \dfrac{\sigma_2^2}{N_2}}$ $\qquad z_2 = \dfrac{\text{Difference in Means}}{\text{Error (2)}}$

(σ and N are Std. DVNS and numbers in the sample respectively)

c) A value for $z_2 > 1{\cdot}96$ indicates a significant difference in means at the 5% level

d) A value for $z_2 > 2{\cdot}40$ indicates a significant difference in means at the 1% level

e) A value for $z_1 < 1{\cdot}00$ is an indication that a significant difference in means may be absent. It should also be noted that this is a preliminary and imprecise method of testing for the existence of significant differences in means.

Items mentioned above and were similarly designated 1 to 11 in the computer print-outs. For convenience, an abbreviated indication of the objective each Item was designed to assess is given below, and will be applicable in all appendices derived from computer print-outs.

ITEM	Questionnaire Item No	OBJECTIVE
1	1	Chemistry as a basis for careers
2	2	Contribution of Chemistry to the individual (general)
3	2	Contribution of Chemistry to the individual (specific)
4	3	Importance of Chemistry to the Community
5	3	Interest and enjoyment in Chemistry
6	4	Importance of Chemistry to the Community
7	4	Interest and enjoyment in Chemistry
8	5	Influence of variables in experiments
9	6	Drawing conclusions from relevant information
10	7	Drawing conclusions from relevant information
11	8	Commitment to apply a scientific approach

An inspection of the means and standard deviations for some Items (e.g. Item 1 on Table 1) gave cause for concern as regards the assumption of normal distribution due to the relatively high values of the standard deviations, and the 'errors' were initially calculated from:

$$\text{error (1)} = \sqrt{\sigma_1^2 + \sigma_2^2}$$

where σ_1 and σ_2 are the standard deviations.

A value for z_1 was then calculated from:

$$z_1 = \frac{\text{Difference in Means}}{\text{Error (1)}}$$

using the mean scores of the science and non-science categories for all pupils. The data is shown on Table 1 together with values for the error (error (2)) and the corresponding values for z_2 derived from them. These second values assume normal distribution and

$$\text{error (2)} = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}$$

where N_1 and N_2 are the numbers in each category. A value of z_1 or $z_2 > 1.96$ indicates a significant difference in means at the 5% level and a value > 2.40 indicates a significant difference in means at the 1% level. As can be seen, only if normal distribution is assumed and the value of z_2 taken, does a significant difference between the two categories emerge and that in all Items except 3 and 10.

The importance of testing for normal distribution was therefore evident and χ^2 values were calculated for science pupils for each Item. Values ranging from 29.80 (Item 9) to 2016.86 (Item 11) were obtained. On reference to tables of percentile values for the χ^2 distribution and using the appropriate number of degrees of freedom for each Item, it was found that normal distribution could not be assumed in this category for any Item. For this reason, reservations must be made when the results

from this initial attempt to analyse the questionnaire scores are examined. At this point, a major re-appraisal of the methods of analysis was made, although, as will be seen below, examination using the same methods were in train for other categories of pupils. As will be mentioned in the next sub-chapter, the results which emerged are included, not only for reference, but as an illustration of the various methods which can be employed to analyse data of this kind and, more important, of how such methods, without rigorous examination, could cause conclusions to be drawn invalidly. It is hoped that it will be clearly shown in Chapter 5.4.4 that the necessity to re-appraise the methods of analysis, in fact produced results which would otherwise have remained unobserved.

Tables 2 and 3 show the results of comparing categories of girls science vs girls non-science and boys science vs boys non-science. Again significant differences are observed between the science and non-science means in these cases when normal distribution is assumed but never when normal distribution is not assumed, and again, the same caveat must be entered. It is a matter of speculation, as well as concern, as to the reasons why normal distribution did not result from the above Items. Assuming homogeneity of the sample (the absence of which would be one reason for a distribution other than normal) it may be that a characteristic of some attitude assessment tests is that it is much more unlikely that the standard of 'difficulty' of the test can be

TABLE 2

Item No.	Girls Science Mean	Girls Science Std Dvn	Girls Non-Science Mean	Girls Non-Science Std Dvn	Difference in Means	z_1	z_2
1	-0•18	11•03	-4•57	10•97	4•39	0•28	5•34
2	23•12	9•04	18•54	11•82	4•58	0•31	5•89
3	0•23	2•48	-0•09	2•76	0•32	0•08	1•64
4	9•65	4•78	8•36	2•61	1•29	0•24	4•38
5	1•46	2•00	0•91	1•12	0•55	0•24	4•44
6	9•18	2•30	8•17	2•74	1•01	0•28	5•38
7	1•68	1•26	1•23	1•29	0•45	0•25	4•72
8	1•72	1•37	1•48	1•31	0•24	0•13	2•39
9	3•41	1•57	2•69	1•38	0•72	0•34	6•48
10	-1•96	3•12	-1•80	3•31	-0•16	0•03	0•66
11	7•49	4•44	6•68	4•09	0•81	0•13	2•53

The notes on Table 1 apply also to the above data.

TABLE 3

Item No	Boys Science Mean	Boys Science Std Dvn	Boys Non-Science Mean	Boys Non-Science Std Dvn	Difference in Means	z_1	z_2
1	-1·58	10·99	-3·74	11·03	2·16	0·14	2·10
2	21·89	9·81	19·80	12·00	2·09	0·14	1·95
3	0·28	2·57	0·23	2·53	0·05	0·01	0·20
4	9·39	2·32	8·33	2·57	1·06	0·31	4·54
5	1·47	1·36	0·83	1·34	0·64	0·20	2·66
6	9·08	2·49	8·41	2·92	0·67	0·17	2·55
7	1·48	1·96	1·01	1·61	0·47	0·18	2·96
8	1·74	1·35	1·55	1·36	0·19	0·10	1·50
9	3·59	1·15	2·59	1·40	1·00	0·55	8·01
10	-2·06	3·71	-1·35	3·47	-0·71	0·14	2·16
11	6·85	4·75	5·43	4·97	1·42	0·21	3·10

The notes on Table 1 apply also to the above data

adjusted to meet the average 'ability' of the sample with accuracy. The words 'difficulty' and 'ability' have been placed in inverted commas since, in the context of attitude measurement, they are imprecise and do not convey the concepts involved. In a sense, this may be illustrative of an inherent constraint in many attitude measurements which are subsequently exposed to statistical methods more often used to analyse parameters such as cognitive test scores or I.Q. i.e. a normal distribution must not only not be assumed, but, in fact, its absence accepted as the more likely result when assessing a concept as complex as an adolescent's attitudes, especially in relation to criterion-referenced objectives. Reference to this will be made later in Chapter 6.2 when suggestions for further work are being considered. It must also be accepted that a more rigorous treatment of the pre-test results may have indicated this difficulty in advance of the main test, although it does not follow that even a major re-appraisal of the testing instrument would have obviated the difficulty.

5.4.3 Comparison of means of further categories of pupils

Following the comparison of means between science and non-science categories of pupils as described in the preceding sub-chapter, it had been decided to compare other categories of pupils in the same way. The computer had been programmed to provide the following comparisons and the resulting data appears in the Tables listed:-

TABLE 4

	Girls		Boys		Difference		Norm	
	Mean	Std. Dvn	Mean	Std. Dvn	1-2	Error(1)	Error(2)	z
1	-2•57	11•21	-2•13	11•04	-0•44	15•74	0•61	0•71
2	20•63	10•89	21•35	10•46	-0•73	15•09	0•59	-1•24
3	0•06	2•64	0•27	2•56	-0•21	3•68	0•14	-1•48
4	8•95	3•81	9•12	2•43	-0•17	4•52	0•17	-0•98
5	1•16	1•61	1•31	1•38	-0•15	2•12	0•08	-1•77
6	8•63	2•60	8•91	2•62	-0•28	3•69	0•14	-1•93
7	1•44	1•30	1•36	1•89	0•08	2•29	0•09	0•83
8	1•59	1•34	1•69	1•36	-0•10	1•91	0•07	-1•37
9	3•02	1•51	3•33	1•29	-0•32	1•99	0•08	-4•09
10	-1•87	3•23	-1•88	3•66	0•00	4•88	0•19	0•03
11	7•05	4•27	6•49	4•85	0•56	6•46	0•25	2•22

The notes on Table 1 also apply to the above data

TABLE 5

	Comprehensive		Others		Difference		Norm	
	Mean	Std. Dvn	Mean	Std. Dvn	1-2	Error (1)	Error (2)	z
1	-0•97	11•10	-1•06	10•83	0•09	15•51	0•90	0•10
2	22•45	9•65	22•29	9•09	0•17	13•26	0•77	0•22
3	0•47	2•49	-0•36	2•54	0•83	3•56	0•21	3•98
4	9•45	2•16	9•66	6•11	-0•22	6•48	0•45	-0•49
5	1•46	1•81	1•49	1•11	-0•03	2•12	0•11	-0•27
6	9•24	2•28	8•78	2•76	0•45	3•58	0•22	2•07
7	1•50	1•34	1•76	2•50	-0•26	2•83	0•19	-1•37
8	1•76	1•38	1•65	1•26	0•11	1•87	0•11	1•05
9	3•52	1•41	3•50	1•12	0•03	1•80	0•10	0•26
10	-2•13	3•21	-1•69	4•15	-0•44	5•25	0•33	-1•35
11	6•68	4•81	8•45	3•77	-1•77	6•11	0•34	-5•26

The notes on Table 1 also apply to the above data

Comparison of means	Table
Girl pupils/Boy pupils	4
Pupils in comprehensive schools/ Pupils in schools other than Comprehensive	5

Here again, normal distribution of scores could not be assumed but the value of z which appears on the tables has been calculated from the 'normal error' quoted which does assume normal distribution. The emergence of an apparently significant difference between means in these categories has been marked by an asterisk for the Items concerned but again, the same reservations are made as in the previous sub-chapter.

These results, together with the caveats entered, have been included however, not only for completion of the computer programme which had been prepared to produce them, but also to provide a reference to which the results which emerged during the next stage in the analysis of the data can be made. The comparison may indeed produce a great deal of food for thought concerning the treatment of data emanating from attitude measurements of this nature.

5.4.4 Percentage frequency of scores for each Item for various categories

Following the difficulties explained above concerning the distribution of the total scores for each Item for various categories of pupils, it was decided to prepare a computer programme which would provide the percentage

TABLE 6

Percentiles of χ^2

Item No.	Girls Science vs Boys Science	Girls Science vs Girls Non-Science	Boys Science vs Boys Non-Science	Science vs Non-Science
1	0•05	5•0	10•0	80•0
2	0•05	25•0	10•0	97•0 *
3	25•0	50•0	25•0	80•0
4	1•0	99•0 *	90•0 *	99•0 *
5	95•0 *	99•0 *	99•0 *	99•0 *
6	< 0•05	97•0 *	25•0	99•0 *
7	90•0 *	99•0 *	50•0	99•0 *
8	5•0	75•0	50•0	97•0 *
9	99•0 *	99•0 *	99•0 *	99•0 *
10	5•0	5•0	75•0	90•0 *
11	25•0	25•0	90•0 *	75•0

Note: The percentiles marked with an asterisk indicate significant differences at levels from 1% to 10% as shown.

frequency of the scores attained by the same categories of pupils for each Item. Appendices 5-10 to 5-17 list the raw and percentage frequencies of each possible score in Items 1 to 11. In addition, the same data has been presented graphically in the text for the comparison of certain categories of pupils in Items where significant differences in the scores attained have emerged. χ^2 values were calculated for each category in each Item and percentile values of χ^2 found for the four pairs of categories which were compared. The percentile values of χ^2 for the categories compared are listed in Table 6 for each Item, and where a significant difference is present they have been indicated on the Table.

It can immediately be seen that significant differences, mainly at the 1% level, have been found in all Items except 1, 3 and 11 between the science and non-science categories. This result can be compared with that reported in Chapter 5.4.2 which showed significant differences at the same level for the same categories but in all categories except 3 and 10 i.e. the results are similar in Items 2, 3, 4, 5, 6, 7, 8 and 9. It will also be seen that in Item 9 (concerned with drawing conclusions from relevant information) significant differences have emerged at the 1% level for all of the categories compared. Furthermore, in Items 4, 5, 6 and 7 which could collectively be called those assessing interest and enjoyment coupled with an appreciation of the value of chemistry, significant differences are present between the science and non-science

groups compared in twelve cases out of a possible sixteen. It must be noted that in the light of these results, the reservations made in Chapter 5.4.2 on the subject of normal distribution may appear to have been rather pessimistic in nature. Nevertheless they were made in a desire to attain complete objectivity for any observations made in this work.

No significant differences have been found between any of the pairs of categories compared for the Item assessing the awareness of chemistry as a basis for careers although a significant difference had been suggested by the method of comparison of means made previously. In the Items which tested the pupils' assessment of chemistry's contribution to the full development of the individual (Items 2 and 3) only the comparison of the science and non-science categories produced a significant difference and, as in the method of comparison of means, no significant difference emerged for the science and non-science comparison (or for any other comparison) for Item 3 which considered the specific attributes of a scientist, particularly in connection with the image of 'human' as opposed to 'inhuman' and 'interested in people' as opposed to 'interested in things'. In the next sub-chapter (5.4.5) an examination of the frequency of response to all of the word pairs used in this assessment of the pupils' image of the scientist is made for the various categories.

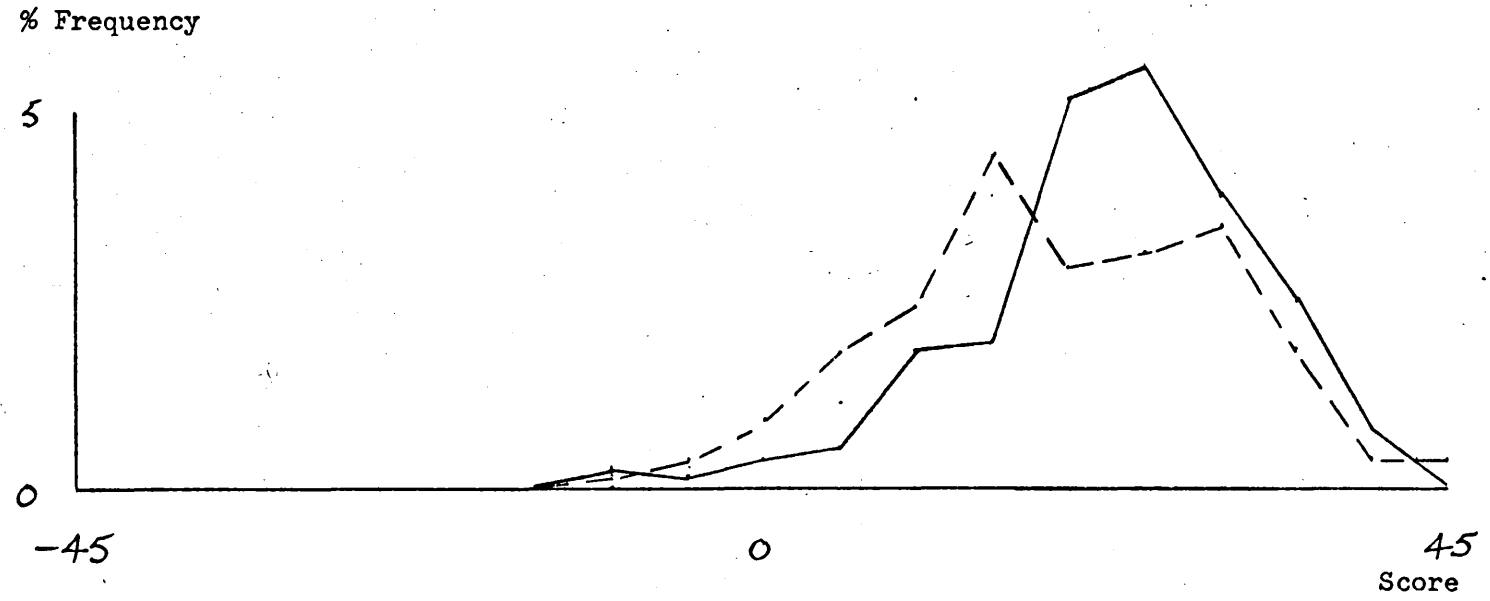
It should be noted that Item 10 produced a significant difference by the method of compared frequencies, whereas

in the previous method no such differences were found. It might have been expected that Items 9 and 10 should have produced similar results since they both tested the pupils' ability to draw conclusions from relevant information. The absence of agreement in the comparison of the categories, with the exception of the science/non-science comparison where agreement was found, is surprising in that Item 10 appeared to be the most discriminating method since it contained a Likert-type scale whereas Item 9 required the selection of a response from four choices. Perhaps the fact that two of the six sub-Items in Item 10 were written in a scientific context as opposed to two of the five sub-Items in Item 9 may have marginally favoured the science pupils in this latter Item.

No significant difference was found between the science and non-science category for Item 11 which was designed to test the pupils' commitment to apply a scientific approach to new situations. However, in the case of boys science vs boys non-science, a significant difference was shown whereas no such difference emerged for similar girls categories.

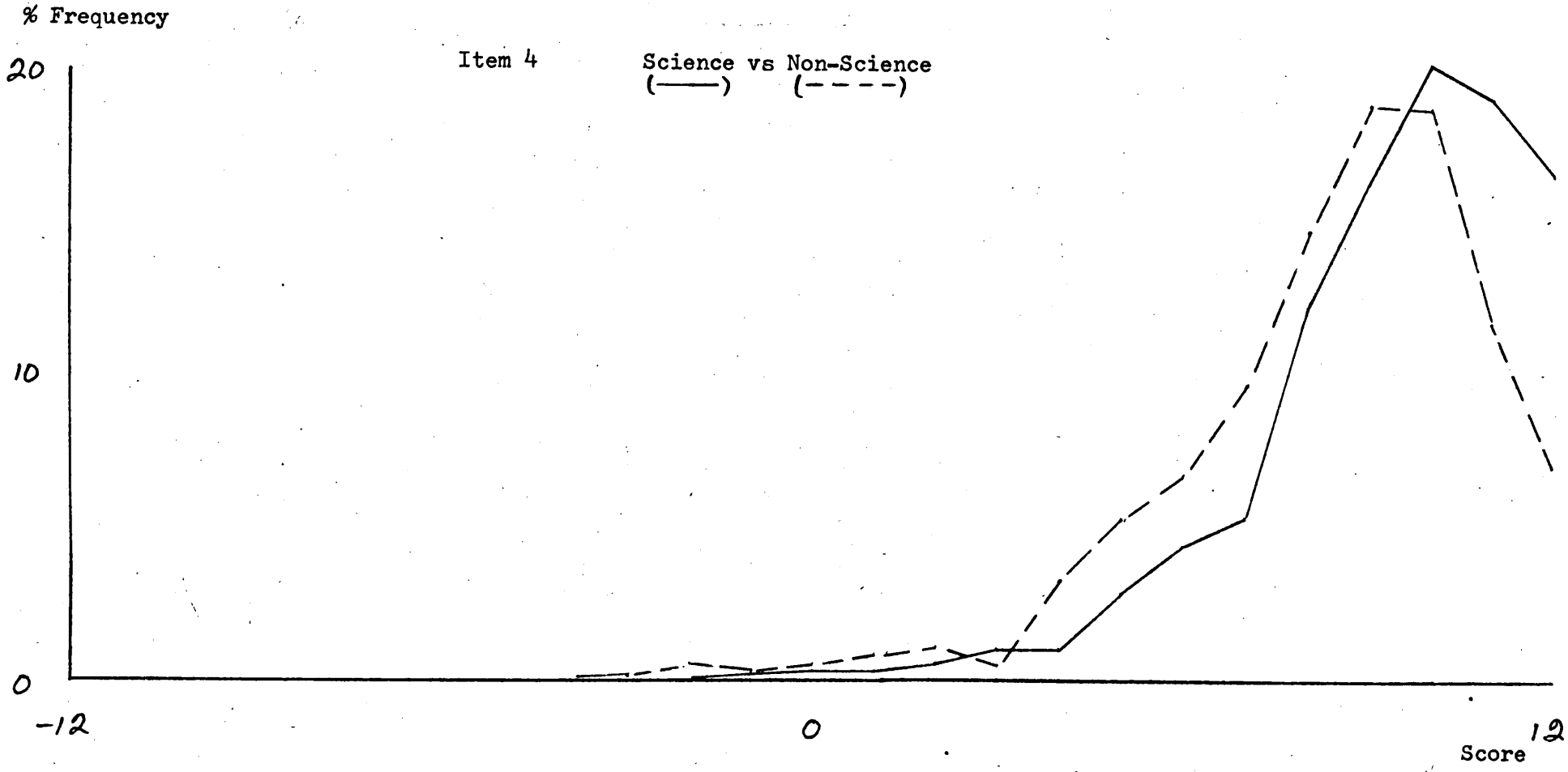
The graphs of the percentage frequencies for all possible scores for Item 2 comparing science and non-science pupils where a significant difference was shown are on Page 95 and indicate that for both of these categories a favourable image of the scientist emerges. In both cases the more desirable characteristics, which were awarded a positive score, have a considerably higher percentage frequency than

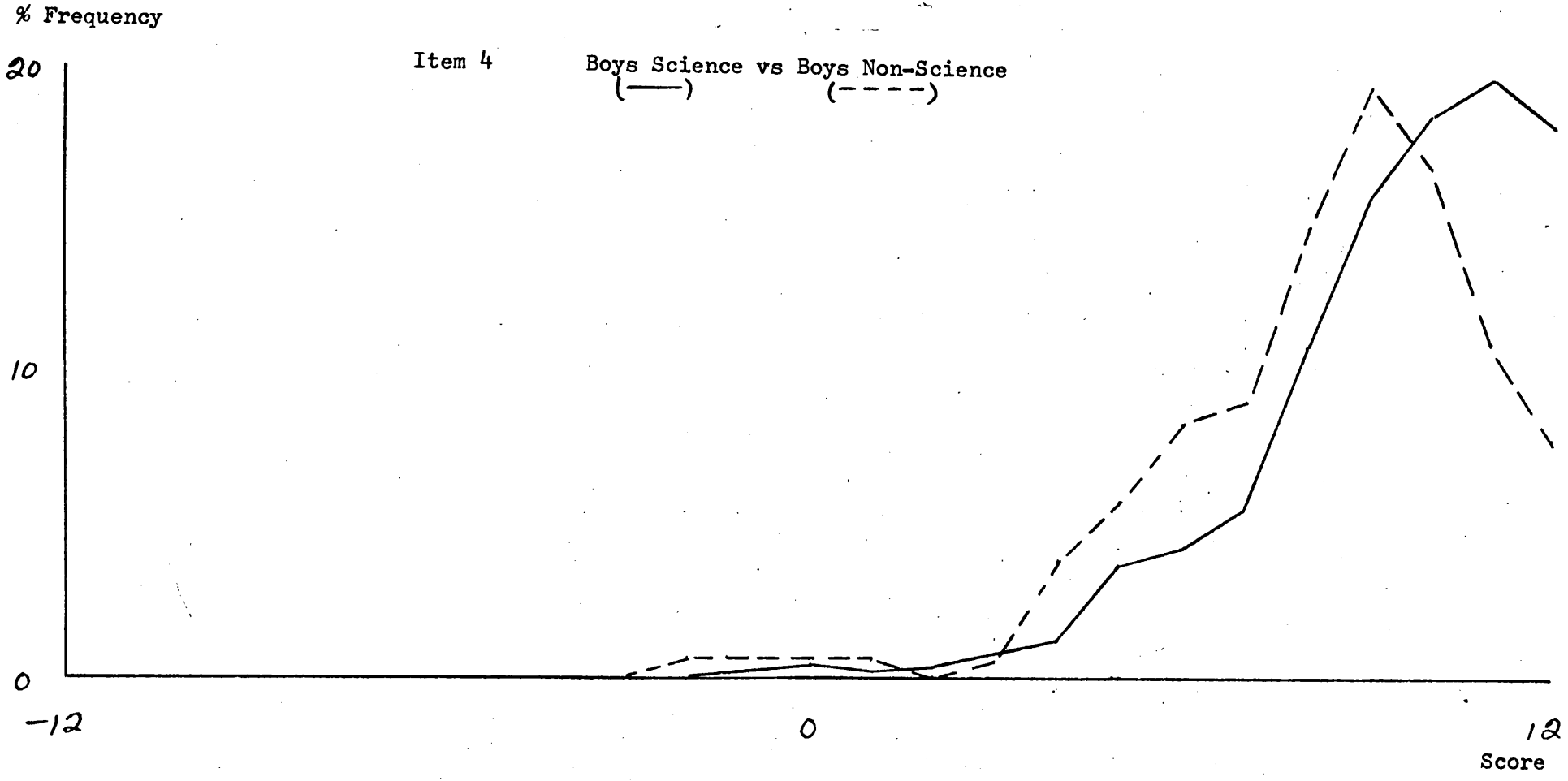
Item 2 Science vs Non-Science
(——) (- - - -)

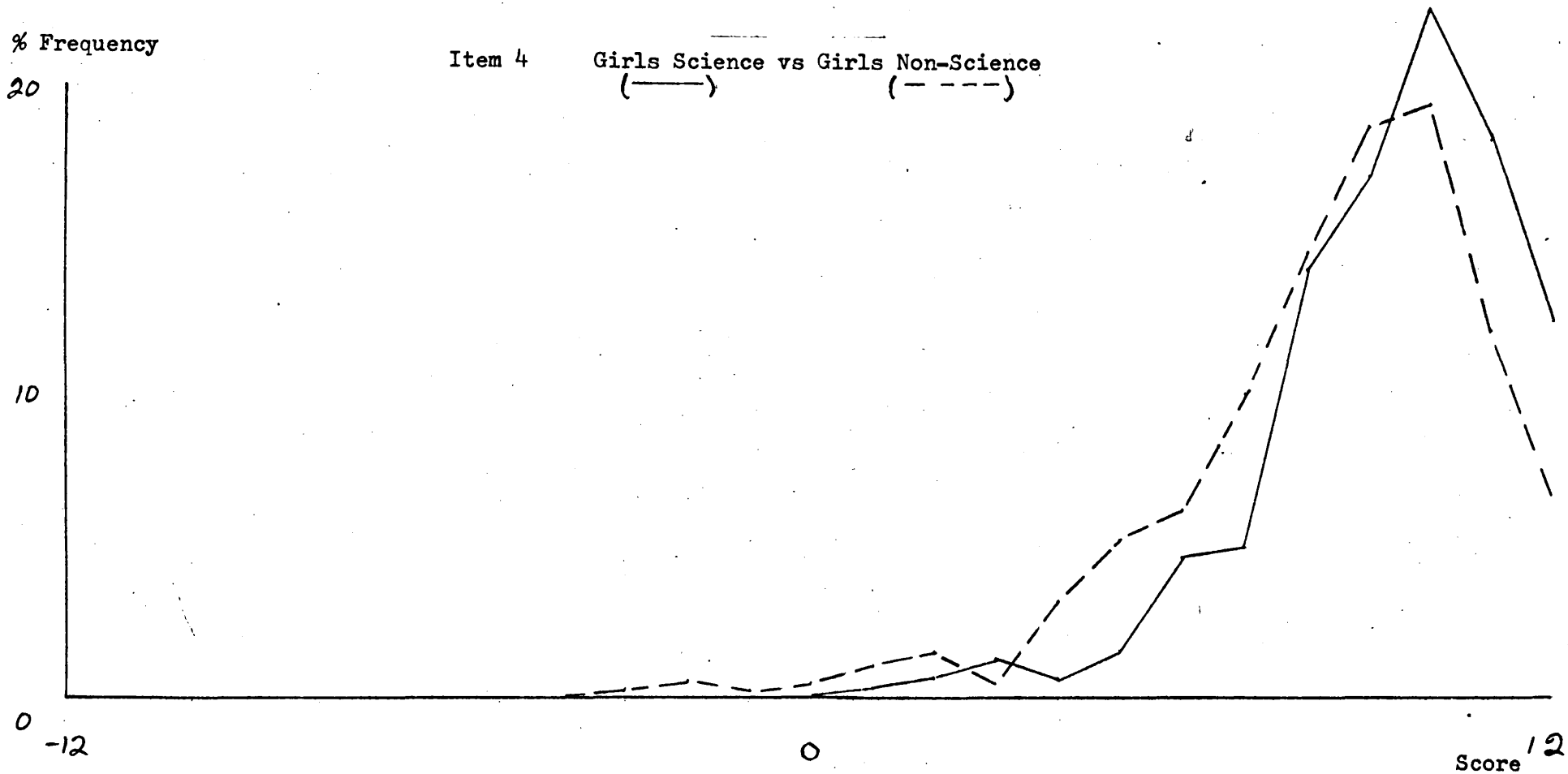


the less desirable and negatively scored characteristics. In this graph only every fifth possible score with its corresponding frequency has been included due to the limitations of the scale, but a clear indication is given of the relative percentage frequencies of the two categories which resulted in a significant difference between them.

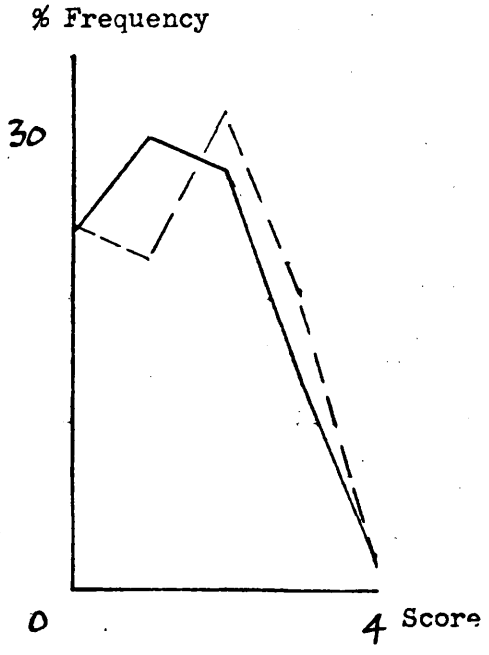
The graphs on Pages 97, 98 and 99 for Item 4 show where significant differences were found and again in both cases a bias towards positive scores is observed. The item, which tested the pupils' appreciation of chemistry's contribution to the welfare of the community shows a good appreciation of the four sub-Items which had an obviously scientific bias and which were the only ones marked. It should be noted here that a closer examination of the items assessing the important affective objectives of interest and enjoyment and the awareness of the importance of chemistry to the individual and to the community viz., Items 1, 2, 4, 5, 6 and 7 has been made in the next sub-chapter (5.4.5). Item 11 has also been similarly examined. The results from Item 5 (interest and enjoyment in chemistry) are shown graphically on Page 100. Significant differences between all categories compared were found here and the percentage frequencies of the five possible scores are shown. Pages 101 and 102 show that in Item 6 which also tested the awareness of the contribution of chemistry to the community, the appreciable frequencies lie on the positive and more favourable side in both cases, with differences between girls science and non-science categories and between


% Frequency
Item 4
Science vs Non-Science
(——) (- - - -)
20
10
0
-12
0
12
Score

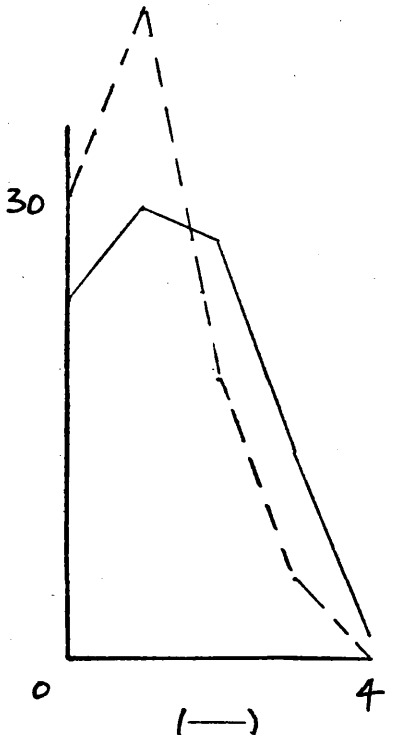

% Frequency
Item 4
Boys Science vs Boys Non-Science
(——)
(- - - -)
20
10
0
-12
0
12
Score


% Frequency
Item 4 Girls Science vs Girls Non-Science
(——) (– – –)
20
10
0
-12
0
12
Score

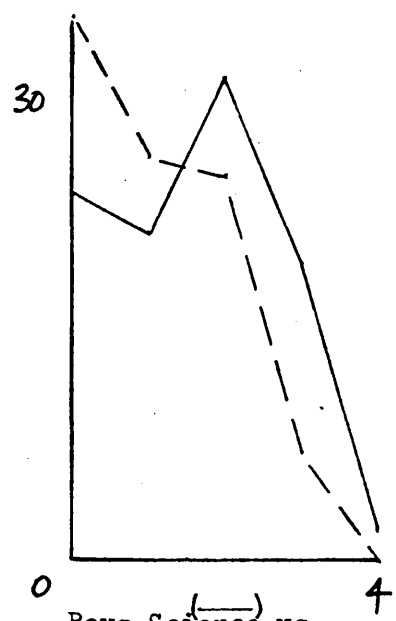
Item 5



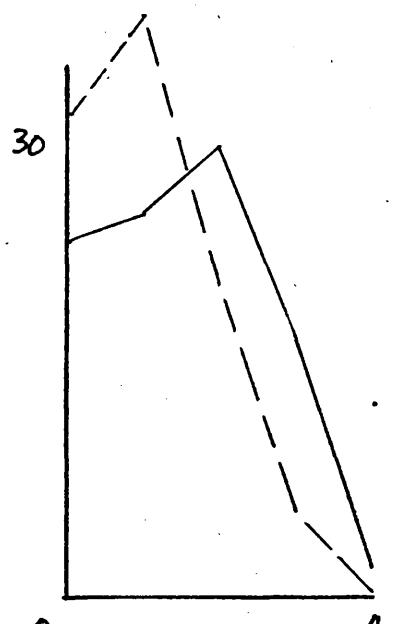
Girls Science vs
(——) Boys Science
(- - - -)



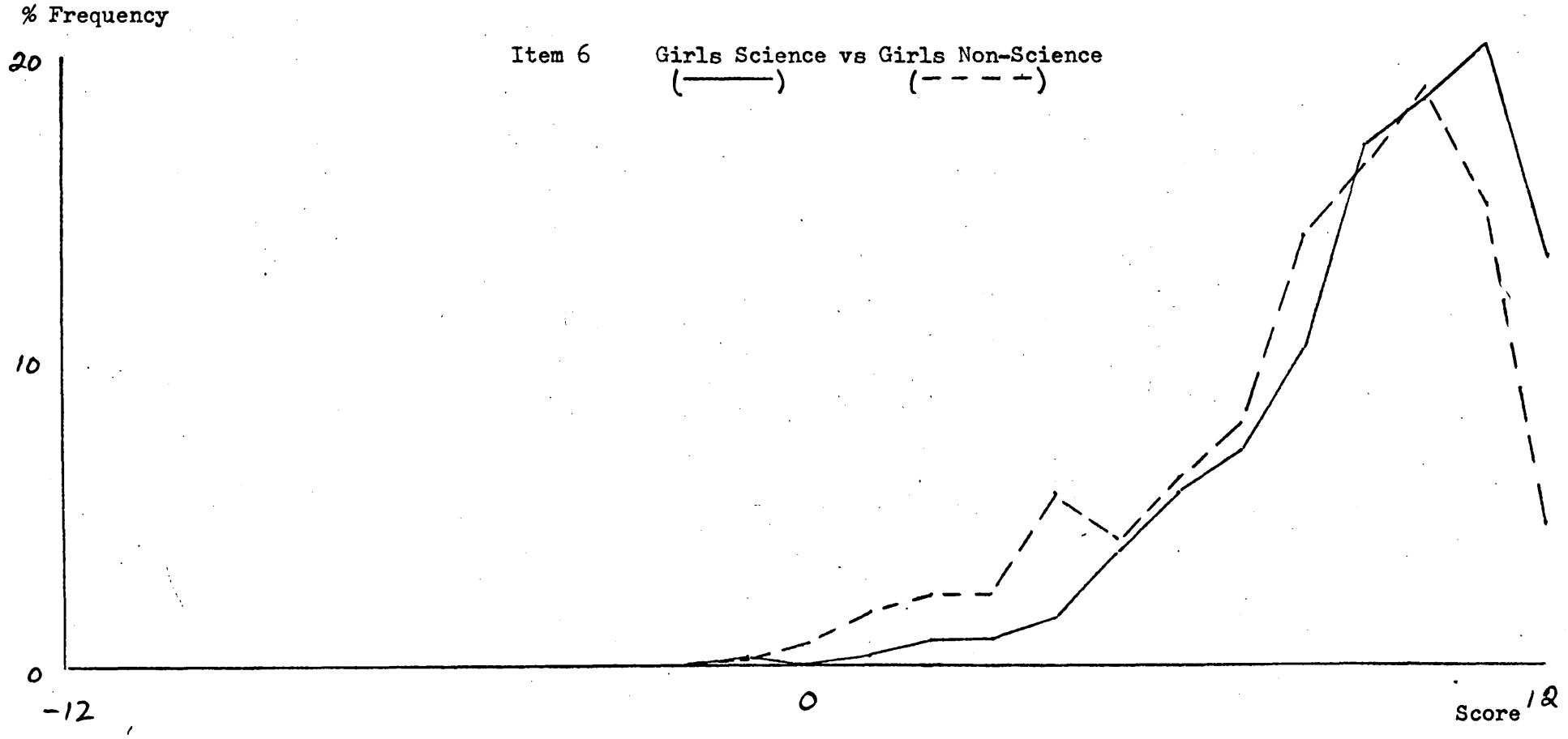
(——)
Girls Science vs
Girls Non-Science
(- - - -)

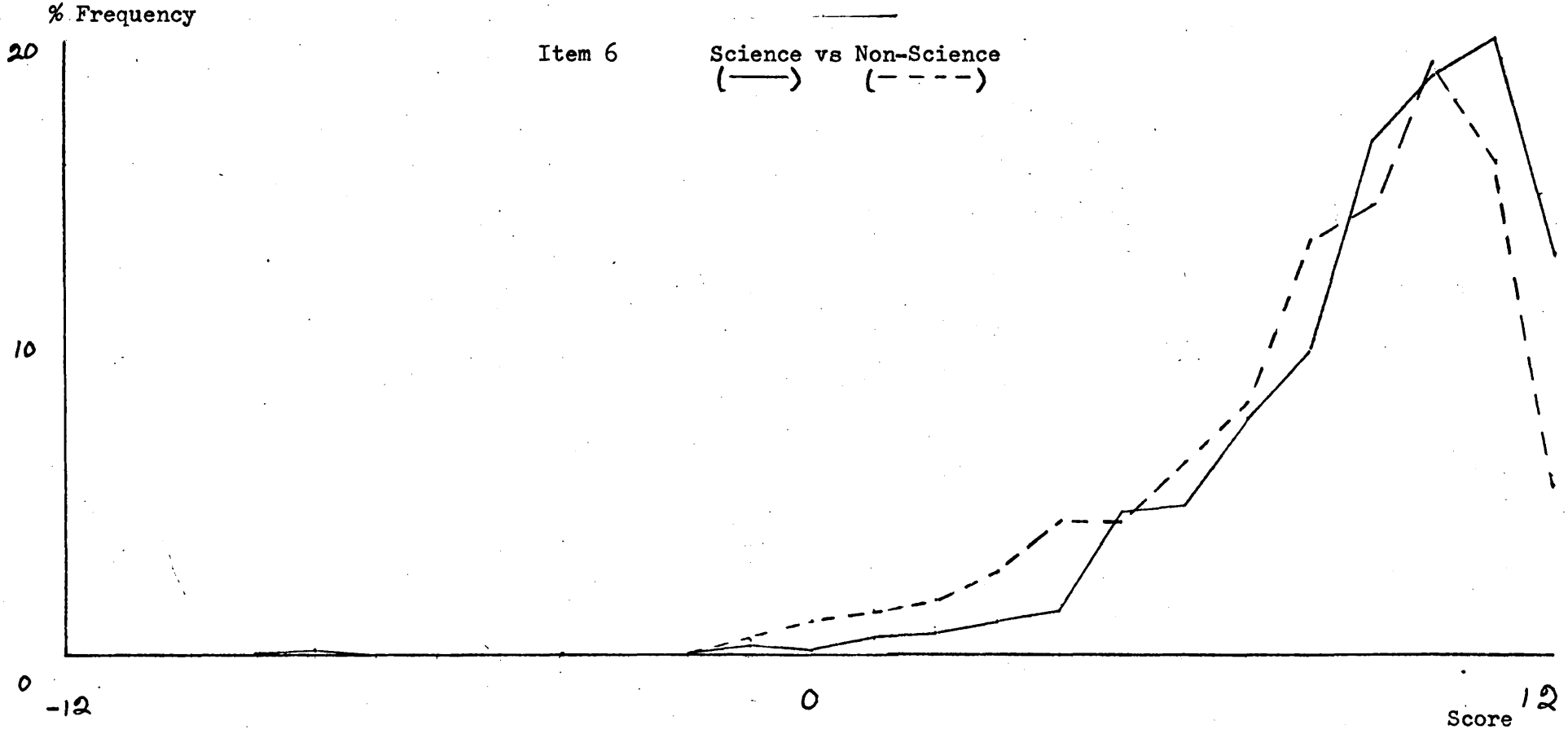


(——)
Boys Science vs
Boys Non-Science
(- - - -)



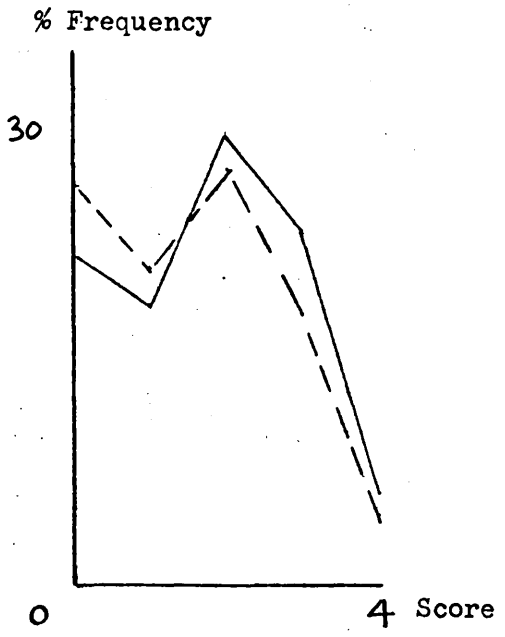
Science vs Non-Science
(——) (- - - -)


% Frequency
Item 6 Girls Science vs Girls Non-Science
(———) (- - - -)
20
10
0
-12
0
12
Score


% Frequency
20
10
0
Item 6
Science vs Non-Science
(——) (- - - -)
-12
0
12
Score

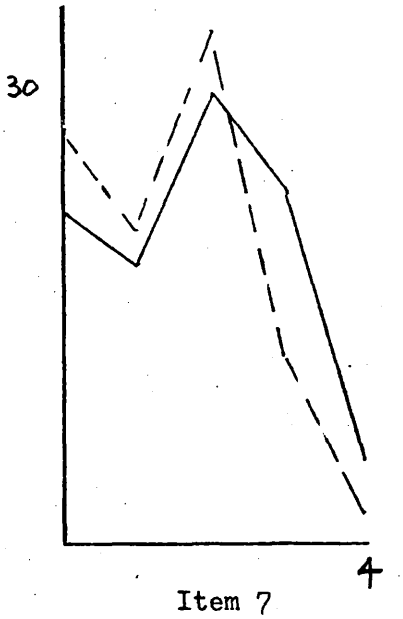
all science and non-science categories sufficient to be significant. The interest and enjoyment objective tested in Item 7 produced significant differences in the three categories indicated on Page 104. The same page also contains graphically the science/non-science result which was significant for Item 8 which assessed the pupils' ability to handle variables. From the graph, it would appear that this result must have been marginal and it would have been interesting here to have known which pupils being assessed were mathematics students. The results from Item 9 testing the ability to draw conclusions from relevant information shown on Page 105 show what appears to be a clear indication that all of the categories compared, with the possible exception of the girls science/boys science, are significantly different in favour of the scientists.

The graphical representation of Item 10 which was similar to Item 9 in its objective shown on Page 106 is interesting in that the Likert scale employed has produced results where both the science and non-science categories of pupils have scored most frequently near the zero point. It is possible here that the format of the sub-items was such that the Likert scale provided an opportunity for pupils to adopt a neutral position since a zero score could be chosen which indicated that the pupil was 'not sure'. Another possibility is, of course, that the nature of the sub-items polarised the scores chosen equally in both negative and positive directions for many pupils. The



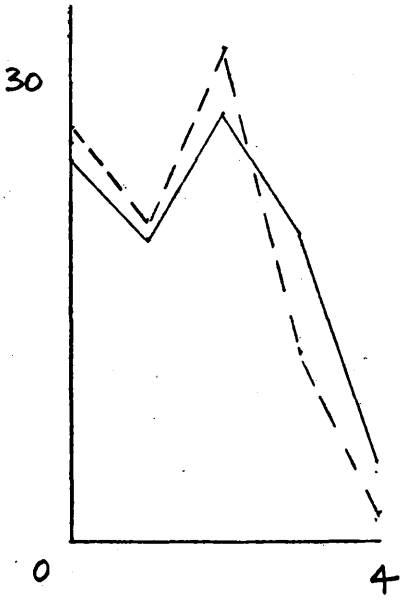
Item 7

Girls Science vs Boys Science
(———) (– – – –)



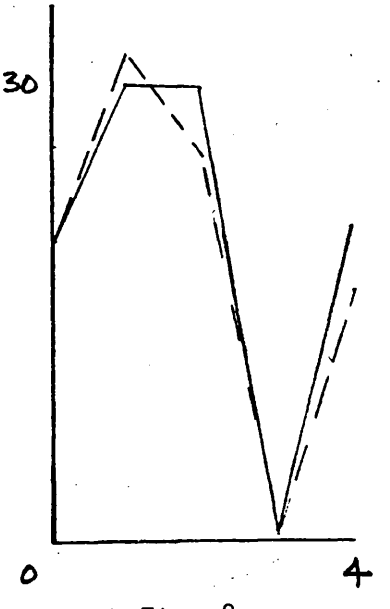
Item 7

Girls Science vs Girls Non-Science
(———) (– – – –)



Item 7

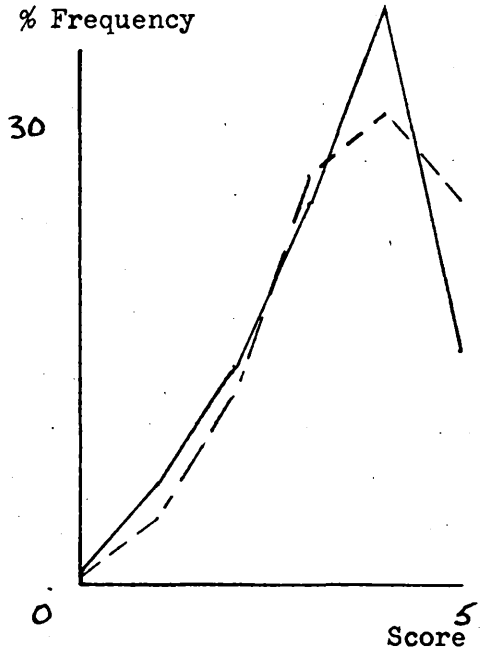
Boys Science vs Boys Non-Science
(———) (– – – –)



Item 8

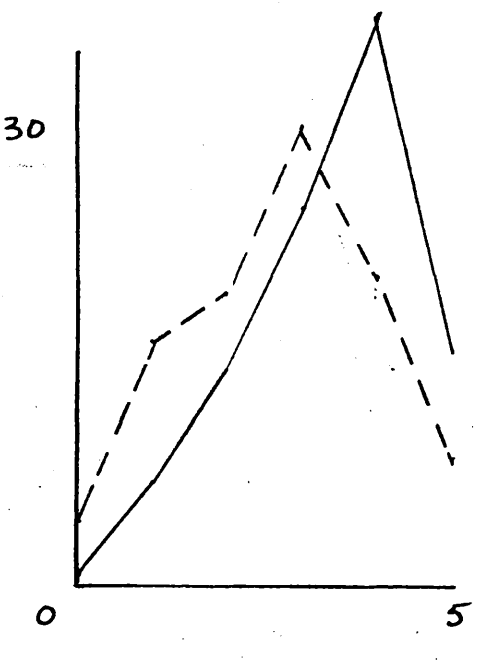
Science vs Non-Science
(———) (– – – –)

Item 9



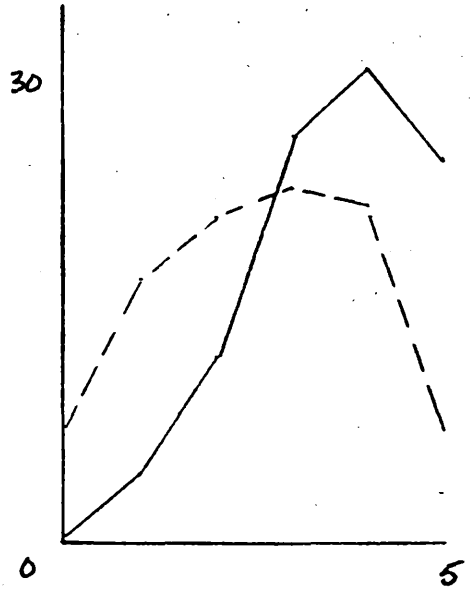
Girls vs Boys

(——) (- - -)



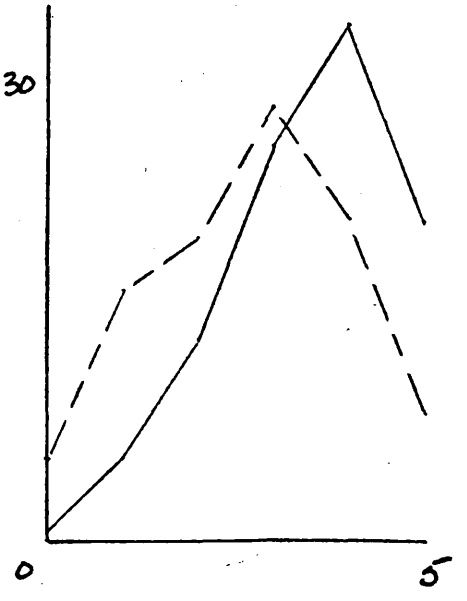
Girls Science vs Girls Non-Science

(——) (- - - -)



Boys Science vs Boys Non-Science

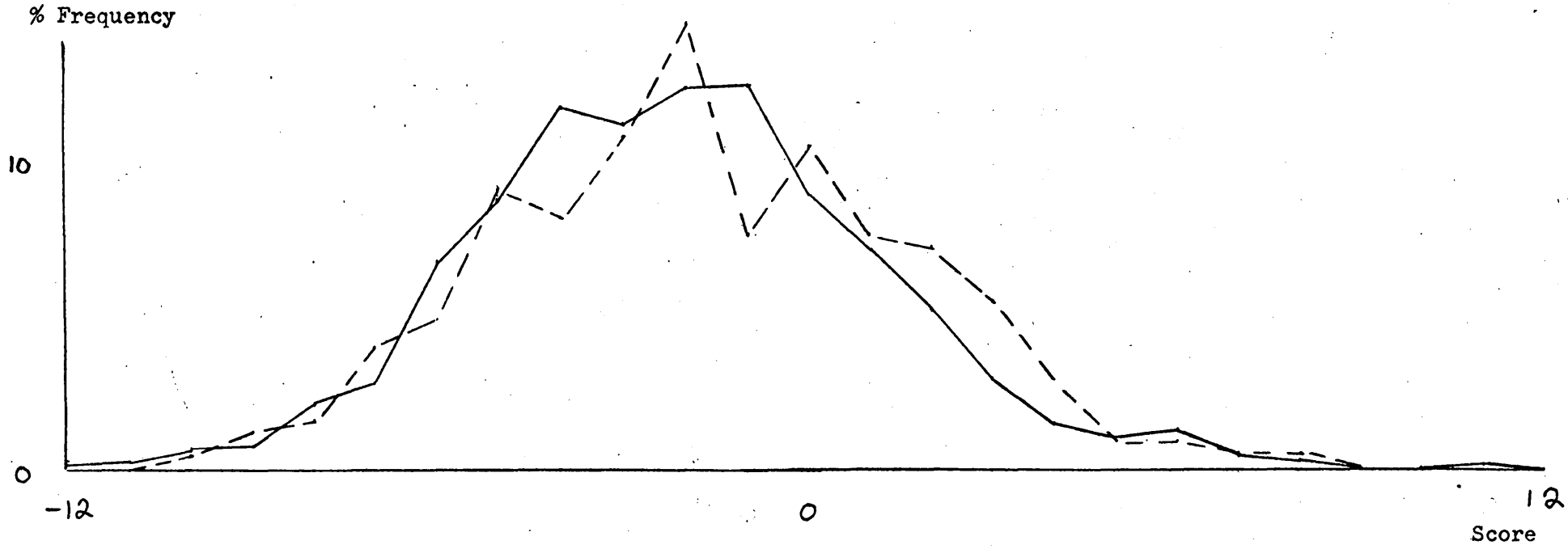
(——) (- - - -)



Science vs Non-Science

(——) (- - - -)

Item 10 Science vs Non-Science
(——) (– – – –)



differences shown on the graphs were sufficient, however, to produce significant discrimination between these categories.

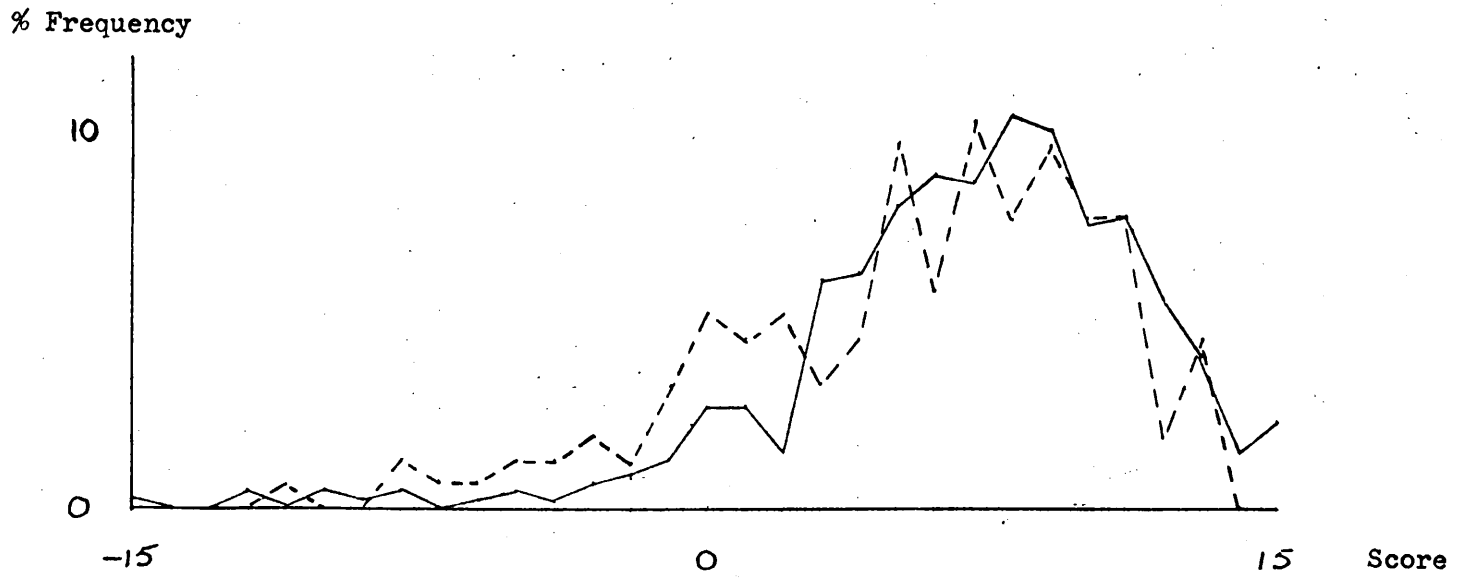
Item 11 produced a significant difference in only the comparison of boys science and non-science categories and the frequency distributions are shown on Page 108. Only the 'scientific' procedures posed in this item were scored, and as can be seen, both of the categories were inclined to accept them as important with a significant difference in favour of the science pupils.

5.4.5 Percentage frequency of scores of sub-items for certain Items for science and non-science pupils

Reservations have already been made concerning conclusions drawn from the method of compared means for categories of pupils in any item. As has been seen, the method of comparing percentage frequencies of scores has been used to analyse the data which the computer programme produced for each of the items subjected to it. A third method will now be reported which was used to present the same data for certain items for science and non-science pupils. This is the subject of this sub-chapter. Chapter 5.4.6 which follows compares the results for the categories of science pupils of comprehensive schools and science pupils of non-comprehensive schools. It can be seen that, in addition to the assessment of affective objectives which was a stated objective of this present work, a secondary, but perhaps equally important finding has

Item 11 Boys Science vs Boys Non-Science

(——) (- - - - -)



evolved as the attempt to present the data as meaningfully and as validly as possible has progressed viz., a critical assessment of accepted methods which have been widely used in previous investigations of this nature to draw conclusions from attitude measurement techniques.

As has been seen in Chapter 1.4 earlier, the designation of certain points on an attitude continuum as, for example, from "very valuable" to "of very little value" has been made in accepted methods by assigning to these points a range of numerical values such as +3 to -3. Two serious indictments of this method can now be made on the basis of the experience gained in the present work:-

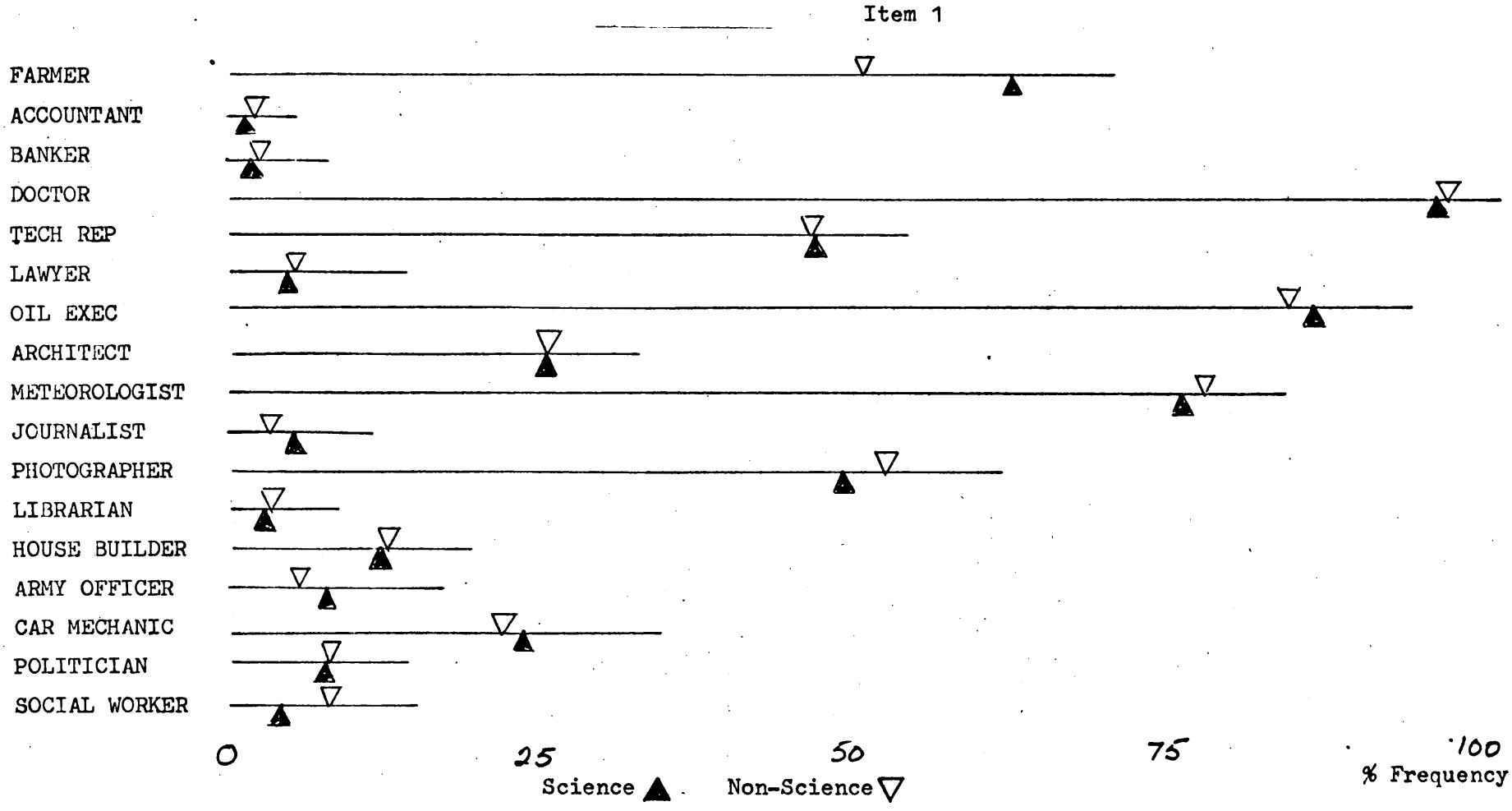
(a) The use of negative numbers in responses for attitude assessment is certain to result in the screening of a great deal of information if the numbers in sub-items are summated. For example, a respondent who has assigned to ten sub-items in a summated item five +3 scores and five -3 scores would appear to have a completely neutral stance on the attitude being assessed whereas, in fact, extreme views are held for those facets of the attitude which have been used in the measurement technique.

(b) Even if negative numbers are not used in an attitude scale, the use of numbers may be dangerous in that, if summated, the assumption is made that the response designated by the numeral 4, for example, is quantitatively twice the value of that designated by 2 and four times the value of that designated by 1. In an attitude response

scale ranging from "very valuable" to "of very little value" there would appear to be very little justification for making this assumption and, in fact, every reason to view with reservations the results produced from such summated scores even although they appear to be statistically viable. It must be said here that many of the reports reviewed in Chapter 2 would be worthy of re-appraisal in the light of the above reservations.

The solution to both of the difficulties indicated above obviously lies in any procedure where the designating scores are not summated, and, in fact, the use of any other method of designation such as letters of the alphabet, would serve instead of numerals. The percentage frequency of selection of each point on the attitude response continuum can then be reported. This method was accordingly used for Items 1, 2, 4, 5, 6, 7 and 11 to compare the selections of science and non-science pupils in this sub-chapter, and comprehensive science pupils and non-comprehensive pupils in the following sub-chapter.

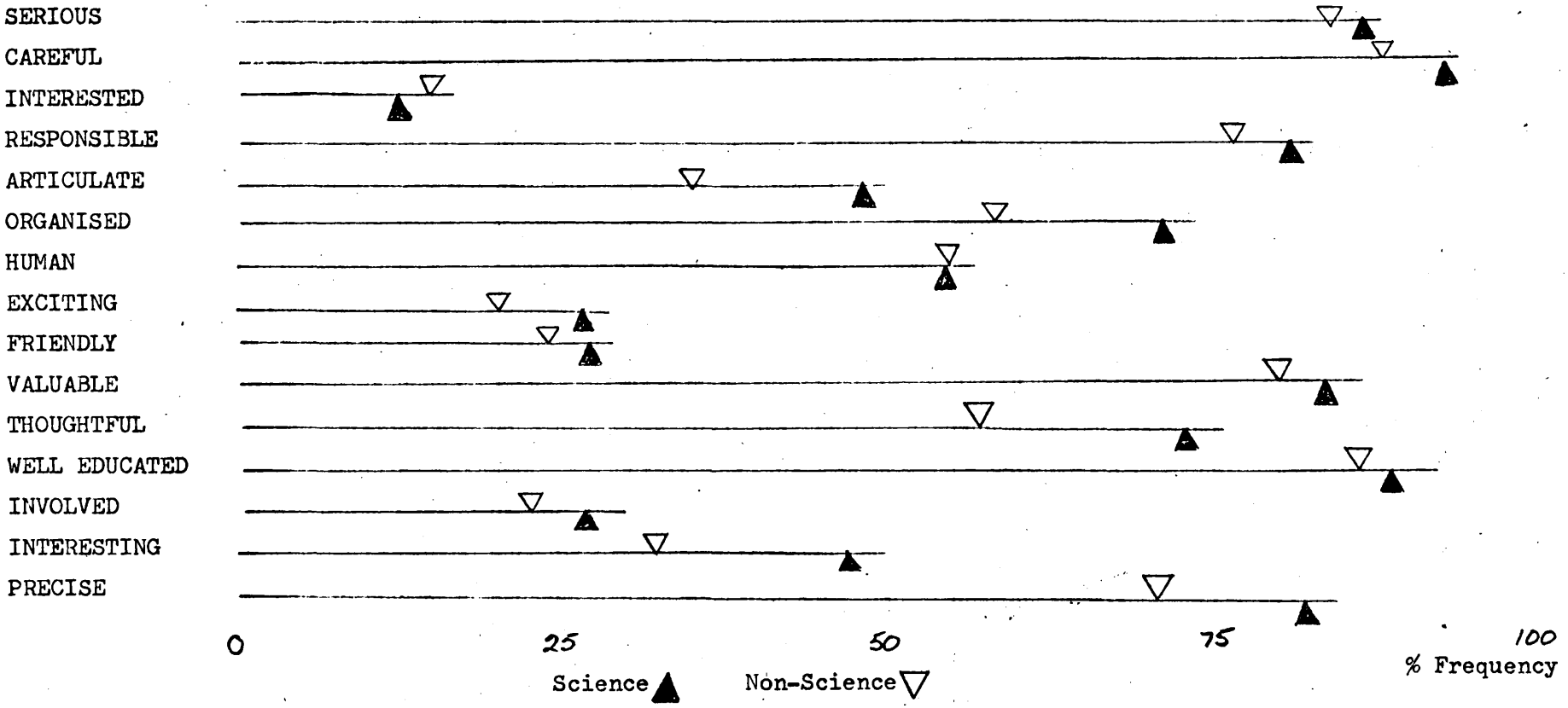
Appendix 5-18 and the graph on Page 111 show the results from Item 1 for science and non-science pupils. The percentage frequency of response in each column for each sub-item is indicated on Appendix 5-18 and the graph shows the total percentage frequency for those responses which fell in the two extreme left columns i.e. those which indicated a favourable response to the question as to whether chemistry provided a valuable basis on which to build many satisfying careers. The two central


Item 1
FARMER
ACCOUNTANT
BANKER
DOCTOR
TECH REP
LAWYER
OIL EXEC
ARCHITECT
METEOROLOGIST
JOURNALIST
PHOTOGRAPHER
LIBRARIAN
HOUSE BUILDER
ARMY OFFICER
CAR MECHANIC
POLITICIAN
SOCIAL WORKER
0
25
50
75
100
% Frequency
Science
Non-Science

columns were considered to represent a fairly neutral view and the two extreme right columns an unfavourable response. Only the two extreme columns have been taken into consideration here, although the examination could have been extended to the other columns. This was not done because of the limitations already expressed. It is not considered that the summation of percentage frequencies from two columns is in any way comparable to the procedures mentioned in (a) and (b) above and therefore not subject to the same criticism. The summation was carried out to achieve, if possible, greater discrimination between the categories of pupils being compared. The same procedure has been carried out for each of the items examined with the exception, as will be seen, of Items 5 and 7. It should be noted that, in all cases, a difference in percentage frequency greater than 3·25 indicates a significant difference at the 1% level.

The results from Item 1 suggest that, in most cases, science pupils cannot be said to have a higher opinion of the value of chemistry as a basis for careers than non-science pupils. Item 2 however (Appendices 5-19 and the graph on Page 113) indicates a more favourable view by science pupils of the contribution of chemistry to the development of the individual as personified by "the scientist". It is interesting to note that no difference in the "human" qualities of the scientist has appeared, whereas the characteristic "involved with people" (abbreviated as most sub-items have been throughout the

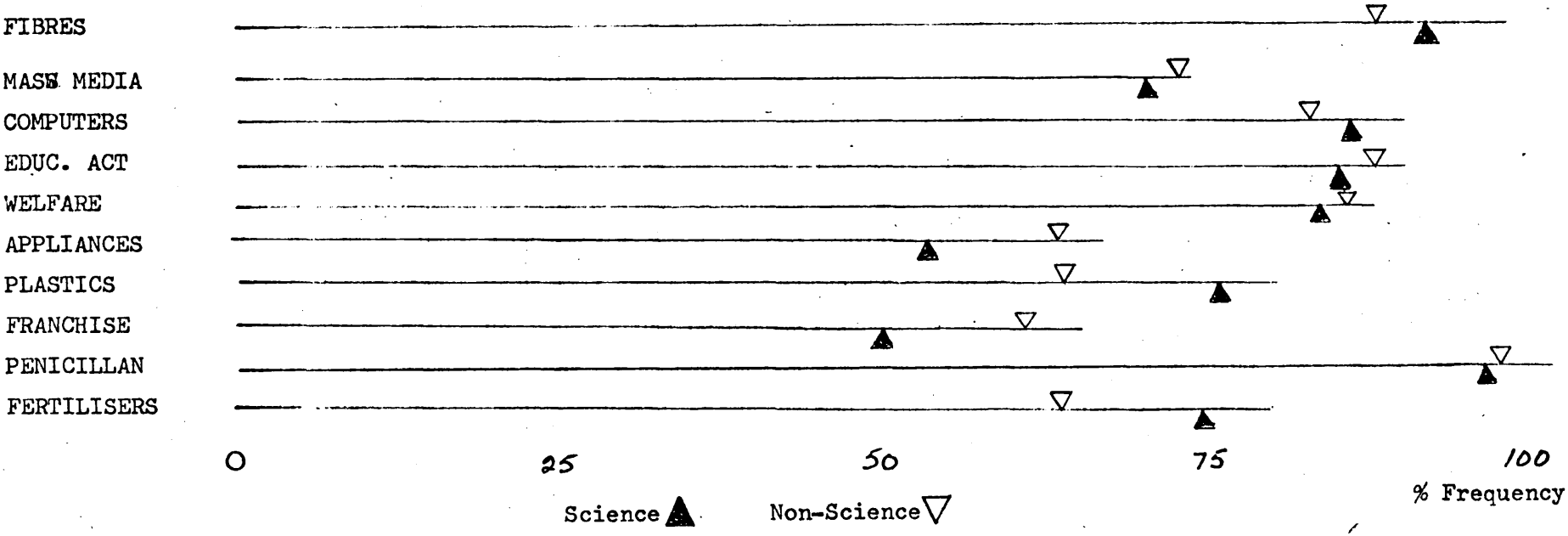
Item 2

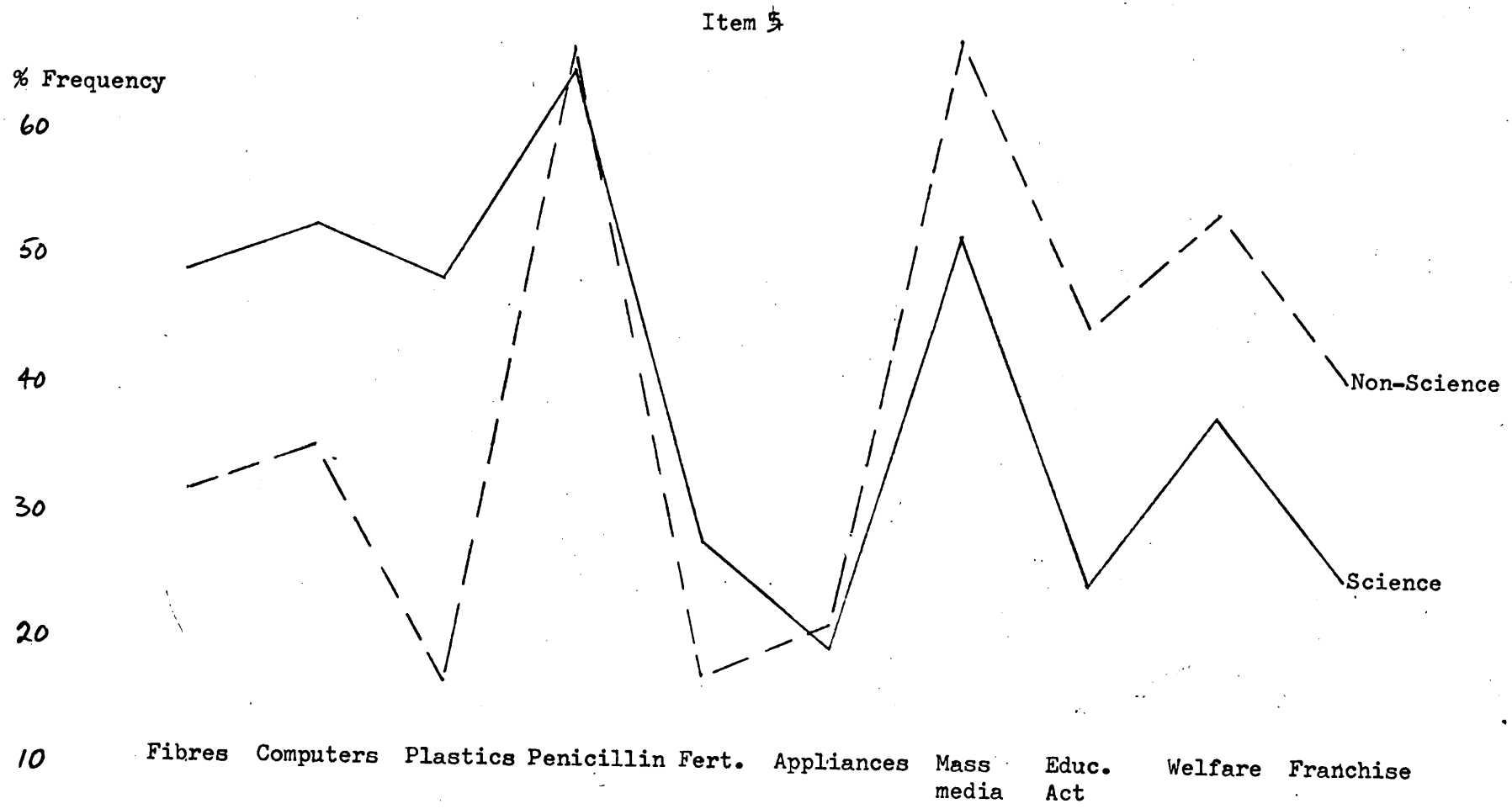

SERIOUS
CAREFUL
INTERESTED
RESPONSIBLE
ARTICULATE
ORGANISED
HUMAN
EXCITING
FRIENDLY
VALUABLE
THOUGHTFUL
WELL EDUCATED
INVOLVED
INTERESTING
PRECISE
0
25
50
75
100
% Frequency
Science
Non-Science

appendices and graphs) indicates a more favourable opinion from the science pupils. The alternate placings of the indicators representing the categories on the graphs on Page 115 which are based on the data on Appendix 5-20 for Item 4 indicates inconsistency of opinions between the categories in assessing the sub-items, but notice should be taken that except for the "penicillin" sub-item a significant difference appears in favour of the science pupils in assessing the contribution to the community to the scientifically biased sub-items "fibres", "plastics" and "fertilisers".

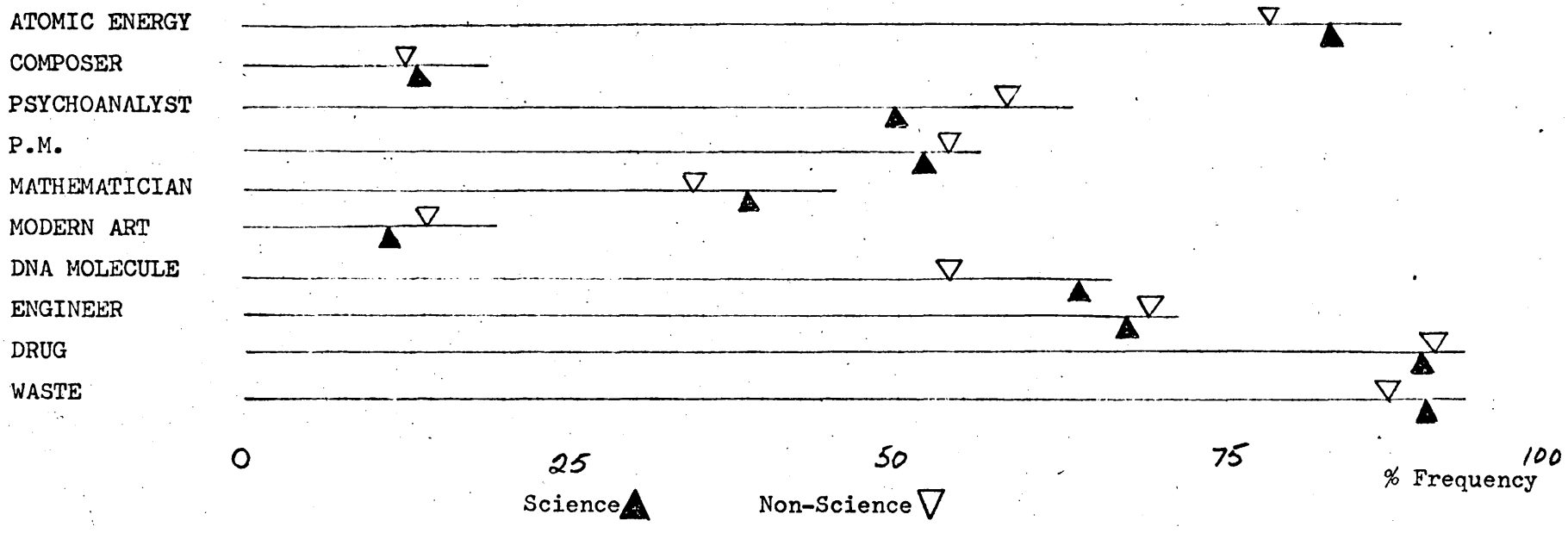
The graphs on Page 116 show the percentage frequency of selection of the four "free books" used as an interest test in Item 5. The scientifically biased selections have been grouped nearer the origin and it can be seen that a wide range of differences are present between the categories for these interests in favour of the scientists. The lines are however transposed as the non-scientifically biased selections are reached in favour of the non-science pupils and provide a striking example of the differences in interests expressed by this method. Item 6 (Appendix 5-21) is similar in objective to Item 4 and similar results have emerged on the corresponding graphs (Page 117) in that significant differences at the 1% level are shown to exist in favour of the science pupils for two of the four "science" sub-items and at the 5% level for a third. A significant difference is also present in the consideration of the mathematician as an important contributor to the

Item 4


FIBRES
MASS MEDIA
COMPUTERS
EDUC. ACT
WELFARE
APPLIANCES
PLASTICS
FRANCHISE
PENICILLAN
FERTILISERS
0
25
50
75
100
% Frequency
Science
Non-Science


Item 5
% Frequency
60
50
40
30
20
10
Non-Science
Science
Fibres
Computers
Plastics
Penicillin
Fert.
Appliances
Mass media
Educ. Act
Welfare
Franchise

Item 6

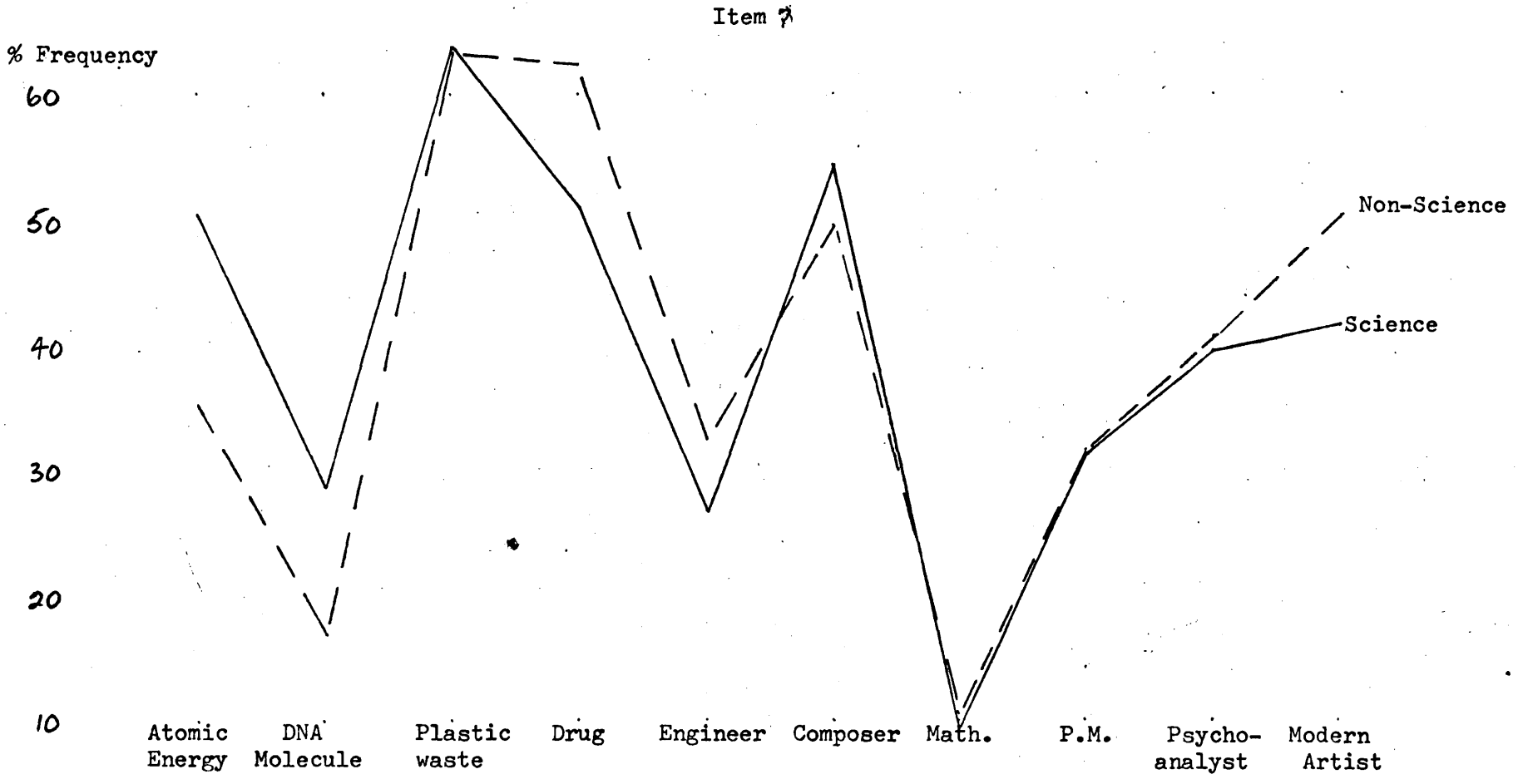

ATOMIC ENERGY
COMPOSER
PSYCHOANALYST
P.M.
MATHEMATICIAN
MODERN ART
DNA MOLECULE
ENGINEER
DRUG
WASTE
0
25
50
75
100
% Frequency
Science
Non-Science

community. Item 7 shown graphically on Page 119 is also a test of interest as was Item 5, but here a less apparent transposition of interest as the "non-science" sub-items are approached can be seen. The test for a commitment to apply scientific methods as expressed by Item 11 (Appendix 5-22) and shown graphically on Page 120 show that of the five sub-items which were, in a previous method, scored as "scientific" procedures, and which are marked by an asterisk, a significant difference at the 1% level has been found for four of them and that the scientists have favoured the fifth procedure also but at a 5% level of significance. It is interesting to note here that of the six "non-scientific" procedures, the non-science pupils have favoured them more compared to the science pupils in three cases and that in only one case is there a significant difference in favour of the science pupils at the 1% level.

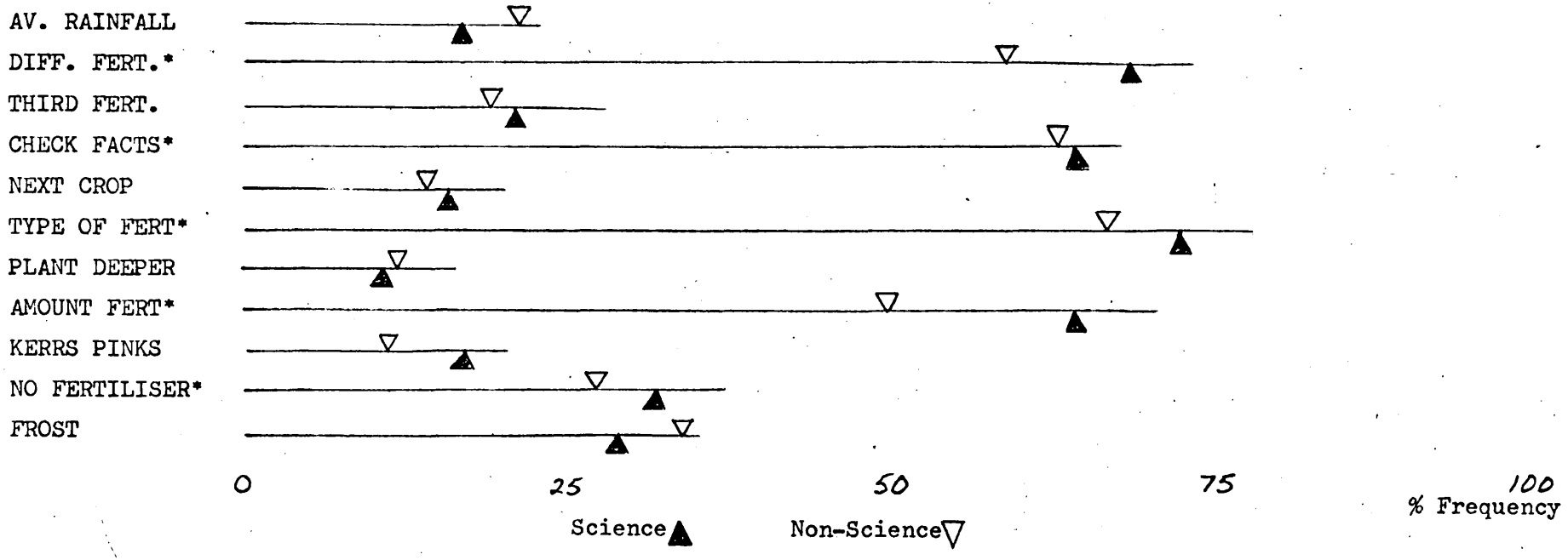
5.4.6 Percentage frequency of scores of sub-items for certain Items for science pupils in Comprehensive and Non-Comprehensive schools

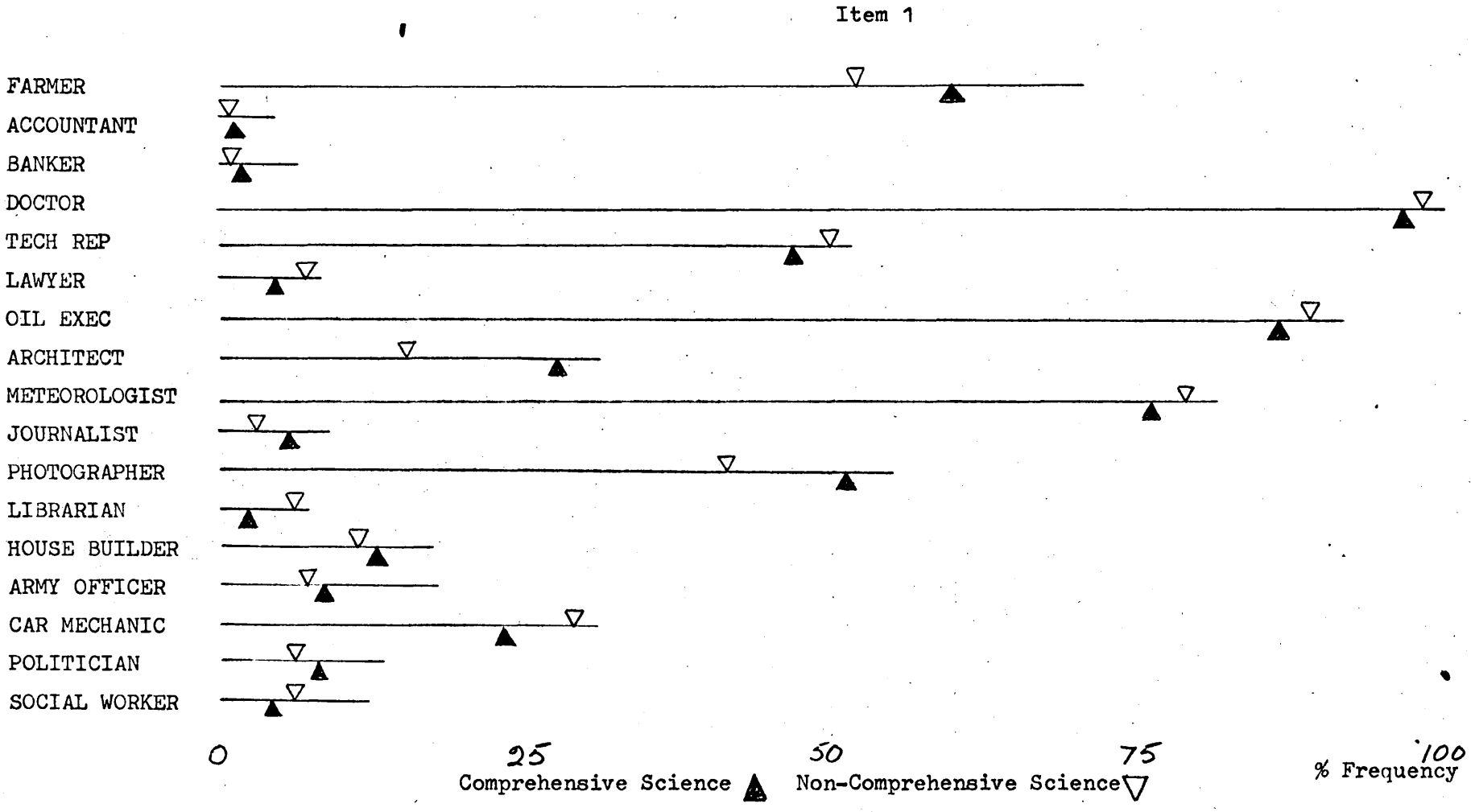
The method used in the previous chapter was again used to compare science pupils in comprehensive schools with their counterparts in schools which were non-comprehensive in nature.

It can be seen that in Item 1 (Appendix 5-23 and the graphs on Page 121) certain significant differences exist between the two categories in assessing the importance

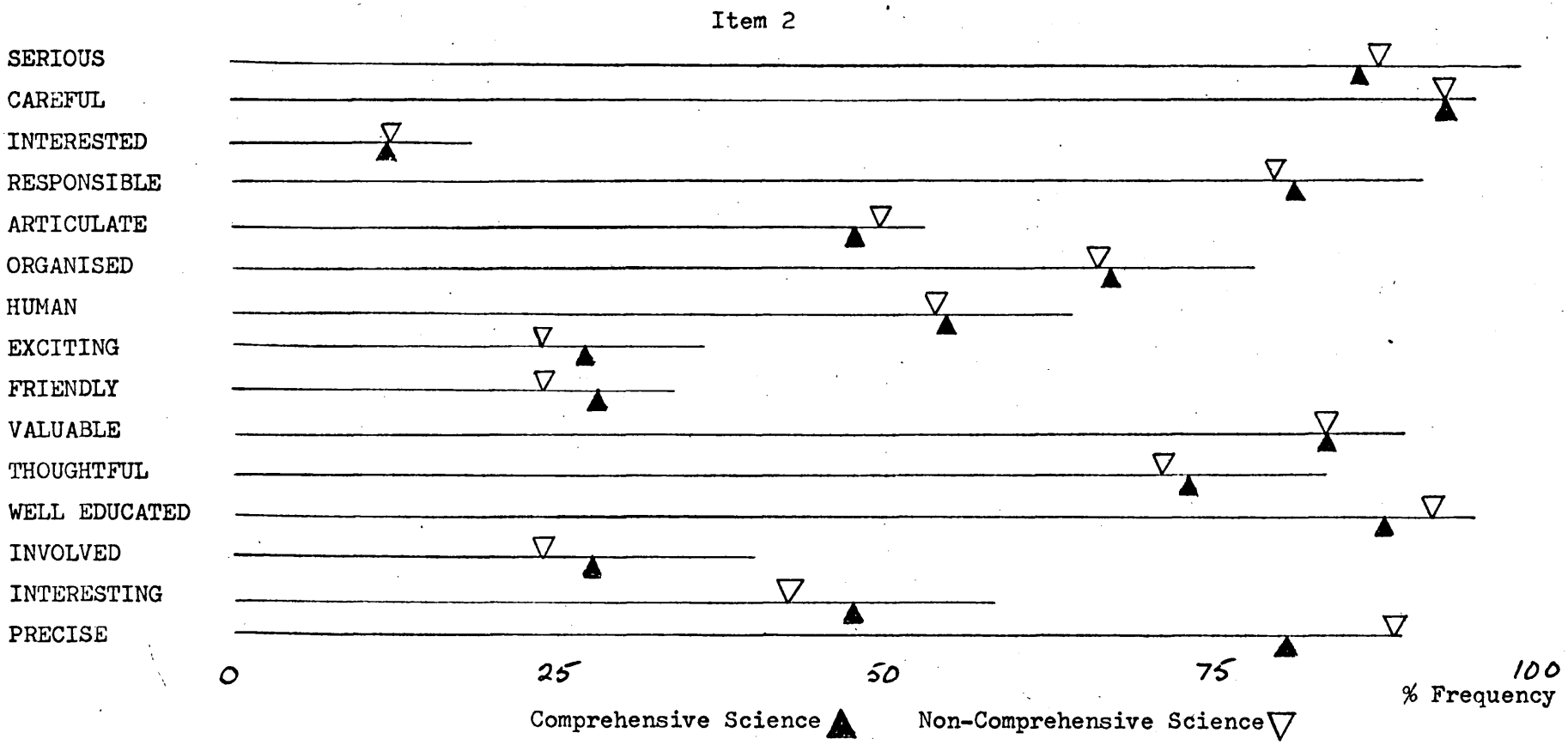

Item 7
% Frequency
60
50
40
30
20
10
Non-Science
Science
Atomic Energy
DNA Molecule
Plastic waste
Drug
Engineer
Composer
Math.
P.M.
Psycho-analyst
Modern Artist

Item 11

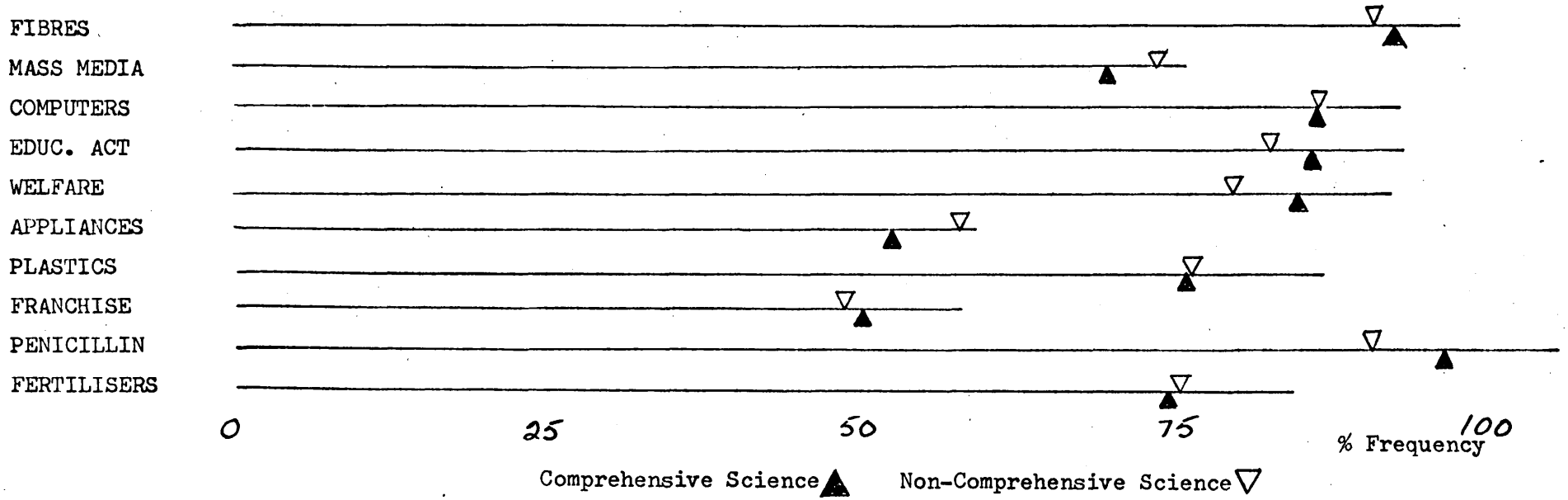

AV. RAINFALL
DIFF. FERT.*
THIRD FERT.
CHECK FACTS*
NEXT CROP
TYPE OF FERT*
PLANT DEEPER
AMOUNT FERT*
KERRS PINKS
NO FERTILISER*
FROST
0
25
50
75
100
% Frequency
Science
Non-Science

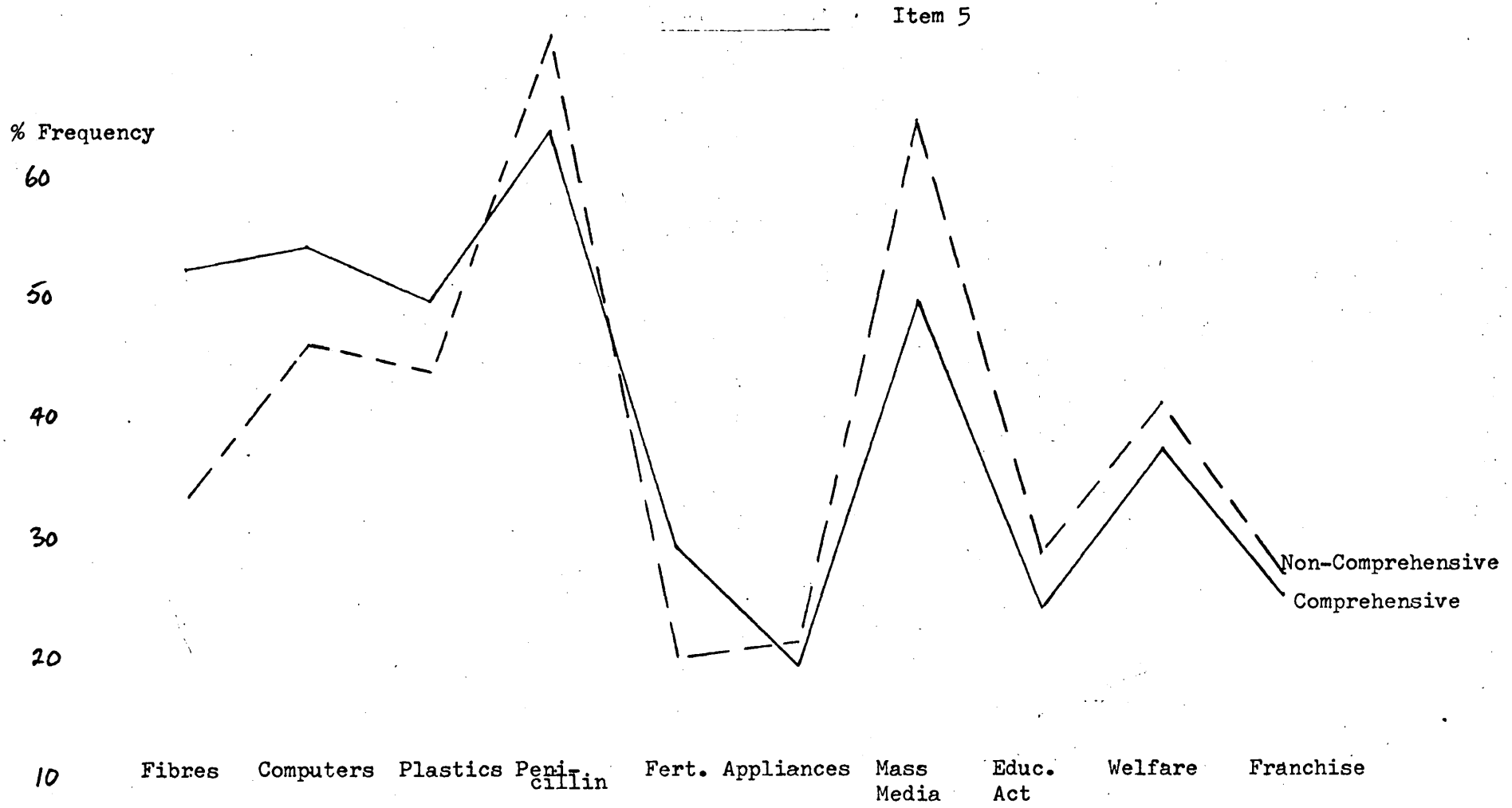

Item 1
FARMER
ACCOUNTANT
BANKER
DOCTOR
TECH REP
LAWYER
OIL EXEC
ARCHITECT
METEOROLOGIST
JOURNALIST
PHOTOGRAPHER
LIBRARIAN
HOUSE BUILDER
ARMY OFFICER
CAR MECHANIC
POLITICIAN
SOCIAL WORKER
0
25
50
75
100
% Frequency
Comprehensive Science
Non-Comprehensive Science

of chemistry as a basis for certain careers but that, on balance, an overall picture showing no obvious discrimination emerges in favour of one group rather than the other. This pattern is continued in Item 2 (Appendix 5-24 and the graphs on Page 123) where the opinion of the scientist seems to be fairly well balanced in relation to his more desirable characteristics. Again in Item 4 (Appendix 5-25 and the graphs on Page 124) no pattern has emerged to show any significant differences between the categories except in the case of the penicillin sub-item where a more favourable response has been shown by the comprehensive science pupils. The graphs on Page 125 show that in the interest Item (No. 5) comprehensive science pupils show more interest in the science sub-items whereas the non-comprehensive science pupils are relatively more interested in the non-science sub-items. It may well be that the subject options available in these schools could be a factor here. As in Item 4, Item 6 (Appendices 5-26 and the graphs on Page 126) show no important differences between the categories in relation to their attitude to chemistry as an important contributor to the welfare of the community. Similarly, the interest measurement in Item 7 as illustrated by the graphs on Page 127 shows no significant differences for any of the sub-items. It can be seen, however, from the graphs on Page 128derived from the data in Appendix 5-27, however, that in Item 11, the importance assigned to the "scientific" procedures marked with an asterisk is significantly different at the 1% level in favour of the science pupils from non-comprehensive schools.

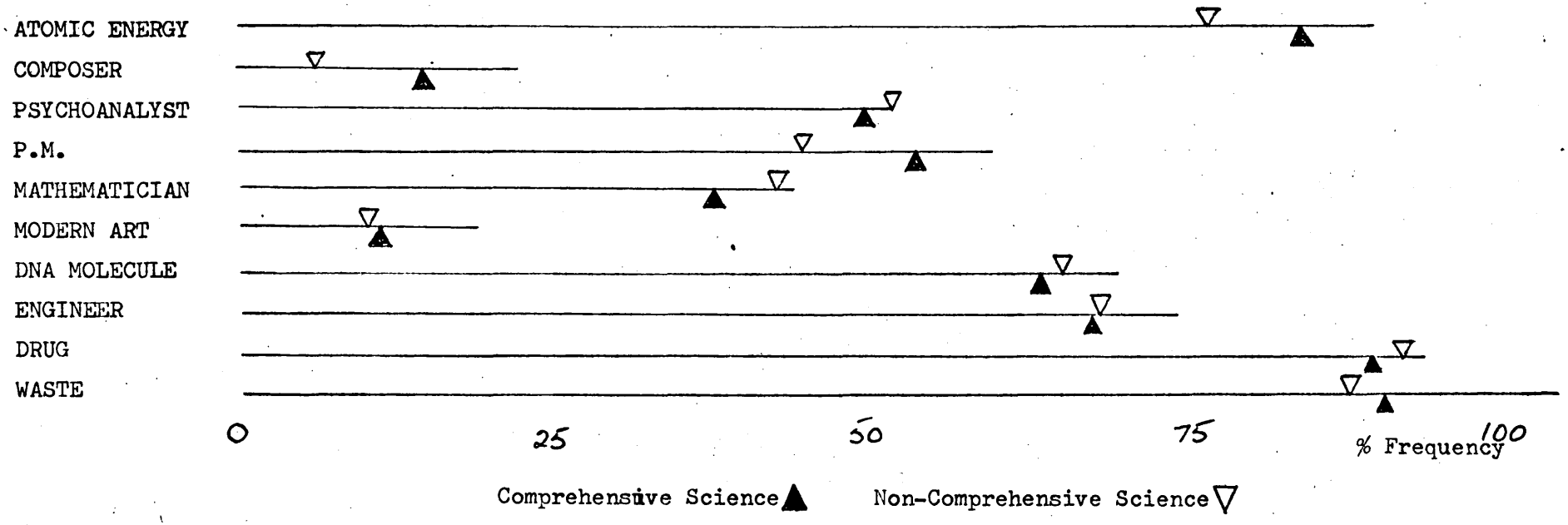

Item 2
SERIOUS
CAREFUL
INTERESTED
RESPONSIBLE
ARTICULATE
ORGANISED
HUMAN
EXCITING
FRIENDLY
VALUABLE
THOUGHTFUL
WELL EDUCATED
INVOLVED
INTERESTING
PRECISE
0
25
50
75
100
% Frequency
Comprehensive Science
Non-Comprehensive Science

Item 4

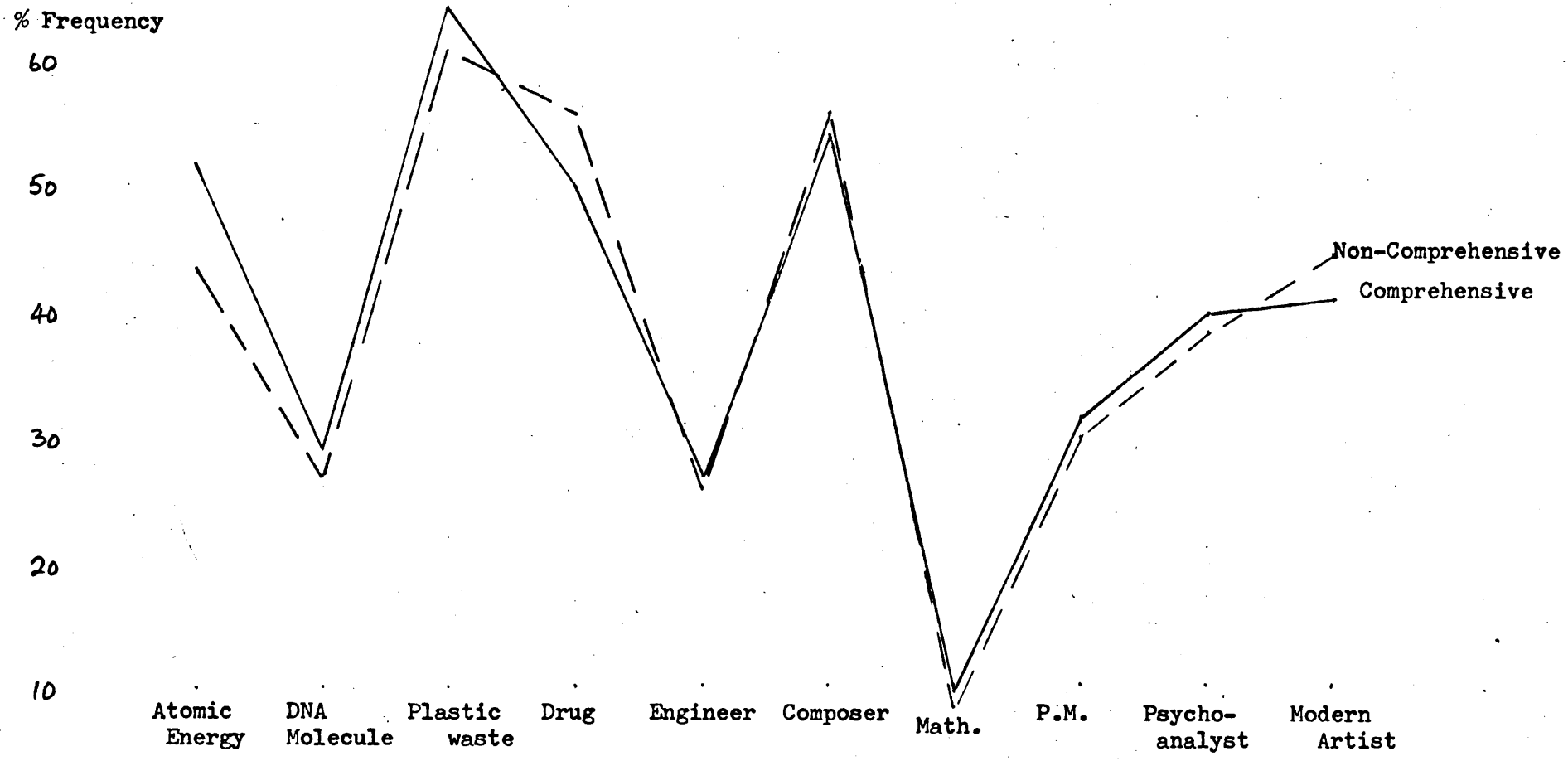

FIBRES
MASS MEDIA
COMPUTERS
EDUC. ACT
WELFARE
APPLIANCES
PLASTICS
FRANCHISE
PENICILLIN
FERTILISERS
0
25
50
75
100
% Frequency
Comprehensive Science
Non-Comprehensive Science


Item 5
% Frequency
60
50
40
30
20
10
Fibres
Computers
Plastics
Penicillin
Fert.
Appliances
Mass Media
Educ. Act
Welfare
Franchise
Non-Comprehensive
Comprehensive

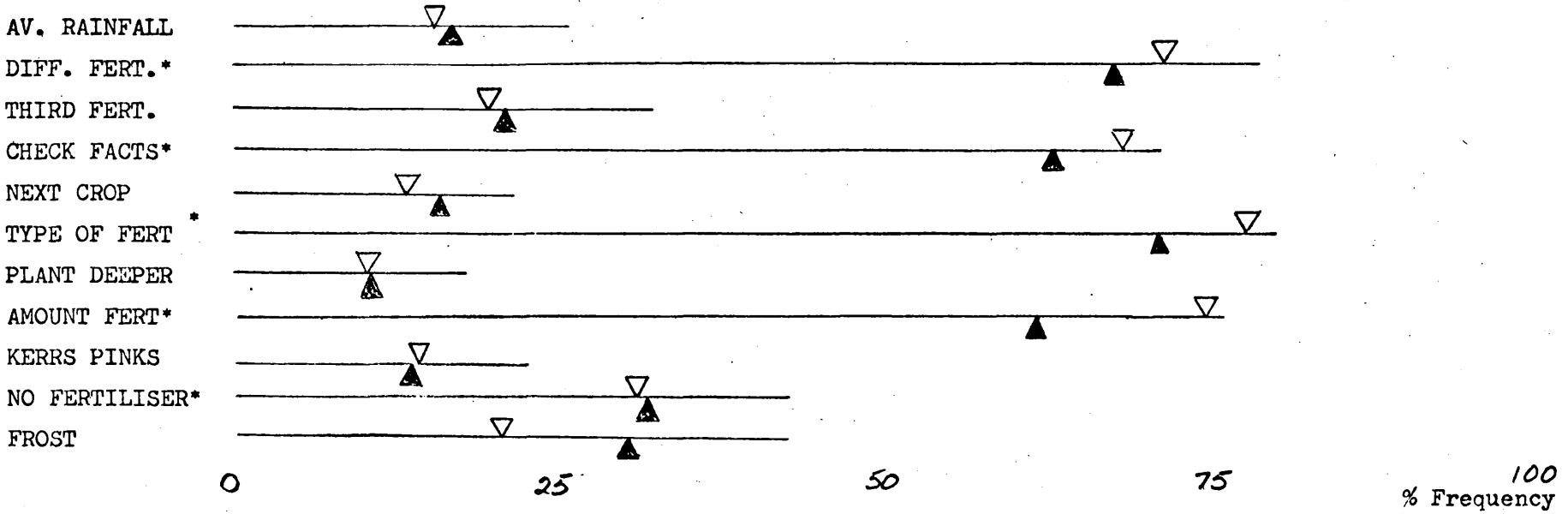
Item 6


ATOMIC ENERGY
COMPOSER
PSYCHOANALYST
P.M.
MATHEMATICIAN
MODERN ART
DNA MOLECULE
ENGINEER
DRUG
WASTE
0
25
50
75
100
% Frequency
Comprehensive Science
Non-Comprehensive Science

Item 7


% Frequency
60
50
40
30
20
10
Non-Comprehensive
Comprehensive
Atomic Energy
DNA Molecule
Plastic waste
Drug
Engineer
Composer
Math.
P.M.
Psycho-analyst
Modern Artist

Item 11



▲ Comprehensive Science Pupils

▽ Non-Comprehensive Science Pupils

Of the twenty nine schools who participated in the main test, twenty two were described as comprehensive schools. Of the seven non-comprehensive schools, four were described as Senior High Schools and the remainder were selective in nature. It is possible that pupils in the non-comprehensive schools were on average of higher academic ability than those from comprehensive schools. Apart from this, it would be unwise to assume anything further regarding the nature of individual schools (although further information is available and will be discussed in the final sub-chapters) since the character and status of many schools in Scotland are, at present, undergoing radical changes in the educational climate which exists at present. As can be seen, however, no important differences have been detected between science pupils from these categories of schools, except in Item 11 reported above, and the comparison will not be extended further in this work. Instead, a more fruitful area would seem to be an investigation of possible causes of differences of interest and appreciation of the value of chemistry in individual schools which is reported in the final sub-chapters.

5.4.7 Results from individual schools

It is probable that many authorities on the development of attitudes towards a school subject, particularly with regard to the interest and enjoyment aroused by that subject and an appreciation of its value, would agree that a major factor is the environment in which the subject is taught. Another factor is the method by which the subject is presented to the pupils, and a third (perhaps the most important) is the personality and enthusiasm of the teacher. More will be said on these factors in sub-chapter 5.4.8. What will be considered here is the identification of certain schools where the science pupils attained extremely high or low scores in the four items which were designed to test interest and enjoyment in chemistry and an appreciation of the contribution of chemistry to the community i.e. Items 4, 5, 6 and 7.

To this end, the mean of the school means for all science pupils (778 in number) were calculated for the above four items and are listed as follows with the corresponding standard deviations:

Item No.							
4		5		6		7	
Mean	Std. Dvn.	Mean	Std. Dvn.	Mean	Std. Dvn.	Mean	Std. Dvn.
9.60	0.89	1.39	0.90	9.20	0.72	1.48	0.92

Theoretically, the procedure could now have been that a calculation, for any item, of the mean of the school means

$\pm 2.58\sigma$, $\pm 2.33\sigma$, $\pm 1.96\sigma$ and 1.64σ (where σ is the standard deviation quoted above) would have identified the 0.5%, 1%, 2.5% and 5% respectively of those schools whose means fell outwith these limits. However, the reservations as to the existence of a normal distribution already expressed in Chapter 5.4.2, together with the relatively small number of schools (29) being considered made it necessary to replace the above statistical procedure with an examination of the school means as compared with the mean of school means. By this method five schools were identified which had extremely high or low means in Items 4, 5, 6 or 7. As can be seen from the data for these four items for all 29 schools on Table 7 on Page 132, the schools which were identified were as follows:

Item No.	Affective Objective	School No.
4 and 6	Importance of the contribution of chemistry to the community	
	Extremely good	4 and 28
	Extremely poor	17
5 and 7	Interest and enjoyment in chemistry	
	Extremely good	25
	Extremely poor	11

In Table 7 containing the results for all twenty nine schools, reference numbers 15, 26 and 32 have been omitted, as these were the reference numbers assigned to the three schools

Table 7

School No.	Item No. 4 Mean	4 Std. Dvn.	5 Mean	5 Std. Dvn.	6 Mean	6 Std. Dvn.	7 Mean	7 Std. Dvn.
1	10.24	1.44	1.95	0.90	11.10	0.97	2.33	1.13
2	8.81	1.91	-0.18	0.38	9.24	1.48	-0.06	0.24
3	8.91	1.95	1.00	0.60	8.23	2.56	1.64	0.83
4*	13.40	17.22	1.95	1.12	8.95	2.52	2.25	1.04
5	9.50	2.54	2.20	2.04	9.15	2.08	2.05	1.16
6	7.20	3.19	0.80	0.51	8.15	2.01	1.10	1.09
7	9.30	2.07	1.61	0.92	8.85	2.08	1.73	1.08
8	9.65	2.35	1.85	1.01	9.10	2.07	1.70	1.15
9	9.79	1.73	1.74	0.92	8.97	2.27	1.56	0.81
10	9.14	2.39	1.52	1.01	10.00	1.96	2.10	1.07
11*	10.00	2.37	-0.50	1.96	10.20	2.16	-0.10	0.44
12	9.28	2.02	1.55	1.00	9.24	2.19	1.97	1.03
13	9.09	2.62	1.72	0.86	9.00	2.66	2.26	4.24
14	9.54	2.12	1.80	1.44	9.25	2.16	1.85	1.10
16	9.39	2.02	1.83	1.01	9.22	2.13	1.65	1.17
17*	8.94	2.31	1.53	0.92	7.70	3.15	1.68	1.01
18	9.66	2.13	1.71	1.00	9.40	2.22	1.87	1.10
19	10.55	1.80	1.91	0.85	8.55	3.04	1.91	1.12
20	9.38	1.96	-0.33	1.29	9.48	1.33	0.00	0.00
21	9.20	1.92	-0.24	0.59	9.04	2.03	-0.40	0.98
22	9.10	1.66	-0.05	0.21	9.05	1.68	-0.48	0.91
23	9.05	2.06	2.15	0.96	9.00	2.00	1.95	0.92
24	8.52	2.22	1.91	0.78	9.52	2.38	2.13	0.90
25*	8.24	2.57	2.86	5.18	8.38	2.92	2.48	1.16
27	9.10	2.70	2.10	0.83	8.50	2.24	2.13	0.88
28*	10.30	2.28	0.90	0.83	10.50	2.16	1.20	0.98
29	9.24	1.82	-0.12	0.33	10.20	1.39	-0.20	0.57
30	9.62	2.13	1.81	1.22	7.71	3.53	1.76	1.11
31	9.22	1.13	1.00	0.94	9.33	1.89	1.67	1.25

used in the Pretest. The reference numbers of the five schools identified above have been marked with an asterisk.

To conclude the present work, it was decided to carry out and investigation by questionnaires into the attitudes of teachers in all twenty nine schools and, by comparison, to determine any factors which might emerge for the five schools identified as having extreme values in the items already mentioned. In addition, personal visits were made to the five schools to determine whether any peculiar factors of environment, methods of teaching and characteristics of teachers might account for their identification as described above.

5.4.8 Teachers' attitude questionnaire

A questionnaire was designed and sent to the Principal Teachers of the twenty nine schools who had participated in the main test for pupils. Prior to this, Principal Teachers had agreed to cooperate further in this way, and had supplied an approximate number of their staff who had agreed to complete a questionnaire. Of the twenty nine schools who had agreed to participate, all but one returned completed questionnaires and a total of one hundred teachers took part, so that, in this case, the raw and percentage frequencies of responses listed in the tables are the same, except in the case of Table 10 which contains the part of the questionnaire answered by Principal Teachers only. In this case the raw frequencies of

Table 8

Please indicate, by ticking the appropriate box, how valuable you consider the following to be in providing a good course in Chemistry at Secondary School level.

(% Frequency)

	Very Valuable	Fairly Valuable	Of Some Value	Of Little Value	Of Fairly Little Value	Of Very Little Value
Purpose built Chemistry labs	69	20	9	0	0	0
Wall charts	10	34	45	6	3	0
Periodic table on display	78	21	0	0	0	0
3-dimensional molecular models	43	36	19	2	0	0
Overhead projector	9	33	41	7	4	5
Filmstrips and loops	11	31	44	6	6	2
Movie films with sound commentary	15	32	40	7	0	2
"Chalk and Talk"	48	34	15	0	0	2
Textbooks	22	47	22	4	3	0
Pupil experiments	48	39	9	3	1	0
Demonstration experiments	43	37	15	3	2	0
Integrated Science Worksheets	12	29	35	8	3	8
Printed Notes for S.C.E. pupils	34	28	25	7	5	1
Homework	37	35	23	4	1	0
School Science Club	2	17	47	19	3	10
School Science Library	11	30	41	8	3	4
Visiting speakers on science subjects	2	20	37	26	6	6
Visits by pupils to laboratories, universities, etc.	5	22	45	20	4	3
Discussions on T.V. programmes, e.g. "Tomorrow's World"	6	17	41	22	4	5
Pupils' experimental project work	12	39	32	10	2	1

response from twenty eight Principal Teachers are included.

Tables 8 and 9 show the parts of the questionnaire which all teachers were asked to complete, and the percentage frequencies of the responses made in each of the boxes provided are shown. In a few cases no responses were made, as can be shown by summation. Table 8 was concerned with the teachers' evaluation of twenty teaching aids and methods. As can be seen, the teachers considered these to be at least of some value in the majority of cases (the column headed "of some value" contains the most frequent response in ten cases). It is interesting to note the aids or methods where the most frequent response was "very valuable". Purpose built labs and the use of the Periodic Table are two of these as are pupil and demonstration experiments with the former having a marginally better vote. It is noticeable that traditional methods of "chalk and talk" and the use of homework have also received the approval of most teachers.

Of the five schools identified as having extremely good or extremely poor results for Items 4, 5, 6 and 7, four had returned teachers' questionnaires. These questionnaires were examined to determine the number of responses on each which deviated from the most frequent response made by teachers from all schools. Where the deviation was to the left of the most frequent response (Table 8) it is indicated by the word "above" in the list that follows, and by the word "below" where the deviation was to the right.

School No.	Teacher	Deviation	
		Above	Below
4	Principal	6	4
(contribution of chemistry - extremely good)	Assistant	2	9
	Assistant	4	8
17	Principal	3	9
(contribution of chemistry - extremely poor)	Assistant	5	9
	Assistant	2	10
	Assistant	3	6
	Assistant	6	3
25	Principal	5	7
(interest and enjoyment - extremely good)	Assistant	1	13
	Assistant	2	8
	Assistant	10	4
	Assistant	3	6
11	Principal	4	10
(interest and enjoyment - extremely poor)	Assistant	4	10
	Assistant	2	9

It would appear from the above list that some marginal difference exists in favour of the "extremely good" schools, when all of the above teachers are taken into consideration, in their attitudes to the twenty stated aims and methods. More illuminating, perhaps, is a comparison of the data from Principal Teachers' questionnaires where more favourable

Table 9

Please answer the following questions briefly:-

(Yes/No will suffice in most cases).

	% Frequency		
	Yes	No	Other
Do you think that, in general, science discoveries have benefited mankind?	100	0	0
Do you think previous employment other than teaching is, in general, valuable for a teacher?	85	10	5
Did you find your science subjects to be the most interesting at University?	71	15	14
Do you think that, in general, scientists are more interested in "things" than in people?	24	72	4
Do you think Chemistry helps to prepare pupils for a wider range of careers than does Geography?	61	28	11
Do you think Science should be taught to ROSLA pupils?	65	29	6
Do you teach only one subject, viz. Chemistry?	33	65	0
Are you a member of a Science Teachers' Association?	35	65	0
Are you a member of the Association for Science Education?	28	72	0
Do you subscribe to any Science journal?	35	65	0
Have you attended Science In-Service courses?	80	20	0
How long is your total teaching experience?			
How long have you taught in your present school?			
Are you male or female?			
Apart from the acquisition of scientific knowledge and manual skills, what do you consider to be the main beneficial effect that the study of science has on secondary pupils?			

deviations from the most frequent response are shown by the two "extremely good" Principal Teachers and more of the least favourable by the "extremely poor" Principal Teachers. If it can be assumed that, in every case, the attitudes of the Principal Teachers are influential (and this is discussed later) the above results may be at least a pointer to the differences exhibited by the pupils of the schools concerned.

The questionnaire embodied in Table 9 was concerned with the affective objectives assessed by Items 4, 5, 6 and 7 and with some personal information from teachers. The percentage frequency of responses shows, in general, a favourable attitude to the affective objectives. It is interesting that a minority of teachers are members of Science Teachers' Association or take Scientific Journals. Very little of significance emerged from an inspection of the results from the four schools which had exhibited extreme results in this part of the questionnaire. The responses in almost all cases were in accordance with the most frequent given by all teachers as shown on the table. In School No. 17 which showed an extremely poor awareness by pupils of the contribution of chemistry to the community, all of the teachers taught chemistry only as did the teachers in School No. 11 where interest and enjoyment of chemistry by pupils was extremely poor. It would be expedient to conclude from this an academic attitude only by these teachers, but the reverse could also be argued i.e. interest should be inculcated by teachers whose prime concern is

their own subject. No differences of any significance were shown in comparing lengths of teaching experience or in the answer to the final question on this part of the questionnaire. It is interesting to note that the vast majority of all one hundred teachers considered that habits of objective and logical thought were the main beneficial effects that the study of science imparted to secondary pupils.

The final part of the teachers' questionnaire is shown on Table 10. This was competed by Principal Teachers only and gave details of the structure of the school and of the science departments. In addition, some indication of methods of teaching employed were included. The frequencies of responses from the twenty eight Principal Teachers who completed a questionnaire are shown after each possible response. Points of note are that although an integrated science course is favoured in most schools, the Heinemann worksheets seem to be losing ground. None of the pupils in the schools has not been exposed to science teaching at some stage in their school careers and, in general, science is still more popular with boys than with girls. Science clubs are not popular but most schools have a science library. The most commonly used textbook was "Chemistry Takes Shape" by Johnstone and Morrison. Worksheets are used in eleven of the schools in S3 and S4 presumably prepared by the Principal Teachers since none is available commercially. This may suggest a need for such material. The schools varied widely in their

Table 10

For Principal Teachers of Chemistry only

(Frequencies fo responses from 28 Principal Teachers are in brackets after each response)

Please underline the answer which applies to your school.

1. The school is:- (a) 6 year comprehensive (21)
(b) Senior High (3) (c) Junior High (1)
(d) Other (please specify) (3)

2. The pupils in the school are:- (a) all girls (2)
(b) all boys (0) (c) girls and boys (26)

3. The stage to which Chemistry is taught is:-
(a) S4 (1) (b) S5 (1) (c) S6 (26)

4. The stage to which some form of science is taught is:-
(a) S4 (3) (b) S5 (4) (c) S6 (21)

5. Do 1st and 2nd year pupils follow an Integrated Science Course? (a) Yes (20) (b) No (8)

6. Do you use the Heinemann Worksheets?
(a) Yes (11) (b) No (17)

7. The approximate size of most S.C.E. Science classes is:
(a) 0-10 (0) (b) 11-15 (1) (c) 16-20 (21)
(d) over 20 (6)

8. The approximate number of candidates presented for Chemistry in S.C.E. examinations each year is:
(a) 0-15 (0) (b) 16-30 (1) (c) 31-45 (2)
(d) over 45 (25)

9. Are there any pupils in the school who have been taught no Science?
(a) Yes (0) (b) No (28)

10. Most pupils who do science are:-
(a) boys (14) (b) girls (1)
(c) about the same number of boys and girls (13)

11. Does the school have a Science Club?
(a) Yes (5) (b) No (23)

12. Does the Science Department have a Science Library?
(a) Yes (17) (b) No (11)

13. Do you use a Textbook with S.C.E. Chemistry classes:-
(a) Yes (24) (b) No (4)

(If 'Yes', please specify .....
.....)

Table 10 (cont.)

14. Do you issue printed notes to S.C.E. Chemistry classes?
(a) Yes (17) (b) No (11)

15. Do you use a form of worksheet in S.C.E. Chemistry classes in S3 and later years?
(a) Yes (11) (b) No (17)

16. The school has a principal teacher of:
(a) Science (4) (b) Chemistry (23)
(c) Biology (24) (d) Physics (25)

17. The subjects that can be taken as alternatives to Chemistry are:-

(Please specify.....
.....)

18. The number of periods each week in which Chemistry is taught to '0' grade is:-

(Please specify.....
.....)

optional subjects at 'O' grade and the number of periods used for Chemistry varied from four to seven.

It cannot be said that any differences that could be considered significant were found when comparisons of results from the four schools being specially scrutinised were made either with one another or with the frequencies of responses listed in the table. It should, however, be remembered that one of the "good" schools is a Junior High (the only one used in the Main Test) and a "poor" school is a Senior High (one of three used). Each school was using an integrated course in S1 and S2 with Heinemann worksheets except the Senior High who had, of course, no S1 or S2. Only the Senior High was not using "Chemistry Takes Shape" and all four schools allotted six periods a week to the study of Chemistry.

5.4.9 Characteristics of Certain Schools

One of the limitations of a questionnaire is that it is very often difficult to see through the written responses to the flesh and blood of the respondents, to assess the principles by which he works and the influences of his working environment. Because of these limitations it was considered that this examination of the five schools, which have been the subject of this sub-chapter, would not be complete without a personal visit by the examiner to each of the schools to attempt to assess, albeit subjectively, whether important factors causing the placing of the five

schools in the extreme positions already discussed, could be detected. The visits served a dual purpose in that it gave the present writer an opportunity to express his appreciation, personally, of the cooperation that the schools had afforded. It should be recorded that in each school visited a cordial welcome was received and that the discussions which ensued with the teachers involved were frank and friendly and an opportunity was afforded, in each case, to view the staff and pupils in their place of work. A brief account of the visits to schools no. 4, 25 and 28 which gave extremely "good" results is now given, followed by an account of visits to schools no. 11 and 17 which had given "poor" results.

School No. 28 was the only school which had not returned the teachers' questionnaires so that findings for this school are based completely on the visit. It is a large, modernised comprehensive school with a roll of upwards of 2000 and situated in an industrial town with a population of about 50000. A long tradition of chemistry examination success up to S.Y.S. level has been achieved in excellent science facilities with a staff of five chemistry teachers. Many of the Chemistry pupils go on to further study of the subject at University and Colleges of Further Education. Many pupils secure employment in industry and technical services locally. The Chemistry Department is run by a very impressive Principal Teacher who held several views on the teaching of his subject and on Education in general to which many science teachers would not have

subscribed, but whose enthusiasm and expertise were beyond question. The teaching of Chemistry was dis-integrated from both Physics and Biology throughout the school in all six years. The thought which had been given to the teaching of Chemistry to non-certificate pupils was particularly impressive. The over-all picture was one of a highly competant, experienced and successful Principal Teacher leading a team of Assistants with a sure and dedicated hand.

School No. 4 is a Junior High School with a roll of just over one thousand located in a small town with population in the region of 10000. It is adjacent to a larger centre of population and the academic "high-flyers" are transferred to a Senior High School in this larger centre at the end of S2. The remainder are classified as non-certificate or certificate pupils and the latter are offered a wide range of 'O' Grade subjects. On successful completion of these, transfer to the Senior High School can take place. Science teaching facilities are extremely good and the staffing position appears to have been stable in recent years except that the present Principal Teacher has only recently been appointed and has succeeded a teacher who left for promotion and who had an apparently well-deserved record of academic success and enthusiasm. The Head Teacher of this school was formerly the Adviser in Science for a large county. The science staff in this school expressed satisfaction for the interest in chemistry which exists among the pupils who take the subject and

attributed this, in large measure, to the competence and enthusiasm of both the former and present Principal Teachers.

Also located in a small town (population 15000) in an industrial area is School No. 25 which is a large comprehensive six year school. As in School No. 4, the Heinnemann worksheets are used in S1 and S2 with modifications. The school is housed in two modern buildings which constitute what is virtually an upper and lower school, but the buildings are adjacent to each other. The Principal Teacher has held the position for over eleven years and has a very good record of academic success. A shortage of science staff which at present exists in the school could not detract from the impression of competence and diligence given during the short visit. The Principal Teacher appears to be an influential team leader who expressed interesting opinions on the teaching of his subject which had obviously been formulated during a long and successful teaching career.

The pupils of two schools attained extremely poor results in Items 4, 5, 6 and 7. They were School Nos. 11 and 17. School No. 11 is a six year comprehensive school in a small industrial town where the manufacturing industries are thought to be on the wane. The science teachers are working under the considerable difficulty of having S1 and S2 years in a separate building a mile away from the main building. The science facilities in

the annexe are inferior to those in the main building and the five science teachers are required to commute between buildings. The length of science periods are often shortened because of this since provision has not been made, in many cases, for travelling. Chemistry is the most popular science subject in terms of 'O' grade presentations. Some disquiet was expressed by the Principal Teacher on the subject of the non-certificate chemistry courses proposed by his County Authorities and in the content of the Heinemann worksheets which he has recently modified to try to suit the needs of the school. It is perhaps unfair to make comparisons in attitudes of teachers on the basis of a relatively short visit, but it nevertheless should be stated that the sense of enthusiasm and teamwork very evident in the three schools already considered was not as evident in this case.

The fifth school visited was No. 17 which is a Senior High School operating in a county where remnants of a two-tier system still exist. The school is situated in a residential small town near a large centre of population and is fed by two Junior High Schools in similar non-industrialised settings. The Senior High has a well-deserved reputation for academic excellence and is housed in a modern building with excellent science facilities. Relevant factors when consideration is given to the extremely poor results obtained for this school in the attitudes already described may well be that all considerations in the teaching of subjects may be governed by the nature

of the school as a place of preparation for further education in many cases, the presence of "creamed-off" pupils only from a very good socio-economic area, and the presentation of the subject as examination-orientated by teachers who are clearly very academic by training (three hold Doctorate degrees). A combination of all of these factors, in the case of this Senior High School, may have produced science courses where affective objectives have consequently been relegated to a low position in the order of attainments.

A summary of all of these facts with a selection of those which are considered to be the most salient for the five schools which have been examined in detail, is made in the general summary of findings from this work in Chapter 6 which follows.

Appendix 5-1

(1) THIS IS NOT A TEST. THERE ARE NO "RIGHT" OR "WRONG" ANSWERS.

(2) YOU ARE ASKED TO READ EACH ITEM ON THE FOLLOWING PAGES AND, IN EACH CASE, PUT YOUR ANSWER (WHICH, IN MANY CASES, IS SIMPLY YOUR OPINION) INTO THE EMPTY "BOXES" PROVIDED. PLEASE USE A BALL-POINT PEN.

(3) PLEASE WRITE YOUR CHRISTIAN NAME ONLY BELOW:-

- - - - - - - - - - - -

(4) PLEASE SCORE OUT "DO" OR "DO NOT" IN THE FOLLOWING SENTENCE SO THAT IT APPLIES TO YOU:-

I DO / DO NOT INCLUDE SCIENCE IN THE SUBJECTS I TAKE AT SCHOOL.

THANK YOU FOR TACKLING THESE ITEMS. YOUR EFFORT WILL PROVIDE INFORMATION THAT WOULD OTHERWISE HAVE BEEN IMPOSSIBLE TO OBTAIN.

Appendix 5-2

ITEM 1

How valuable do you think the study of Chemistry would be if you were preparing for the following careers?

Rate Chemistry on the following scale:-

+3 very valuable
+2 fairly valuable
+1 of some value

-1 of little value
-2 of fairly little value
-3 of very little value

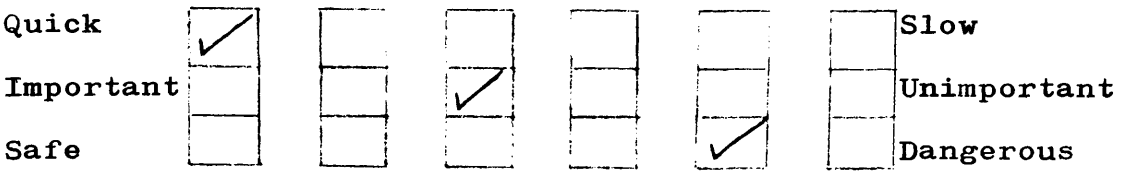
Place your rating in the box provided.

Career	Rating
Farmer	
Accountant	
Banker	
Doctor	
Technical Representative	
Lawyer	
Oil Company Executive	
Architect	
Meteorologist	
Journalist	
Photographer	
Librarian	
House Builder	
Army Officer	
Car Mechanic	
Politician	
Social Worker	

Appendix 5-3

ITEM 2

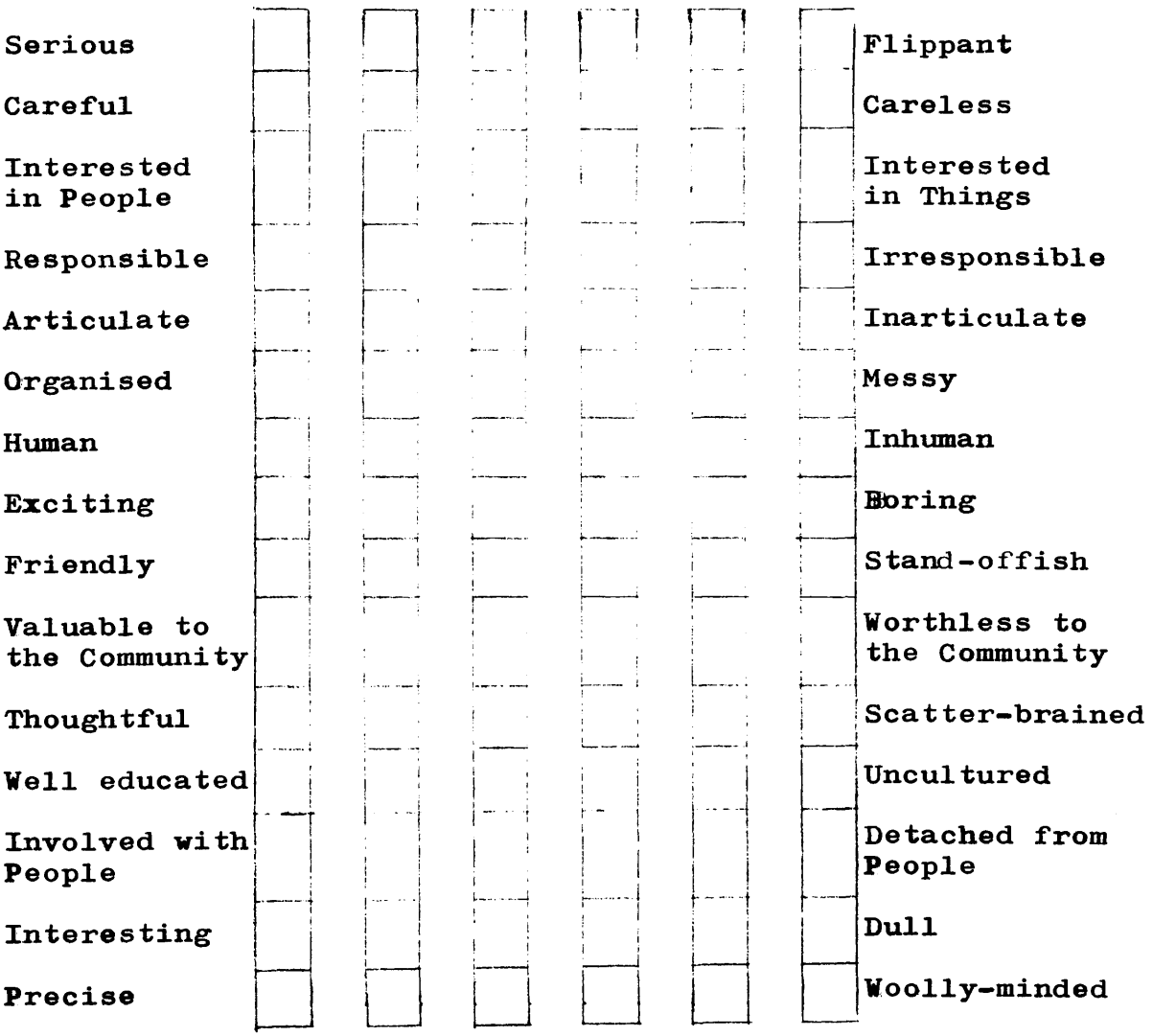
How do you describe different things? If you had to describe "A Racing Car" you could do it like this:-



The positions of the ticks between the word pairs show that you describe it as very quick, slightly more important than unimportant, and quite dangerous.

Use the same method of ticking the box you think most appropriate to describe:-

"A Scientist"



Appendix 5-4

ITEM 3

How valuable do you consider the following contributions to the benefit of the people of Britain over the past 100 years? Rate them on the following scale:-

+3 very valuable
+2 fairly valuable
+1 of some value

-1 of little value
-2 of fairly little value
-3 of very little value

Put the number of your choice in the box marked "IMPORTANCE" after each subject.

	IMPORTANCE	FREE BOOK
The manufacture of man-made fibres, e.g. Terylene, Nylon		
The rise of the mass media (T.V., radio, newspapers, cinema)		
Computers		
The Education Act (1872), setting up State-controlled education		
The introduction of the Welfare State (1948)		
Labour-saving devices (washing-machines, vacuum cleaners etc.)		
The Growth of the plastics industry, (polystyrene, PVC, polythene, etc.)		
The extension of the right to vote (1887, 1918, 1928, 1970)		
The discovery of penicillin		
Use of artificial fertilisers in farming.		

If, as an introductory FREE OFFER, a Book Club offered you four books on the subjects listed above, tick in the box marked "FREE BOOK" the four you would choose.

Appendix 5-5

ITEM 4

How valuable to the community do you consider the work of the people listed in the table below? Rate them on the following scale:-

+3 very valuable
+2 fairly valuable
+1 of some value

-1 of little value
-2 of fairly little value
-3 of very little value

Put the number of your choice in the box marked "VALUE" after the person's name.

	VALUE	INTEREST
A scientist who has discovered how energy can be harnessed from the atom		
Composer of electronic music		
Psychoanalyst		
Prime Minister of Britain		
A Mathematician who wrote a famous work on new fields in mathematics		
Painter of modern art		
Biochemists who discovered the structure of the DNA molecule		
Engineer and famous bridge-builder		
A research chemist who discovered a new pain-killing drug		
The discoverer of a chemical which can turn plastic waste into a harmless liquid		

Put a tick in the box marked "INTEREST" opposite four of these people you would consider to be the most interesting to have on Parkinson's T.V. "chat" show.

ITEM 5

Six test runs were made on the same motor-cycle to find out the relative importance of four factors when economical performance is required, i.e. the best miles per gallon (m.p.g.). From the following results, place the four factors (Type of petrol, Average Speed, Town or Country Driving and the Experience of the Driver) in the order in which you think that they are important in giving the best m.p.g. Give the most important factor a letter A in the box provided, the second best a letter B, third C and fourth D.

Test Run No.	Type of Petrol (cost/gallon)	Average Speed on journey (m.p.h.)	Town and Country Driving	Experienced or Learner Driver	m.p.g. obtained
1	38p	35	Mainly Country	Experienced	125
2	38p	60	Mainly Country	Learner	90
3	38p	60	Mainly Country	Experienced	95
4	38p	35	Mainly Country	Learner	120
5	38p	35	Mainly Town	Experienced	105
6	32p	35	Mainly Town	Experienced	105

Factor	Importance
Type of Petrol	
Average Speed	
Town/Country driving	
Experienced/Learner Driver	

Appendix 5-7

ITEM 6

(1) Natasha, the eminent astrologer, proclaims:- "Due to the alignment of the planets Jupiter and Mars, and the coming ascendency of Saturn, powerful forces will prevail over Sagittarians this month causing them to become moody and ill at ease".

Which course of action satisfied <u>your</u> acceptance or rejection of her proclamation?

(a) Dismiss her as a crank. ☐

(b) See if her predictions were in agreement with the facts known about the current position of planets and the behaviour of Sagittarians that month. ☐

(c) Accept her judgement as she is very knowledgeable in matters of this kind. ☐

(d) Ask other astrologers their opinion ☐

(2) On the way back to Newtown Police Station, Sergeant Lynch remarked, "All the evidence points to Reilly as the burglar. His landlady says he was out all night on the night of the burglary, and three people have identified him as the man they saw running away from the burgled house. We've even found a jemmy back in his flat." "No, Bert," said Inspector Barlow, "it's definitely Anderson. I know we've nothing to pin on him at present, but when you've been in this business as long as I have, you get this feeling, call it 'copper's intuition' if you like. But I just <u>know</u> that Anderson's the burglar."

Of the two opinions about who committed the burglary, whose are you more inclined to accept?

(a) Inspector Barlow ☐

(b) Sergeant Lynch ☐

(c) Neither, because they are both equally convincing? ☐

(3) / over

(3) Twenty years ago Immanuel Velikovsky published a theory that during the fifteenth century B.C. the Earth was narrowly missed by a comet, and this comet eventually struck Mars to produce the planet Venus.

Which of the following satisfies <u>you</u> as the best method of deciding to approve or to reject Velikovsky's theory?

(a) See what facts of astronomy can be collected to support his theory. ☐

(b) Accept the judgement of the thousands of famous scientists who disagree with him. ☐

(c) Find out what his qualifications as a scientist are. ☐

(d) Ignore his theory, because you have never heard of him before. ☐

(4) A famous atomic physicist has stated that a new radioactive element of atomic number 114 exists. Which of the following would satisfy <u>you</u> as to the correctness of this?

(a) Believe him, since he is a famous physicist. ☐

(b) Carry out experiments to detect this new radioactive element. ☐

(c) Accept this, as a great many people have been saying this for fifty years. ☐

(d) Believe him if his shrewd guesses have turned out to be correct in the past. ☐

(5) Your teacher has said that when we add $10cm^3$ of one liquid to $12\ cm^3$ of a different liquid, the resulting total volume will always be $22\ cm^3$.

Which of the following do <u>you</u> consider the most satisfactory way of deciding whether or not this is correct?

(a) / over

(5) (a) Consult a textbook ☐

(b) Make a calculated guess ☐

(c) Ask another teacher of chemistry ☐

(d) Do experiments with volumes of several liquids. ☐

Appendix 5-8

ITEM 7

In each of the following passages a conclusion has been drawn. You are asked to judge how fair it is to draw the conclusion. Rate the conclusion on the following scale:-

+2 very fair
+1 fair
0 if you are not sure
-1 unfair
-2 very unfair

Place your rating in the box provided.

(1) Liverpool's 6-1 victory over A.C. Milan last week raises hopes for their prospects in the forthcoming English-Italian competition. If Liverpool can scourge the scintillating signors who are, remember, the Italian champions, then Shankly's stunners will steamroller their way over the weaker Italian teams in the tournament.

(2) If sensitive chemical tests cannot detect the presence of copper or zinc in a compound, we can conclude that copper or zinc are absent in that compound.

(3) "Of course, Paul, you realise that Raymond Chandler's detective novels are much better than anything Georges Simenon has written."

"Why? Who says so?"
"Oh .... eminent literary critics; they say so."
"And how would I recognise these 'eminent literary critics'?"
"Simple. They prefer Chandler's novels to Simenon's novels."

(4) The metal, Scotium, will displace hydrogen from acid. Since this reaction occurs for one metal - Scotium - it will occur for all other metals.

(5) / over

(5) Ghosts do not exist because no one has produced reliable enough evidence to support their existence.

(6) Film makers, responding to changes in the public's tastes, stepped up their emphasis on themes of violence. And what happened? As a result, figures for violent crime during that year showed a dramatic increase.

Appendix 5-9

ITEM 8

A farmer noticed that, on gathering his crop of "Golden Wonder" potatoes, the crop from one part of the field was very good, and that from the rest of the field was very poor. He suspected that the reason was that he had added two different types of artificial fertiliser to the soil at different parts of the field. He decided to investigate to try to prove his suspicions correct.

How important do you think each of the following would be in his investigations? Rate them on the following scale:-

+3 must be done
+2 very important
+1 important

-1 unimportant
-2 very unimportant
-3 does not matter at all

	Rating
Check the average rainfall during the time the potatoes had grown	
Sow "Golden Wonder" potatoes in two patches of soil, each treated with a different fertiliser and check the crop obtained	
Sow "Golden Wonder" potatoes in soil with a third fertiliser and check the crop obtained	
Make sure that the original facts about the good and poor crops were correct	
Wait until next year's crop had been obtained from the same field before making the investigation	
Analyse soil from several parts of the field to find what type of fertiliser had been added	
Plant a trial batch of "Golden Wonders" deeper in the soil	
Analyse soil from several parts of the field to find how much fertiliser had been added	
Plant "Kerr's Pinks" potatoes in the field and record the crop from various parts of the field	
Sow "Golden Wonder" potatoes in soil containing no artificial fertiliser	
Check whether or not frost had occurred during the time the potatoes had grown.	

Appendix 5-10

QUESTION 1

MARK	PAM FREQUENCIES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	PERCENTAGES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
-51	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-50	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-49	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-48	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-47	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-46	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-45	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-44	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-43	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-42	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-41	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-40	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-39	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-38	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-37	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-36	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-35	1	0	0	0	1	0	0.30	0.0	0.0	0.0	0.13	0.0
-34	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-33	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-32	0	0	1	0	0	1	0.0	0.0	0.26	0.0	0.0	0.18
-31	0	1	2	0	1	2	0.0	0.22	0.51	0.0	0.13	0.37
-30	0	0	1	0	0	1	0.0	0.0	0.26	0.0	0.0	0.18
-29	0	0	2	1	0	3	0.0	0.0	0.51	0.65	0.0	0.55
-28	1	0	2	1	1	3	0.30	0.0	0.51	0.65	0.13	0.55
-27	1	3	2	0	4	2	0.30	0.67	0.51	0.0	0.51	0.37
-26	1	2	4	1	3	5	0.30	0.45	1.02	0.65	0.39	0.91
-25	2	1	3	1	3	4	0.61	0.22	0.77	0.65	0.39	0.73
-24	1	0	1	2	1	3	0.30	0.0	0.26	1.29	0.13	0.55
-23	0	3	4	0	3	4	0.0	0.67	1.02	0.0	0.39	0.73
-22	1	2	1	3	3	4	0.30	0.45	0.26	1.94	0.39	0.73
-21	3	2	8	3	5	11	0.91	0.45	2.04	1.94	0.64	2.01
-20	1	5	7	3	6	10	0.30	1.11	1.79	1.94	0.77	1.83
-19	2	8	3	5	10	8	0.61	1.78	0.77	3.23	1.29	1.46
-18	3	8	6	0	11	6	0.91	1.78	1.53	0.0	1.41	1.10
-17	5	8	8	0	13	8	1.52	1.78	2.04	0.0	1.67	1.46
-16	6	8	8	3	14	11	1.82	1.78	2.04	1.94	1.80	2.01
-15	4	9	8	4	13	12	1.22	2.00	2.04	2.58	1.67	2.19

Appendix 5-10 (cont)

-14	8	9	14	5	17	19	2.43	2.00	3.57	3.23	2.19	3.47
-13	6	11	6	1	17	7	1.82	2.45	1.53	0.65	2.19	1.28
-12	6	8	14	2	14	16	1.82	1.78	3.57	1.29	1.80	2.93
-11	6	8	8	4	14	12	1.82	1.78	2.04	2.58	1.80	2.19
-10	9	8	16	6	17	22	2.74	1.78	4.08	3.87	2.19	4.02
-9	9	20	10	6	29	16	2.74	4.45	2.55	3.87	3.73	2.93
-8	9	12	14	3	21	17	2.74	2.67	3.57	1.94	2.70	3.11
-7	10	12	12	6	22	18	3.04	2.67	3.06	3.87	2.83	3.29
-6	11	18	15	3	29	18	3.34	4.01	3.83	1.94	3.73	3.29
-5	12	17	15	6	29	21	3.65	3.79	3.83	3.87	3.73	3.84
-4	9	12	13	4	21	17	2.74	2.67	3.32	2.58	2.70	3.11
-3	9	11	22	14	20	36	2.74	2.45	5.61	9.03	2.57	6.58
-2	9	20	15	2	29	17	2.74	4.45	3.83	1.29	3.73	3.11
-1	15	21	10	9	36	19	4.56	4.68	2.55	5.81	4.63	3.47
0	10	16	8	1	26	9	3.04	3.56	2.04	0.65	3.34	1.65
1	11	17	15	9	28	24	3.34	3.79	3.83	5.81	3.60	4.39
2	6	7	16	7	13	23	1.82	1.56	4.08	4.52	1.67	4.20
3	23	6	14	6	29	20	6.99	1.34	3.57	3.87	3.73	3.66
4	12	19	4	2	31	6	3.65	4.23	1.02	1.29	3.98	1.10
5	8	16	11	3	24	14	2.43	3.56	2.81	1.94	3.08	2.56
6	7	21	6	3	28	9	2.13	4.68	1.53	1.94	3.60	1.65
7	8	15	5	2	23	7	2.43	3.34	1.28	1.29	2.96	1.28
8	9	9	10	5	18	15	2.74	2.00	2.55	3.23	2.31	2.74
9	12	8	10	2	20	12	3.65	1.78	2.55	1.29	2.57	2.19
10	7	4	3	3	11	6	2.13	0.89	0.77	1.94	1.41	1.10
11	7	7	8	2	14	10	2.13	1.56	2.04	1.29	1.80	1.83
12	6	7	2	1	13	3	1.82	1.56	0.51	0.65	1.67	0.55
13	4	5	2	1	9	3	1.22	1.11	0.51	0.65	1.16	0.55
14	6	9	4	3	15	7	1.82	2.00	1.02	1.94	1.93	1.28
15	10	9	2	0	19	2	3.04	2.00	0.51	0.0	2.44	0.37
16	2	3	6	1	5	7	0.61	0.67	1.53	0.65	0.64	1.28
17	4	6	1	2	10	3	1.22	1.34	0.26	1.29	1.29	0.55
18	2	1	2	1	3	3	0.61	0.22	0.51	0.65	0.39	0.55
19	3	3	2	0	6	2	0.91	0.67	0.51	0.0	0.77	0.37
20	4	3	2	1	7	3	1.22	0.67	0.51	0.65	0.90	0.55

Appendix 5-10 (cont)

21	0	2	2	0	2	2	0.0	0.45	0.51	0.0	0.26	0.37
22	1	1	1	0	2	1	0.30	0.22	0.26	0.0	0.26	0.18
23	4	4	0	0	8	0	1.22	0.89	0.0	0.0	1.03	0.0
24	0	1	0	1	1	1	0.0	0.22	0.0	0.65	0.13	0.18
25	2	2	0	0	4	0	0.61	0.45	0.0	0.0	0.51	0.0
26	0	0	1	0	0	1	0.0	0.0	0.26	0.0	0.0	0.18
27	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
28	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
29	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
30	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
31	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
32	1	0	0	0	1	0	0.30	0.0	0.0	0.0	0.13	0.0
33	0	0	0	1	0	1	0.0	0.0	0.0	0.65	0.0	0.18
34	0	1	0	0	1	0	0.0	0.22	0.0	0.0	0.13	0.0
35	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
36	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
37	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
38	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
39	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
40	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
41	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
42	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
43	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
44	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
45	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
46	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
47	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
48	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
49	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
50	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
51	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NON	SCIENCE-NON SCIENCE
54.55	76.16	88.45	113.96

DEGREES OF FREEDOM = 103

Appendix 5-11

QUESTION 2

MARK	RAW FREQUENCIES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	PERCENTAGES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
-45	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-44	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-43	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-42	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-41	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-40	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-39	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-38	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-37	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-36	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-35	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-34	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-33	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-32	0	0	0	1	0	1	0.0	0.0	0.0	0.65	0.0	0.18
-31	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-30	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-29	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-28	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-27	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-26	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-25	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-24	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-23	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-22	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-21	0	0	1	0	0	1	0.0	0.0	0.26	0.0	0.0	0.18
-20	0	0	1	0	0	1	0.0	0.0	0.26	0.0	0.0	0.18
-19	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-18	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-17	0	1	0	0	1	0	0.0	0.22	0.0	0.0	0.13	0.0
-16	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-15	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix 5-11 (cont)

-14	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-13	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-12	0	0	1	0	0	1	0.0	0.0	0.26	0.0	0.0	0.18
-11	0	1	1	0	1	1	0.0	0.22	0.26	0.0	0.13	0.18
-10	0	2	1	0	2	1	0.0	0.45	0.26	0.0	0.26	0.18
-9	0	2	0	0	2	0	0.0	0.45	0.0	0.0	0.26	0.0
-8	1	0	3	1	1	4	0.30	0.0	0.77	0.65	0.13	0.73
-7	0	0	4	0	0	4	0.0	0.0	1.02	0.0	0.0	0.73
-6	0	0	2	0	0	2	0.0	0.0	0.51	0.0	0.0	0.37
-5	0	1	1	1	1	2	0.0	0.22	0.26	0.65	0.13	0.37
-4	0	1	2	1	1	3	0.0	0.22	0.51	0.65	0.13	0.55
-3	1	2	3	0	3	3	0.30	0.45	0.77	0.0	0.39	0.55
-2	0	1	2	1	1	3	0.0	0.22	0.51	0.65	0.13	0.55
-1	1	1	1	0	2	1	0.30	0.22	0.26	0.0	0.26	0.18
0	0	4	6	4	4	10	0.0	0.89	1.53	2.58	0.51	1.83
1	1	0	5	6	1	11	0.30	0.0	1.28	3.87	0.13	2.01
2	3	4	1	3	7	4	0.91	0.89	0.26	1.94	0.90	0.73
3	3	0	6	1	3	7	0.91	0.0	1.53	0.65	0.39	1.28
4	0	1	8	1	1	9	0.0	0.22	2.04	0.65	0.13	1.65
5	1	3	5	1	4	6	0.30	0.67	1.28	0.65	0.51	1.10
6	3	5	12	1	8	13	0.91	1.11	3.06	0.65	1.03	2.38
7	5	5	13	2	10	15	1.52	1.11	3.32	1.29	1.29	2.74
8	3	8	9	1	11	10	0.91	1.78	2.30	0.65	1.41	1.83
9	4	5	5	3	9	8	1.22	1.11	1.28	1.94	1.16	1.46
10	3	11	10	3	14	13	0.91	2.45	2.55	1.94	1.80	2.38
11	4	11	8	3	15	11	1.22	2.45	2.04	1.94	1.93	2.01
12	8	2	11	6	10	17	2.43	0.45	2.81	3.87	1.29	3.11
13	9	10	8	5	19	13	2.74	2.23	2.04	3.23	2.44	2.38
14	7	9	4	2	16	6	2.13	2.00	1.02	1.29	2.06	1.10
15	8	7	18	6	15	24	2.43	1.56	4.59	3.87	1.93	4.39
16	9	12	9	5	21	14	2.74	2.67	2.30	3.23	2.70	2.56
17	12	12	16	3	24	19	3.65	2.67	4.08	1.94	3.08	3.47
18	8	16	17	7	24	24	2.43	3.56	4.34	4.52	3.08	4.39
19	13	26	14	7	39	21	3.65	5.79	3.57	4.52	5.01	3.84

Appendix 5-11 (cont)

20	8	32	12	4	40	16	2.43	7.13	3.06	2.58	5.14	2.93
21	14	14	5	4	28	9	4.26	3.12	1.28	2.58	3.60	1.65
22	15	14	13	4	29	17	4.56	3.12	3.32	2.58	3.73	3.11
23	18	23	16	6	41	22	5.47	5.12	4.08	3.87	5.27	4.02
24	16	12	11	5	28	16	4.86	2.67	2.81	3.23	3.60	2.93
25	19	24	12	5	43	17	5.78	5.35	3.06	3.23	5.53	3.11
26	12	11	12	8	23	20	3.65	2.45	3.06	5.16	2.96	3.66
27	9	17	15	5	26	20	2.74	3.79	3.83	3.23	3.34	3.66
28	15	18	8	3	33	11	4.56	4.01	2.04	1.94	4.24	2.01
29	12	18	12	6	30	18	3.65	4.01	3.06	3.87	3.86	3.29
30	10	20	16	3	30	19	3.04	4.45	4.08	1.94	3.86	3.47
31	10	18	12	2	28	14	3.04	4.01	3.06	1.29	3.60	2.56
32	14	12	7	5	26	12	4.26	2.67	1.79	3.23	3.34	2.19
33	10	13	4	3	23	7	3.04	2.90	1.02	1.94	2.96	1.28
34	8	10	5	3	18	8	2.43	2.23	1.28	1.94	2.31	1.46
35	8	11	6	4	19	10	2.43	2.45	1.53	2.58	2.44	1.83
36	5	3	6	2	8	8	1.52	0.67	1.53	1.29	1.03	1.46
37	3	3	3	2	6	5	0.91	0.67	0.77	1.29	0.77	0.91
38	5	4	3	1	9	4	1.52	0.89	0.77	0.65	1.16	0.73
39	3	2	3	1	5	4	0.91	0.45	0.77	0.65	0.64	0.73
40	5	1	2	0	6	2	1.52	0.22	0.51	0.0	0.77	0.37
41	2	2	0	1	4	1	0.61	0.45	0.0	0.65	0.51	0.18
42	1	2	1	0	3	1	0.30	0.45	0.26	0.0	0.39	0.18
43	0	1	0	0	1	0	0.0	0.22	0.0	0.0	0.13	0.0
44	0	1	0	1	1	1	0.0	0.22	0.0	0.65	0.13	0.18
45	0	0	0	2	0	2	0.0	0.0	0.0	1.29	0.0	0.37

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NON	SCIENCE-NON SCIENCE
59.51	85.00	77.69	118.86

DEGREES OF FREEDOM = 91

Appendix 5-12

QUESTION 5

MARK	RAW FREQUENCIES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	PERCENTAGES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
0	86	115	132	64	201	196	26.14	25.61	33.67	41.29	25.84	35.83
1	98	98	167	41	196	208	29.79	21.83	42.60	26.45	25.19	38.03
2	91	140	72	39	231	111	27.66	31.18	18.37	25.16	29.69	20.29
3	46	88	20	11	134	31	13.98	19.60	5.10	7.10	17.22	5.67
4	8	8	1	0	16	1	2.43	1.78	0.26	0.0	2.06	0.18

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NPN	SCIENCE-NON SCIENCE
12.14	50.11	32.92	103.32

DEGREES OF FREEDOM = 5

QUESTION 3

MARK	RAW FREQUENCIES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	PERCENTAGES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
-6	7	11	12	1	18	13	2.13	2.45	3.06	0.65	2.31	2.38
-5	6	10	24	4	16	28	1.82	2.23	6.12	2.58	2.06	5.12
-4	16	20	22	7	36	29	4.86	4.45	5.61	4.52	4.63	5.30
-3	20	23	19	11	43	30	6.08	5.12	4.85	7.10	5.53	5.48
-2	32	40	42	19	72	61	9.73	8.91	10.71	12.26	9.25	11.15
-1	35	58	36	17	93	53	10.64	12.92	9.18	10.97	11.95	9.69
0	58	65	64	24	123	88	17.63	14.48	16.33	15.48	15.81	16.09
1	13	30	12	12	43	24	3.95	6.68	3.06	7.74	5.53	4.39
2	100	139	115	39	239	154	30.40	30.96	29.34	25.16	30.72	28.15
3	22	25	23	6	47	29	6.69	5.57	5.87	3.87	6.04	5.30
4	14	16	15	8	30	23	4.26	3.56	3.83	5.16	3.86	4.20
5	6	9	4	4	15	8	1.82	2.00	1.02	2.58	1.93	1.46
6	0	3	4	3	3	7	0.0	0.67	1.02	1.94	0.39	1.28

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NPN	SCIENCE-NON SCIENCE
8.79	15.49	10.38	18.82

DEGREES OF FREEDOM = 13

Appendix 5-13

QUESTION 4

MARK	RAW FREQUENCIES						PERCENTAGES					
	GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
-12	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-11	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-10	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-9	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-8	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-7	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-6	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-5	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-4	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-3	0	0	1	0	0	1	0.0	0.0	0.26	0.0	0.0	0.18
-2	0	0	2	1	0	3	0.0	0.0	0.51	0.65	0.0	0.55
-1	0	1	1	1	1	2	0.0	0.22	0.26	0.65	0.13	0.37
0	1	2	2	1	3	3	0.30	0.45	0.51	0.65	0.39	0.55
1	1	1	4	1	2	5	0.30	0.22	1.02	0.65	0.26	0.91
2	2	2	6	0	4	6	0.61	0.45	1.53	0.0	0.51	1.10
3	4	4	2	1	8	3	1.22	0.89	0.51	0.65	1.03	0.55
4	2	6	12	6	8	18	0.61	1.34	3.06	3.87	1.03	3.29
5	5	17	20	9	22	29	1.52	3.79	5.10	5.81	2.83	5.30
6	15	19	24	13	34	37	4.56	4.23	6.12	8.39	4.37	6.76
7	16	25	39	14	41	53	4.86	5.57	9.95	9.03	5.27	9.69
8	46	49	57	23	95	80	13.98	10.91	14.54	14.84	12.21	14.62
9	56	71	73	30	127	103	17.02	15.81	18.62	19.35	16.32	18.83
10	74	83	76	26	157	102	22.49	18.49	19.39	16.77	20.18	18.65
11	60	88	47	17	148	64	18.24	19.60	11.99	10.97	19.02	11.70
12	47	81	26	12	128	38	14.29	18.04	6.63	7.74	16.45	6.95

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NON	SCIENCE-NON SCIENCE
11.89	45.72	34.53	81.50

DEGREES OF FREEDOM = 25

QUESTION 6

MARK	RAW FREQUENCIES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	PERCENTAGES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
-12	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-11	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-10	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-9	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-8	0	1	0	0	1	0	0.0	0.22	0.0	0.0	0.13	0.0
-7	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-6	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-5	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-4	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-3	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-2	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-1	1	1	1	2	2	3	0.30	0.22	0.26	1.29	0.26	0.55
0	0	1	3	3	1	6	0.0	0.22	0.77	1.94	0.13	1.10
1	1	3	7	1	4	8	0.30	0.67	1.79	0.65	0.51	1.46
2	3	2	9	1	5	10	0.91	0.45	2.30	0.65	0.64	1.83
3	3	5	9	6	8	15	0.91	1.11	2.30	3.87	1.03	2.74
4	5	6	22	2	11	24	1.52	1.34	5.61	1.29	1.41	4.39
5	12	24	16	8	36	24	3.65	5.35	4.08	5.16	4.63	4.39
6	19	18	24	10	37	34	5.78	4.01	6.12	6.45	4.76	6.22
7	23	37	31	14	60	45	6.99	8.24	7.91	9.03	7.71	8.23
8	34	43	55	19	77	74	10.33	9.58	14.03	12.26	9.90	13.53
9	56	75	64	16	131	80	17.02	16.70	16.33	10.32	16.84	14.63
10	61	86	74	32	147	106	18.54	19.15	18.88	20.65	18.89	19.38
11	67	89	59	29	156	88	20.36	19.82	15.05	18.71	20.05	16.09
12	44	58	18	12	102	30	13.37	12.92	4.59	7.74	13.11	5.48

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NON	SCIENCE-NON SCIENCE
5.99	42.36	22.62	62.10

DEGREES OF FREEDOM = 25

QUESTION 9

MARK	RAW FREQUENCIES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	PERCENTAGES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
0	5	2	20	12	7	32	1.52	0.45	5.10	7.74	0.90	5.85
1	21	20	63	27	41	90	6.38	4.45	16.07	17.42	5.27	16.45
2	47	55	76	33	102	109	14.29	12.25	19.39	21.29	13.11	19.93
3	82	120	120	36	202	156	24.92	26.73	30.61	23.23	25.96	28.52
4	124	139	80	35	263	115	37.69	30.96	20.41	22.58	33.80	21.02
5	50	113	33	12	163	45	15.20	25.17	8.42	7.74	20.95	8.23

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NON	SCIENCE-NON SCIENCE
20.12	63.73	87.65	149.88

DEGREES OF FREEDOM = 6

QUESTION 8

MARK	RAW FREQUENCIES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	PERCENTAGES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
0	68	83	101	40	151	141	20.67	18.49	25.77	25.81	19.41	25.78
1	93	139	127	47	232	174	28.27	30.96	32.40	30.32	29.82	31.81
2	98	131	100	39	229	139	29.79	29.18	25.51	25.16	29.43	25.41
3	2	3	2	1	5	3	0.61	0.67	0.51	0.65	0.64	0.55
4	68	93	62	28	161	90	20.67	20.71	15.82	18.06	20.69	16.45

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NON	SCIENCE-NON SCIENCE
1.28	8.55	5.25	14.58

DEGREES OF FREEDOM = 5

QUESTION 7

MARK	RAW FREQUENCIES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	PERCENTAGES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
0	77	133	124	54	210	178	23.40	29.62	31.63	34.84	26.99	32.54
1	60	94	81	34	154	115	18.24	20.94	20.66	21.94	19.79	21.02
2	96	122	132	44	218	176	29.18	27.17	33.67	28.39	28.02	32.18
3	76	80	47	21	156	68	23.10	17.82	11.99	13.55	20.05	12.43
4	20	20	8	2	40	10	6.08	4.45	2.04	1.29	5.14	1.83

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NON	SCIENCE-NON SCIENCE
9.31	31.78	6.42	30.71

DEGREES OF FREEDOM = 5

Appendix 5-16

QUESTION 10

MARK	RAW FREQUENCIES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	PERCENTAGES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
-12	0	1	0	0	1	0	0.0	0.22	0.0	0.0	0.13	0.0
-11	1	1	0	0	2	0	0.30	0.22	0.0	0.0	0.26	0.0
-10	1	4	2	1	5	3	0.30	0.89	0.51	0.65	0.64	0.55
-9	2	4	4	3	6	7	0.61	0.89	1.02	1.94	0.77	1.28
-8	8	9	7	2	17	9	2.43	2.00	1.79	1.29	2.19	1.65
-7	7	15	17	5	22	22	2.13	3.34	4.34	3.23	2.83	4.02
-6	20	33	19	8	53	27	6.08	7.35	4.85	5.16	6.81	4.94
-5	28	40	38	12	68	50	8.51	8.91	9.69	7.74	8.74	9.14
-4	40	53	34	11	93	45	12.16	11.80	8.67	7.10	11.95	8.23
-3	40	48	42	18	88	60	12.16	10.69	10.71	11.61	11.31	10.97
-2	34	63	62	18	97	80	10.33	14.03	15.82	11.61	12.47	14.63
-1	51	47	34	8	98	42	15.50	10.47	8.67	5.16	12.60	7.68
0	31	40	38	20	71	58	9.42	8.91	9.69	12.90	9.13	10.60
1	26	30	29	13	56	42	7.90	6.68	7.40	8.39	7.20	7.68
2	17	24	29	11	41	40	5.17	5.35	7.40	7.10	5.27	7.31
3	9	14	17	13	23	30	2.74	3.12	4.34	8.39	2.96	5.48
4	3	9	8	8	12	16	0.91	2.00	2.04	5.16	1.54	2.93
5	4	4	2	3	8	5	1.22	0.89	0.51	1.94	1.03	0.91
6	4	6	5	0	10	5	1.22	1.34	1.28	0.0	1.29	0.91
7	2	2	2	1	4	3	0.61	0.45	0.51	0.65	0.51	0.55
8	1	1	3	0	2	3	0.30	0.22	0.77	0.0	0.26	0.55
9	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
10	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
11	0	1	0	0	1	0	0.0	0.22	0.0	0.0	0.13	0.0
12	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NON	SCIENCE-NON SCIENCE
14.07	27.27	25.45	34.75

DEGREES OF FREEDOM = 25

Appendix 5-17

QUESTION 11

MARK	RAW FREQUENCIES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE	PERCENTAGES GIRLS SCIENCE	BOYS SCIENCE	GIRLS NON	BOYS NON	SCIENCE	NONSCIENCE
-15	0	1	0	0	1	0	0.0	0.22	0.0	0.0	0.13	0.0
-14	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-13	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
-12	1	2	0	0	3	0	0.30	0.45	0.0	0.0	0.39	0.0
-11	1	0	0	1	1	1	0.30	0.0	0.0	0.65	0.13	0.18
-10	0	2	0	0	2	0	0.0	0.45	0.0	0.0	0.26	0.0
-9	0	1	0	0	1	0	0.0	0.22	0.0	0.0	0.13	0.0
-8	2	2	1	2	4	3	0.61	0.45	0.26	1.29	0.51	0.55
-7	1	0	0	1	1	1	0.30	0.0	0.0	0.65	0.13	0.18
-6	4	1	4	1	5	5	1.22	0.22	1.02	0.65	0.64	0.91
-5	1	2	2	2	3	4	0.30	0.45	0.51	1.29	0.39	0.73
-4	2	1	4	2	3	6	0.61	0.22	1.02	1.29	0.39	1.10
-3	2	3	3	3	5	6	0.61	0.67	0.77	1.94	0.64	1.10
-2	2	4	1	2	6	3	0.61	0.89	0.26	1.29	0.77	0.55
-1	1	6	4	5	7	9	0.30	1.34	1.02	3.23	0.90	1.65
0	4	14	14	8	18	22	1.22	3.12	3.57	5.16	2.31	4.02
1	6	12	10	7	18	17	1.82	2.67	2.55	4.52	2.31	3.11
2	6	7	10	8	13	18	1.82	1.56	2.55	5.16	1.67	3.29
3	12	27	20	5	39	25	3.65	6.01	5.10	3.23	5.01	4.57
4	17	28	28	7	45	35	5.17	6.24	7.14	4.52	5.78	6.40
5	18	36	29	15	54	44	5.47	8.02	7.40	9.68	6.94	8.04
6	28	40	42	9	68	51	8.51	8.91	10.71	5.81	8.74	9.32
7	34	39	41	16	73	57	10.33	8.69	10.46	10.32	9.38	10.42
8	32	47	40	12	79	52	9.73	10.47	10.20	7.74	10.15	9.51
9	38	45	38	15	83	53	11.55	10.02	9.69	9.68	10.67	9.69
10	34	34	37	12	68	49	10.33	7.57	9.44	7.74	8.74	8.96
11	33	35	28	12	68	40	10.03	7.80	7.14	7.74	8.74	7.31
12	23	25	16	3	48	19	6.99	5.57	4.08	1.94	6.17	3.47
13	18	18	9	7	36	16	5.47	4.01	2.30	4.52	4.63	2.93
14	5	7	9	0	12	9	1.52	1.56	2.30	0.0	1.54	1.65
15	4	10	2	0	14	2	1.22	2.23	0.51	0.0	1.80	0.37

CHI SQUARED FOR FREQUENCY DISTRIBUTIONS

GIRLS SCIENCE-BOYS SCIENCE	GIRLS SCIENCE-GIRLS NON	BOYS SCIENCE-BOYS NON	SCIENCE-NON SCIENCE
27.29	28.18	42.00	34.44

DEGREES OF FREEDOM = 31

Appendix 5-18 Item 1

	SCIENCE						NON-SCIENCE					
	3	2	1	-1	-2	-3	3	2	1	-1	-2	-3
FARMER	14.4	43.4	36.0	3.2	1.2	1.6	13.2	32.3	41.8	7.3	2.0	2.2
ACCOUNTANT	0.2	1.1	5.1	17.6	16.0	60.1	0.2	1.7	3.4	16.6	12.2	65.5
BANKER	0.4	1.4	4.6	15.8	16.5	61.2	1.0	0.7	3.9	13.7	15.2	65.5
DOCTOR	83.7	12.8	2.5	0.4	0.2	0.4	85.8	11.2	2.7	0.2	0.0	0.0
TECH REP	8.1	38.8	33.0	9.8	5.6	4.0	14.4	32.3	30.8	11.2	5.4	4.9
LAWYER	1.6	3.5	18.8	22.5	19.0	34.4	1.5	4.2	13.7	18.1	21.3	41.3
OIL EXEC	58.5	28.1	10.4	1.8	0.9	0.4	48.2	31.5	14.4	3.2	0.7	2.0
ARCHITECT	5.6	19.9	32.3	18.8	11.6	11.4	3.9	16.6	32.5	16.4	12.0	18.6
METEOROLOGIST	37.1	39.2	18.1	2.3	1.1	1.2	45.0	32.8	12.0	5.1	1.5	2.7
JOURNALIST	0.9	4.4	28.1	22.0	20.2	24.4	0.5	2.9	14.4	15.4	19.8	46.7
PHOTOGRAPHER	12.3	37.1	36.2	8.8	1.9	3.5	14.4	38.1	25.4	7.6	4.6	9.5
LIBRARIAN	0.4	2.6	19.5	16.9	19.2	41.7	0.5	2.9	10.3	13.0	17.8	55.5
HOUSE BUILDER	1.9	10.7	32.0	20.4	15.6	19.3	2.0	10.8	24.0	17.8	16.4	29.1
ARMY OFFICER	0.7	7.6	23.4	24.6	17.9	25.3	1.5	4.6	23.0	24.4	17.6	28.9
CAR MECHANIC	1.9	22.1	38.1	17.6	11.4	8.6	4.9	16.9	37.4	16.4	9.8	14.7
POLITICIAN	1.6	6.2	19.7	17.0	16.5	38.7	2.2	5.9	13.7	16.4	17.4	44.5
SOCIAL WORKER	0.9	3.7	16.7	20.6	20.4	37.6	1.5	6.6	16.4	16.4	17.8	41.1

Appendix 5-19 Item 2

	SCIENCE						NON-SCIENCE					
	1	2	3	4	5	6	1	2	3	4	5	6
SERIOUS	43.8	42.5	11.4	1.1	0.4	0.0	52.3	31.5	10.3	2.0	0.2	0.7
CAREFUL	74.5	18.3	4.0	1.1	0.5	0.4	70.2	17.6	6.4	1.2	0.7	1.5
INTERESTED	3.0	9.5	20.2	25.5	22.8	17.8	5.9	9.0	16.9	22.2	24.0	19.8
RESPONSIBLE	52.4	28.5	12.5	3.3	0.7	1.2	51.1	25.2	13.7	5.1	1.5	1.7
ARTICULATE	18.5	29.3	32.5	12.5	2.8	0.5	18.3	26.4	29.3	11.2	6.1	3.4
ORGANISED	42.5	28.5	14.9	6.7	4.4	1.8	36.2	21.8	13.4	10.8	9.0	6.4
HUMAN	27.9	26.4	27.4	9.8	3.0	3.2	30.8	23.7	20.3	14.4	3.2	4.6
EXCITING	6.7	19.7	38.3	18.3	9.5	5.8	6.6	13.4	24.7	15.6	16.1	20.3
FRIENDLY	5.8	21.3	35.7	21.6	9.5	3.7	7.1	16.6	31.1	21.3	14.7	5.9
VALUABLE	55.7	27.9	10.9	2.1	1.1	1.4	56.5	23.5	14.2	2.4	0.2	1.0
THOUGHTFUL	40.9	31.8	15.5	4.9	3.0	2.3	31.1	25.9	17.8	6.8	8.6	6.4
WELL EDUCATED	61.7	27.1	7.7	1.4	0.9	0.4	64.1	24.2	5.4	2.0	1.7	1.2
INVOLVED	7.7	19.2	27.8	23.9	12.1	7.6	6.1	16.4	28.4	18.6	14.9	10.8
INTERESTING	16.0	30.8	29.7	11.8	4.7	4.6	11.7	20.3	25.7	13.0	9.3	17.1
PRECISE	59.4	22.7	10.0	2.6	2.5	1.2	52.8	18.3	12.5	6.4	4.4	3.4

Appendix 5-20 Item 4

	SCIENCE							NON-SCIENCE						
	3	2	1	-1	-2	-3	VOTE	3	2	1	-1	-2	-3	VOTE
FIBRES	56.4	35.5	7.0	0.9	0.0	0.4	48.7	48.2	39.9	9.8	2.0	0.5	0.0	31.3
MASS MEDIA	31.1	39.0	24.3	3.5	1.1	0.7	51.5	36.9	35.9	22.7	2.9	0.7	0.5	67.0
COMPUTERS	55.9	30.2	10.4	1.1	0.2	0.7	52.2	52.8	30.1	13.4	1.7	1.0	0.7	35.0
EDUC. ACT	57.6	27.6	10.0	1.8	0.5	2.3	24.1	67.2	20.8	7.6	2.7	0.7	0.5	44.7
WELFARE	50.1	33.6	11.2	3.0	1.2	0.7	37.1	61.9	24.0	10.8	2.4	1.0	0.0	53.3
APPLIANCES	15.1	38.3	34.4	6.5	3.0	2.5	19.0	19.6	43.8	28.6	5.9	1.7	0.5	20.8
PLASTICS	38.5	37.4	18.6	3.5	0.9	0.9	48.2	24.4	39.6	26.9	5.4	1.7	2.0	16.6
FRANCHISE	24.6	25.3	31.5	9.7	3.9	4.9	24.4	36.2	24.7	25.9	7.8	2.4	2.7	40.1
PENICILLIN	84.4	12.0	2.3	0.2	0.4	0.5	64.5	88.0	9.8	1.5	0.5	0.0	0.0	66.3
FERTILISERS	39.5	35.1	17.4	4.0	1.4	1.8	27.1	24.0	39.4	23.0	5.1	3.9	3.7	16.9

Appendix 5-21 Item 6

	SCIENCE							NON-SCIENCE						
	3	2	1	-1	-2	-3	VOTE	3	2	1	-1	-2	-3	VOTE
ATOMIC ENERGY	57.8	24.8	11.2	2.8	1.1	1.1	50.3	43.0	29.8	17.6	4.6	1.2	2.4	35.2
COMPOSER	4.7	8.6	31.6	25.1	13.5	16.3	54.3	4.6	7.8	28.4	23.7	16.6	18.3	49.6
PSYCHOANALYST	10.7	39.0	35.0	7.4	2.6	3.7	39.5	18.3	39.9	30.6	4.2	2.7	3.4	40.6
P. M.	28.3	23.6	20.2	8.6	3.7	15.6	31.1	32.8	21.0	17.1	7.3	2.9	18.1	31.3
MATHEMATICIAN	9.0	29.3	34.8	10.4	7.0	9.1	9.5	7.8	26.4	35.7	13.0	8.3	8.6	10.3
MODERN ART	2.8	8.4	27.9	28.5	12.5	19.7	41.5	3.4	10.8	30.3	25.9	11.5	17.8	50.1
DNA MOLECULE	23.9	39.7	25.0	6.0	2.5	2.5	28.6	21.5	32.3	24.4	10.5	5.4	4.6	16.9
ENGINEER	23.9	43.6	26.5	3.5	1.6	0.4	26.5	28.9	40.1	23.5	4.6	2.0	0.7	32.5
DRUG	61.0	28.8	7.7	1.1	0.7	0.2	51.0	67.0	24.0	7.1	0.7	0.5	0.2	62.3
WASTE	73.5	16.7	7.7	0.4	0.4	0.4	63.6	67.7	19.8	9.3	1.7	0.5	0.5	63.3

Appendix 5-22 Item 11

	SCIENCE						NON-SCIENCE					
	3	2	1	-1	-2	-3	3	2	1	-1	-2	-3
AV. RAINFALL	5.4	11.2	32.9	24.3	7.6	17.0	8.8	14.4	36.9	21.8	4.9	10.3
DIFF. FERT.	41.5	26.5	24.1	5.6	0.5	1.4	31.3	27.1	30.1	6.6	0.7	1.5
THIRD FERT.	7.9	12.8	29.2	29.5	6.9	12.8	6.8	12.2	30.3	31.5	6.6	10.0
CHECK FACTS	40.4	23.2	26.9	6.7	1.6	0.7	38.9	23.7	25.2	6.8	1.5	2.0
NEXT CROP	5.1	10.5	22.0	35.3	12.8	13.7	5.9	8.1	20.5	34.0	15.4	14.2
TYPE OF FERT	42.5	29.5	18.3	5.3	1.2	1.6	35.5	27.6	24.2	5.1	2.7	2.9
PLANT DEEPER	2.3	8.3	23.2	38.3	13.0	14.2	3.7	8.1	26.2	35.9	11.5	12.5
AMOUNT FERT	28.5	35.3	23.9	6.5	2.5	2.5	20.5	28.9	28.9	12.2	4.9	2.4
KERRS PINKS	4.2	9.7	24.4	27.2	9.8	23.7	2.7	8.3	24.9	24.7	13.2	24.2
NO FERTILISER	12.3	19.2	32.3	19.7	7.9	8.1	9.8	17.1	32.8	21.8	7.6	8.8
FROST	13.4	15.3	26.0	17.6	6.7	19.7	15.4	18.1	31.3	17.4	4.6	10.5

Appendix 5-23

Item 1

	COMPREHENSIVE SCIENCE					
	3	2	1	-1	-2	-3
FARMER	14.2	44.9	34.3	3.4	1.1	1.9
ACCOUNTANT	0.2	1.1	5.1	16.7	16.5	60.4
BANKER	0.4	1.5	4.7	16.7	16.3	60.2
DOCTOR	82.4	13.8	2.8	0.4	0.2	0.4
TECH REP	7.8	38.6	33.7	9.7	5.5	4.0
LAWYER	1.3	3.4	20.6	23.5	16.9	34.1
OIL EXEC	59.5	26.7	10.6	1.9	0.8	0.4
ARCHITECT	5.9	21.6	32.4	18.9	11.0	9.7
METEOROLOGIST	38.3	37.5	18.9	1.9	1.1	1.1
JOURNALIST	1.1	4.7	28.2	24.2	18.4	23.5
PHOTOGRAPHER	12.7	38.3	35.0	8.5	2.3	3.0
LIBRARIAN	0.4	1.9	20.1	17.2	18.9	41.7
HOUSE BUILDER	1.7	11.2	30.5	22.0	14.8	19.7
ARMY OFFICER	0.6	7.8	23.9	25.2	17.2	24.6
CAR MECHANIC	2.1	21.0	38.1	18.4	11.4	8.7
POLITICIAN	1.5	6.6	20.3	18.2	16.3	36.7
SOCIAL WORKER	0.8	3.4	16.9	21.8	19.5	37.3

	NON-COMPREHENSIVE SCIENCE					
	3	2	1	-1	-2	-3
FARMER	15.5	36.1	44.3	2.1	2.1	0.0
ACCOUNTANT	0.0	1.0	5.2	21.6	13.4	58.8
BANKER	0.0	1.0	4.1	11.3	17.5	66.0
DOCTOR	89.7	8.2	1.0	0.0	0.0	0.0
TECH REP	9.3	40.2	29.9	10.3	6.2	4.1
LAWYER	3.1	4.1	10.3	17.5	28.9	36.1
OIL EXEC	53.6	35.1	9.3	1.0	1.0	0.0
ARCHITECT	4.1	11.3	32.0	18.6	14.4	19.6
METEOROLOGIST	30.9	47.4	14.4	4.1	1.0	2.1
JOURNALIST	0.0	3.1	27.8	11.3	28.9	28.9
PHOTOGRAPHER	10.3	30.9	42.3	10.3	0.0	6.2
LIBRARIAN	0.0	6.2	16.5	15.5	20.6	41.2
HOUSE BUILDER	3.1	8.2	39.2	12.4	19.6	17.5
ARMY OFFICER	1.0	6.2	20.6	21.6	21.6	28.9
CAR MECHANIC	1.0	27.8	38.1	13.4	11.3	8.2
POLITICIAN	2.1	4.1	16.5	11.3	17.5	48.5
SOCIAL WORKER	1.0	5.2	15.5	14.4	24.7	39.2

Appendix 5-24

Item 2

	COMPREHENSIVE SCIENCE					
	1	2	3	4	5	6
SERIOUS	44.3	41.7	11.7	1.1	0.2	0.0
CAREFUL	74.2	18.6	4.0	1.1	0.2	0.4
INTERESTED	3.0	9.1	20.6	25.2	22.7	18.0
RESPONSIBLE	53.2	28.0	12.3	3.4	0.8	0.8
ARTICULATE	18.0	29.4	32.0	12.5	3.2	0.6
ORGANISED	43.9	28.2	14.4	5.7	4.4	1.9
HUMAN	27.8	26.7	26.3	10.2	3.0	3.6
EXCITING	6.8	20.1	37.9	17.6	9.7	5.9
FRIENDLY	6.6	21.2	35.0	21.0	10.0	3.8
VALUABLE	55.5	28.2	11.0	1.9	0.8	1.5
THOUGHTFUL	40.5	32.6	15.3	5.1	2.8	2.3
WELL EDUCATED	60.0	28.2	8.3	1.3	1.1	0.4
INVOLVED	8.3	19.3	27.8	23.9	12.1	7.0
INTERESTING	16.7	30.9	28.8	11.0	4.9	5.3
PRECISE	58.9	21.8	10.2	3.0	2.8	1.5

	NON-COMPREHENSIVE SCIENCE					
	1	2	3	4	5	6
SERIOUS	41.2	46.4	10.3	1.0	1.0	0.0
CAREFUL	76.3	16.5	4.1	1.0	2.1	0.0
INTERESTED	3.1	11.3	19.6	26.8	23.7	16.5
RESPONSIBLE	48.5	30.9	13.4	3.1	0.0	3.1
ARTICULATE	20.6	28.9	35.1	12.4	1.0	0.0
ORGANISED	36.1	29.9	17.5	11.3	4.1	1.0
HUMAN	28.9	24.7	33.0	8.2	3.1	1.0
EXCITING	6.2	17.5	40.2	21.6	8.2	5.2
FRIENDLY	2.1	21.6	39.2	24.7	7.2	3.1
VALUABLE	56.7	26.8	10.3	3.1	2.1	1.0
THOUGHTFUL	43.3	27.8	16.5	4.1	4.1	2.1
WELL EDUCATED	70.1	21.6	5.2	2.1	0.0	0.0
INVOLVED	5.2	18.6	27.8	23.7	12.4	10.3
INTERESTING	12.4	29.9	34.0	15.5	4.1	1.0
PRECISE	61.9	26.8	9.3	1.0	1.0	0.0

Appendix 5.25 Item 4

	COMPREHENSIVE SCIENCE						
	3	2	1	-1	-2	-3	VOTE
FIBRES	56.6	35.6	7.4	0.2	0.0	0.4	51.9
MASS MEDIA	29.4	40.0	25.0	3.4	1.1	0.6	48.9
COMPUTERS	57.2	28.8	10.8	1.1	0.0	0.4	53.6
EDUC. ACT	58.3	27.5	9.5	1.3	0.6	2.5	23.3
WELFARE	49.6	35.0	10.8	2.8	1.1	0.6	36.4
APPLIANCES	15.0	37.5	34.7	6.8	2.8	3.0	18.6
PLASTICS	37.3	38.6	18.6	3.6	0.6	1.1	49.2
FRANCHISE	25.0	25.2	31.3	9.3	4.0	4.4	24.2
PENICILLIN	85.0	11.4	2.5	0.2	0.0	0.4	63.1
FERTILISERS	38.8	35.8	18.0	4.4	1.1	1.5	28.6

	NON-COMPREHENSIVE SCIENCE						
	3	2	1	-1	-2	-3	VOTE
FIBRES	55.7	35.1	5.2	4.1	0.0	0.0	33.0
MASS MEDIA	39.2	34.0	20.6	4.1	1.0	1.0	63.9
COMPUTERS	49.5	37.1	8.2	1.0	1.0	2.1	45.4
EDUC. ACT	54.6	27.8	12.4	4.1	0.0	1.0	27.8
WELFARE	52.6	26.8	13.4	4.1	2.1	1.0	40.2
APPLIANCES	15.5	42.3	33.0	5.2	4.1	0.0	20.6
PLASTICS	44.3	32.0	18.6	3.1	2.1	0.0	43.3
FRANCHISE	22.7	25.8	29.9	11.3	3.1	7.2	25.8
PENICILLIN	81.4	14.4	1.0	0.0	2.1	1.0	71.1
FERTILISERS	43.3	32.0	14.4	2.1	3.1	3.1	19.6

Item 6

	COMPREHENSIVE SCIENCE						
	3	2	1	-1	-2	-3	VOTE
ATOMIC ENERGY	59.1	24.8	10.4	2.5	0.8	0.8	51.7
COMPOSER	5.1	9.7	30.5	25.2	13.6	15.9	54.0
PSYCHOANALYST	11.0	38.3	35.4	7.4	3.0	3.6	39.8
P. M.	28.4	25.0	20.3	9.3	3.6	13.3	31.4
MATHEMATICIAN	9.5	28.0	35.0	10.8	7.4	9.1	9.7
MODERN ART	2.8	8.7	27.8	28.2	12.9	19.5	40.9
DNA MOLECULE	24.4	39.0	25.2	5.9	2.1	2.8	29.0
ENGINEER	23.7	43.6	26.7	3.4	1.7	0.4	26.7
DRUG	58.5	30.9	8.3	1.1	0.6	0.2	50.0
WASTE	74.8	15.9	7.6	0.4	0.4	0.0	64.2

	NON-COMPREHENSIVE SCIENCE						
	3	2	1	-1	-2	-3	VOTE
ATOMIC ENERGY	51.5	24.7	15.5	4.1	2.1	2.1	43.3
COMPOSER	3.1	3.1	37.1	24.7	13.4	18.6	55.7
PSYCHOANALYST	9.3	42.3	33.0	7.2	1.0	4.1	38.1
P. M.	27.8	16.5	19.6	5.2	4.1	26.8	29.9
MATHEMATICIAN	6.2	36.1	34.0	8.2	5.2	9.3	8.2
MODERN ART	3.1	7.2	28.9	29.9	10.3	20.6	44.3
DNA MOLECULE	21.6	43.3	23.7	6.2	4.1	1.0	26.8
ENGINEER	24.7	43.3	25.8	4.1	1.0	0.0	25.8
DRUG	73.2	19.6	5.2	1.0	1.0	0.0	55.7
WASTE	67.0	20.6	8.2	0.0	0.0	2.1	60.8

Appendix 5-27 Item 11

	COMPREHENSIVE SCIENCE					
	3	2	1	-1	-2	-3
AV. RAINFALL	4.9	12.1	33.9	24.6	7.4	15.3
DIFF. FERT.	41.1	26.3	24.4	5.7	0.6	1.5
THIRD FERT.	8.1	12.9	29.9	30.5	4.9	12.9
CHECK FACTS	40.7	22.0	27.5	6.8	1.7	0.6
NEXT CROP	4.9	11.2	21.4	35.2	12.3	14.4
TYPE OF FERT	40.9	30.1	19.5	5.7	1.5	1.7
PLANT DEEPER	2.3	8.3	23.9	38.1	12.5	14.0
AMOUNT FERT	26.9	34.7	25.0	7.2	2.5	2.5
KERRS PINKS	4.2	9.5	24.6	27.3	9.1	24.2
NO FERTILISER	11.9	19.7	30.9	20.1	8.3	8.5
FROST	13.3	16.9	25.4	17.2	6.4	19.1

	NON - COMPREHENSIVE SCIENCE					
	3	2	1	-1	-2	-3
AV. RAINFALL	8.2	7.2	27.8	22.7	8.2	25.8
DIFF. FERT.	43.3	27.8	22.7	5.2	0.0	1.0
THIRD FERT.	7.2	12.4	25.8	24.7	16.5	12.4
CHECK FACTS	39.2	28.9	23.7	6.2	1.0	1.0
NEXT CROP	6.2	7.2	24.7	36.1	15.5	10.3
TYPE OF FERT	50.5	26.8	18.6	3.1	0.0	1.0
PLANT DEEPER	2.1	8.2	19.6	39.2	15.5	15.5
AMOUNT FERT	36.1	38.1	18.6	3.1	2.1	2.1
KERRS PINKS	4.1	10.3	23.7	26.8	13.4	21.6
NO FERTILISER	14.4	16.5	39.2	17.5	6.2	6.2
FROST	13.4	7.2	28.9	19.6	8.2	22.7

Appendix 5-28

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FORTRAN IV G LEVEL  21                  FREDIF                  DATE = 75014          16/50/35

0001                  SUBROUTINE FREDIF(LL,JJ,KK,K,IR,N,T,IT,ITT,X)
                C     LL IS NO. COMPARISONS,JJ NO. CATEGORIES, KK IS NO. CLASSES
                C     K IS ITEM NUMBER
                C     IR IS FREQUENCY ARRAY
                C     N IS NO. PER CATEGORY ARRAY
                C     X IS CHI**2 ARRAY
                C     IT, ITT ARE ARRAYS THAT CONTROL DISTRIBUTIONS TO BE COMPARED
0002                  DIMENSION IR(18,5,8),N(1),X(1),T(1),IT(1),ITT(1)
0003                  DO 1 L=1,LL
0004                1 X(L)=0.
0005                  DO 2 L=1,JJ
0006                2 T(L)=1/FLOAT(N(L))
0007                  DO 3 I=1,LL
0008                  DO 3 J=1,KK
0009                  P=(IR(J,K,IT(L))+IR(J,K,ITT(L)))/FLOAT(N(IT(L))+N(ITT(L)))
0010                  IF(P.EQ.0.)GO TO 3
0011                  S=SQRT(P*(1-P)*(T(IT(L))+T(ITT(L))))
0012                  P1=IR(J,K,IT(L))*T(IT(L))
0013                  P2=IR(J,K,ITT(L))*T(ITT(L))
0014                  X(L)=X(L)+((P1-P2)/S)**2
0015                3 CONTINUE
0016                  RETURN
0017                  END
```

```
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0001                  DIMENSION NP(8),NK(4),NSC(30),IS(16,8),NO(8),
                     *U(4),NO(8),NO(4,13,8),DN(10,2,8),DCV(14,3,5,8),IR(16,5,8),
                     *TT(6),TTT(6),X(5),Z(8),C(5,5),ALI(4,17,5),IO(4)
0002                  INTEGER IO(6,16,8,8)/6912*0/,NP(10,2,8)/160*0/,NV(3,8)/24*0/,
                     *DCV(16,3,5,8)/2160*0/
0003                  NSU=0
0004                  DO 1 I=1,4
0005                  NP(I)=0
0006                1 NK(I)=0
0007                  DO 2 I=1,30
0008                2 NSC(I)=0
0009                  READ(5,100)(NO(I),I=1,8)
0010                  READ(5,100)(NOO(I),I=1,8)
0011                  DO 3 I=1,1500
0012                  DO 5 J=1,3
0013                  DO 5 K=1,8
0014                5 NV(J,K)=0
0015                  READ(5,101)(IO(J),J=1,4),(IS(J,1),J=1,17),(IS(J,2),J=1,15),
                     *  (IS(J,3),J=1,3)
0016                  IF(IO(1),EQ.9)GO TO 4
0017                  READ(5,102)(IS(J,3),J=4,10),(IS(J,4),J=1,10),(IS(J,5),J=1,10),
                     *  (IS(J,6),J=1,8)
0018                  READ(5,103)(IS(J,6),J=9,10),(IS(J,7),J=1,6),(IS(J,8),J=1,11)
0019                  NP(IO(1))=NP(IO(1))+1
0020                  NSC(IO(2))=NSC(IO(2))+1
0021                  NK(IO(3))=NK(IO(3))+1
0022                3 NSU=NSU+1
0023                  JJ=0
0024                  II=IO(1)
0025                  DO 6 J=1,2
0026                  KK=NO(J)
0027                  GO TO (10,11,10,12,10,12,10,10),J
0028                10 DO 8 K=1,KK
0029                  IF(J.EQ.7)GO TO 50
0030                  IF(IS(K,J).EQ.0)GO TO 8
0031                50 ISC=IS(K,J)+4
0032                  IF(J.EQ.7)GO TO 47
0033                  IF(IS(K,J).GT.0)ISC=ISC-1
0034                47 ISC=7-ISC
0035                  IO(ISC,K,J,II)=IO(ISC,K,J,II)+1
0036                  IF(J.EQ.7)GO TO 8
0037                  GO TO (16,16,17,17,18,18),ISC
0038                 8 CONTINUE
0039                  IF(J.EQ.7)GO TO 8
0040                  GO TO 46
0041                11 DO 15 K=1,KK
0042                  IF(IO(K,J).EQ.0)GO TO 14
0043                  ISC=IS(K,J)
0044                  IO(ISC,K,J,II)=IO(ISC,K,J,II)+1
0045                  GO TO(16,16,17,17,18,18),ISC
0046                14 CONTINUE
0047                  GO TO 46
0048                16 NV(1,J)=NV(1,J)+1
0049                  IF(J.EQ.2)GO TO 14
0050                  GO TO 8
0051                17 NV(2,J)=NV(2,J)+1
0052                  IF(J.EQ.2)GO TO 14
0053                  GO TO 8
0054                18 NV(3,J)=NV(3,J)+1
0055                  IF(J.EQ.2)GO TO 14
0056                  GO TO 8
0057                46 DO 23 K=1,3
0058                  NV(K,J)=NV(K,J)+1
0059                  NCV(NV(K,J),K,J,II)=NCV(NV(K,J),K,J,II)+1
0060                23 CONTINUE
0061                  GO TO 8
0062                12 JJ=JJ+1
0063                  DO 15 K=1,KK
0064                15 NP(K,JJ,II)=NP(K,JJ,II)+IS(K,J)
0065                 6 CONTINUE
0066                  NN(5)=NN(1)+NN(2)
0067                  NN(6)=NN(3)+NN(4)
0068                  NN(7)=NN(1)+NN(3)
```

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0069                 NN(8)=NN(2)+NN(4)
0070                 WRITE(6,202)NSU,(NN(I),I=1,8)
0071                 DO 10 J=1,8
0072                 KK=NO(J)
0073                 IF(J.EQ.4)GO TO 20
0074                 IF(J.EQ.8)GO TO 20
0075                 LL=NO(J)
0076                 DO 21 K=1,KK
0077                 DO 21 L=1,LL
0078                 IO(L,K,J,5)=IO(L,K,J,1)+IO(L,K,J,2)
0079                 IO(L,K,J,6)=IO(L,K,J,3)+IO(L,K,J,4)
0080                 IO(L,K,J,7)=IO(L,K,J,1)+IO(L,K,J,3)
0081              21 IO(L,K,J,8)=IO(L,K,J,2)+IO(L,K,J,4)
0082                 GO TO 10
0083              20 DO 22 I=1,2
0084                 DO 22 K=1,KK
0085                 NP(K,I,5)=NP(K,I,1)+NP(K,I,2)
0086                 NP(K,I,6)=NP(K,I,3)+NP(K,I,4)
0087                 NP(K,I,7)=NP(K,I,1)+NP(K,I,3)
0088              22 NP(K,I,8)=NP(K,I,2)+NP(K,I,4)
0089              10 CONTINUE
0090                 DO 24 J=1,8
0091                 IF(J.EQ.4)GO TO 24
0092                 LL=NO(J)+1
0093                 DO 24 K=1,3
0094                 DO 24 L=1,LL
0095                 NOV(L,K,J,5)=NOV(L,K,J,1)+NOV(L,K,J,2)
0096                 NOV(L,K,J,6)=NOV(L,K,J,3)+NOV(L,K,J,4)
0097                 NOV(L,K,J,7)=NOV(L,K,J,1)+NOV(L,K,J,3)
0098                 NOV(L,K,J,8)=NOV(L,K,J,2)+NOV(L,K,J,4)
0099              24 CONTINUE
0100                 DO 25 I=1,8
0101                 DO 26 J=1,8
0102                 IF(J.EQ.4)GO TO 26
0103                 IF(J.EQ.8)GO TO 26
0104                 KK=NO(J)
0105                 LL=NO(J)
0106                 DO 26 K=1,KK
0107                 DO 26 L=1,LL
0108                 PO(L,K,J,I)=IO(L,K,J,I)*100./FLOAT(NN(I))
0109              26 CONTINUE
0110                 DO 27 J=1,2
0111                 DO 27 I=1,10
0112              27 PP(I,J,I)=NP(L,J,I)*100./FLOAT(NN(I))
0113                 DO 28 J=1,8
0114                 IF(J.EQ.4)GO TO 28
0115                 LL=NO(J)+1
0116                 DO 28 K=1,3
0117                 DO 28 L=1,LL
0118                 NOV(L,K,J,I)=NOV(L,K,J,I)*100./FLOAT(NN(I))
0119              28 CONTINUE
0120              25 CONTINUE
0121                 WRITE(6,100)(ITT(I),I=1,5)
0122                 WRITE(6,103)(ITT(I),I=1,5)
0123                 DO 29 I=1,5
0124                 IF(I.EQ.4)GO TO 29
0125                 KK=NO(I)+1
0126                 DO 31 J=1,8
0127                 DO 31 K=1,KK
0128              30 IF(K.I.J)=NOV(K,L,I,J)
0129                 CALL PRINT6(5,8,KK,I,IR,NN,T,IT,ITT,X)
0130                 DO 31 L=1,5
0131              31 P(L,I)=X(L)
0132              29 CONTINUE
0133                 DO 33 I=1,5
0134                 JJ=NO(I)
0135                 IF(I.EQ.5)JJ=1
0136              32 WRITE(6,103)((ALI(K,J,I),K=1,4),J=1,JJ)
0137                 N(1)=17
0138                 N(2)=15
0139                 N(3)=11
0140                 DO 34 I=1,3
0141                 II=I
```

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0142              IF(I.EQ.2)II=5
0143              IJ=1
0144              IF(I.EQ.2)IJ=8
0145              DO 35 K=1,2
0146              IF(K.EQ.1)WRITE(6,203)
0147              IF(K.EQ.2)WRITE(6,208)
0148              WRITE(6,204)
0149              IF(I.EQ.2)WRITE(6,206)
0150              IF(I.NE.2)WRITE(6,205)
0151              JJ=5(I)
0152              DO 35 J=1,JJ
0153           36 WRITE(6,207)(ALI(M,J,II),M=1,4),(PO(L,J,IJ,K),L=1,6),(PO(L,J,IJ,
                 *K+2),L=1,6),(PO(L,J,IJ,K+6),L=1,6)
0154              WRITE(6,209)
0155              IF(I.EQ.2)WRITE(6,224)
0156              IF(I.NE.2)WRITE(6,217)
0157              DO 36 J=1,JJ
0158           36 WRITE(6,210)(ALI(M,J,II),M=1,4),(PO(L,J,IJ,5),L=1,6),(PO(L,J,IJ,
                 *6),L=1,6)
0159              IF(I.EQ.2)GO TO 34
0160              DO 37 K=1,2
0161              IF(K.EQ.1)WRITE(6,203)
0162              IF(K.EQ.2)WRITE(6,208)
0163              WRITE(6,204)
0164              WRITE(6,211)
0165              JK=JJ+1
0166              DO 37 J=1,JK
0167              M=J-1
0168           37 WRITE(6,212)M,(PCV(J,L,II,K),L=1,3),(PCV(J,L,II,K+2),L=1,3),
                 *(PCV(J,L,II,K+4),L=1,3)
0169              WRITE(6,220)
0170              WRITE(6,222)
0171              DO 38 J=1,JK
0172              M=J-1
0173           38 WRITE(6,213)M,(PCV(J,L,II,5),L=1,3),(PCV(J,L,II,6),L=1,3)
0174              WRITE(6,214)(CIJ,I),J=1,5)
0175           34 CONTINUE
0176              DO 39 I=1,2
0177              II=1
0178              IF(I.EQ.2)II=5
0179              DO 40 K=1,2
0180              IF(K.EQ.1)WRITE(6,203)
0181              IF(K.EQ.2)WRITE(6,208)
0182              WRITE(6,204)
0183              WRITE(6,215)
0184              DO 40 J=1,10
0185           40 WRITE(6,216)(ALI(M,J,I+2),M=1,4),(PO(L,J,II,K),L=1,6),
                 *PN(J,I,K),(PO(L,J,II,K+2),L=1,6),PN(J,I,K+2),(PO(L,J,II,K+6),
                 *L=1,6),PN(J,I,K+6)
0186              WRITE(6,209)
0187              WRITE(6,218)
0188              DO 41 J=1,10
0189           41 WRITE(6,219)(ALI(M,J,I+2),M=1,4),(PO(L,J,II ,5),L=1,6),
                 *PN(J,I,5),(PO(L,J,II ,4),L=1,6),PN(J,I,6)
0190              DO 42 K=1,2
0191              IF(K.EQ.2)WRITE(6,208)
0192              IF(K.EQ.1)WRITE(6,203)
0193              WRITE(6,204)
0194              WRITE(6,211)
0195              DO 42 J=1,11
0196              M=J-1
0197           42 WRITE(6,212)M,(PCV(J,L,II,K),L=1,3),(PCV(J,L,II,K+2),L=1,3),
                 *(PCV(J,L,II,K+4),L=1,3)
0198              WRITE(6,220)
0199              WRITE(6,222)
0200              DO 43 J=1,11
0201              M=J-1
0202           43 WRITE(6,213)M,(PCV(J,L,II,5),L=1,3),(PCV(J,L,II,6),L=1,3)
0203              WRITE(6,214)(CIJ,III),J=1,5)
0204           39 CONTINUE
0205              DO 44 K=1,2
0206              IF(K.EQ.1)WRITE(6,203)
0207              IF(K.EQ.2)WRITE(6,208)
```

```
0233              WRITE(6,204)
0234              WRITE(6,291)
0235              DO 44 J=1,6
0236           44 WRITE(6,222)J,(PC(L,J,7,K),L=1,5),(PC(L,J,7,K+2),L=1,5),
                 *  (PC(L,J,7,K+6),L=1,5)
0237              WRITE(6,206)
0238              WRITE(6,295)
0239              DO 45 J=1,6
0240           45 WRITE(6,223)J,(PC(L,J,7,5),L=1,5),(PC(L,J,7,6),L=1,5)
0241              STOP
0242          100 FORMAT(8I3)
0243          101 FORMAT(4I2,2X,35I2)
0244          102 FORMAT(10X,35I2)
0245          103 FORMAT(2014)
0246          200 FORMAT(65,56I2)
0247          201 FORMAT(5X,72I2)
0248          202 FORMAT(///14X,'TOT     G.SCI     B.SCI     G.NON     B.NON     S
                 *CI.     NON-SCI.',7I10.8I10)
0249          203 FORMAT('1',63X,'GIRLS'/)
0250          204 FORMAT('1',63X,'BOYS'/)
0251          205 FORMAT(30X,'SCIENCE',31X,'NON-SCIENCE',27X,'COMBINED',/)
0252          206 FORMAT(10X,'3     2     1    -1    -2    -3',13X,'3     2
                 *    1    -1    -2
                 *   -3',13X,'3     2     1    -1    -2    -3'//)
0253          207 FORMAT(10X,'1     2     3     4     5     6',13X,'1     2
                 *    3     4     5
                 *     6',13X,'1     2     3     4     5     6'//)
0254          208 FORMAT(444,F4.1,5F5.1,F14.1,5F5.1,F14.1,5F5.1/)
0255          209 FORMAT('1',30X,'SCIENCE',31X,'NON-SCIENCE'/)
0256          224 FORMAT(10X,'1     2     3     4     5     6',13X,'1     2
                 *    3     4     5
                 *     6'//)
0257          217 FORMAT(10X,'3     2     1    -1    -2    -3',13X,'3     2
                 *    1    -1    -2
                 *   -3'//)
0258          210 FORMAT(444,F4.1,5F5.1,F14.1,5F5.1/)
0259          211 FORMAT(31X,'POSITIVE   MIDDLE   NEGATIVE',14X,'POSITIVE   MIDDLE
                 *  NEGATIVE'//)
0260          212 FORMAT(11X,F12.2,2F10.2,F15.2,2F10.2,F15.2,2F10.2/)
0261          220 FORMAT(31X,'POSITIVE   MIDDLE   NEGATIVE',14X,'POSITIVE   MIDDLE
                 *  NEGATIVE'/)
0262          213 FORMAT(11X,F12.2,2F10.2,F15.2,2F10.2)
0263          214 FORMAT(54X,'CHI SQUARED  VALUES'//4X,'G.SCIENCE-B.SCIENCE     G.SC
                 *IENCE-GIRLS-NON     B.SCIENCE-BOYS NON     SCIENCE-NON SCI.
                 *     GIRLS-BOYS'//5F23.2/)
0264          216 FORMAT(18X,'3     2     1    -1    -2    -3  VOTE      3     2     1    -
                 *1    -2    -3  VOTE'//)
0265          215 FORMAT(444,F4.1,6F5.1,F9.1,6F5.1,F9.1,6F5.1/)
0266          218 FORMAT(18X,'3     2     1    -1    -2    -3  VOTE      3     2     1    -
                 *1    -2    -3  VOTE'//)
0267          219 FORMAT(444,F4.1,6F5.1,F9.1,6F5.1/)
0268          221 FORMAT(22X,'2     1     0    -1    -2',23X,'2     1     0    -1    -2 ',
                 *22X,'2     1     0    -1    -2'//)
0269          222 FORMAT(I15,F10.1,4F5.1,F10.1,4F5.1,F10.1,4F5.1/)
0270          226 FORMAT(23X,'2     1     0    -1    -2',23X,'2     1     0    -1    -2',//)
0271          223 FORMAT(I15,F10.1,4F5.1,F10.1,4F5.1/)
0272              END
```

Chapter 6

Conclusion

6.1 Summary of the findings from this work

Part of the research which has constituted this work has been into the literature of attitudes, particularly in relation to those inculcated by the study or teaching of Chemistry. It has been found that, in relation to the abundance of research work which has been carried out in other fields of education, the number of investigations into the formation and assessment of attitudes is comparatively small. It is, perhaps, not surprising that this is so, since the extended debates on the exact function of the concept and the difficulty which assessment of it poses, particularly in relation to the developing and variable attitudes of adolescent schoolchildren, must have deflected many would-be researchers of this field onto more familiar and more often trodden paths. It has been seen, however, that a great deal of emphasis has been placed on the importance of the development of desirable attitudes by many leading educationalists especially in recent years, and it is proper that this should be followed by resolute exploration of these relatively uncharted waters so that those responsible for the education of children may be able to appreciate the function of this facet of the personality, determine which attitudes are educationally desirable, and discover how they can best be inculcated and assessed in their teaching practices.

Much of the work which has been reported in the literature survey has emanated from the United States, although notable contributions have been reported from researchers in the United Kingdom and elsewhere. Many of the reports of this work have been interesting, some absorbing and a few, it must be said, spurious. It must also be said that, in some cases, conflicting findings have emerged and it is possible, in the light of the present work now being reported, to make what is hoped to be constructive observations on the general field of previous research.

Reservations have already been expressed as to some of the possible assessment methods and treatment of data emanating from them which have been quoted as accepted practices in attitude research. Whatever else may emerge from the present work, it is possible now to record that the experience of this work has shown that attitude research is fraught with difficulties which very often originate in the practice of applying experimental methods which have been shown to be valid in other fields to the more nebulous and complex concept of the attitudinal component of the personality. The problems of test validity and reliability together with difficulties experienced in interpreting data are intensified in attitude research to the extent that an objective attitude researcher inevitably must come to terms with the limitations which the nature of the work imposes, or abandon it. One limitation, which must reluctantly be accepted, is that it may be unwise to make

definite and unequivocal statements as a result of the work which has been carried out. The temptation to do this is very real, since it would be a most unusual researcher who did not aspire to reveal to those to whom he reports something of consequence and of originality. The role of the attitude researcher may then be to present his findings as pointers or indicators of personality traits or group attitude trends and this role is adopted in this summary.

What then of the definitive and unequivocal statements of attitude researchers already surveyed and reported? It will be appreciated that literature surveys are usually conducted from abstracts of research reports because of the unavailability of the original work and because of the condensed nature of the abstract. Since a major reservation already expressed has been concerned with the treatment of data derived from attitude tests, which is not usually given a prominent place in abstracts (if it appears at all) reservations must be held on much of the work reported until it becomes clear that the methods by which figures for test reliability and validity and other statistical findings have been produced are sound and can endure thorough examination. In an attempt to illustrate the variable results that can be produced from the same attitude tests, the summary of results from this work will make reference to the three distinct methods of treatment of data which have been employed:

1. Numerical scores from sub-items were summated to give a score for each pupil. Categories of pupils were

then established and mean scores produced for each categories. Differences of means between categories were then examined for evidence of statistical significance.

2. The percentage frequencies of all possible scores obtained for each item for certain categories of pupils were calculated. These were then compared for significant differences. The scores were again obtained by summating sub-item scores.

3. The percentage frequencies of scores allocated to sub-items by pupils were calculated for certain items. These were then examined for significant differences between the science and non-science categories, and the comprehensive science pupils and non-comprehensive science pupils only. The limitations in time did not permit this detailed examination of sub-item frequencies for any other categories in the present work. It is noteworthy that this procedure did not involve summation of sub-item or item scores.

Method (3) above is presented here as that which produced the most valid results. The reasons for this have been discussed in some detail in Chapter 5.4.5. It is also the most time-consuming to carry out. Entries in the following tables for each item show whether significant differences have been found, and at what level for comparisons between certain categories made by the three different methods.

N.B. Where a significant difference has been entered, the first named category has been found to be superior in attainment to the second named unless the entry is marked with an asterisk when the reverse is true.

Item 1 Affective Objective: Awareness that Chemistry can form the basis for many satisfying careers.

Categories compared	Method 1	Method 2	Method 3*
Science/Non-Science	Sig (1%)	Not sig	Not sig
Comprehensive Science/ Non-Comprehensive Science	Not sig	-	Not sig
Girls Science/Girls Non-Science	Sig (1%)	Not sig	-
Boys Science/Boys Non-Science	Sig (5%)	Not sig	-
Boys/Girls	Not sig	-	-
Girls Science/Boys Science	-	Not sig	-

*

Method 3 results are included in this and following tables so that the results from all three methods can be compared. It should be borne in mind, however, that in order to do this, the overall trend as to whether significant differences exist has had to be quoted. This trend has been obtained by inspection of all of the results from each sub-Item for the Item reported.

Item 2 Affective Objective: Awareness of the contribution of Chemistry to the full development of the individual.

Categories compared	Method 1	Method 2	Method 3
Science/Non-Science	Sig (1%)	Sig (3%)	Sig (1%)
Comprehensive Science/ Non-Comprehensive Science	Not sig	-	Not sig
Girls Science/Girls Non-Science	Sig (1%)	Not sig	-
Boys Science/Boys Non-Science	Not sig	Not sig	-
Boys/Girls	Not sig	-	-
Girls Science/Boys Science	-	Not sig	-

Item 3 Affective Objective: Awareness of the contribution of Chemistry to the full development of the individual (especially "human" qualities of the scientist)

Categories compared	Method 1	Method 2	Method 3
Science/Non-Science	Not sig	Not sig	Not sig
Comprehensive Science/ Non-Comprehensive Science	Sig (1%)	-	Not sig
Girls Science/Girls Non-Science	Not sig	Not sig	-
Boys Science/Boys Non-Science	Not sig	Not sig	-
Boys/Girls	Not sig	-	-
Girls Science/Boys Science	-	Not sig	-

Item 4 Affective Objective: Awareness of the contribution of Chemistry to the economic and social welfare of the community.

Categories compared	Method 1	Method 2	Method 3
Science/Non-Science	Sig (1%)	Sig (1%)	Sig (1%)
Comprehensive Science/ Non-Comprehensive Science	Not sig	-	Not sig
Girls Science/Girls Non-Science	Sig (1%)	Sig (1%)	-
Boys Science/Boys Non-Science	Sig (1%)	Sig (10%)	-
Boys/Girls	Not sig	-	-
Girls Science/Boys Science	-	Not sig	-

Item 5 Affective Objective: Interest and enjoyment in Chemistry

Categories compared	Method 1	Method 2	Method 3
Science/Non-Science	Sig (1%)	Sig (1%)	Sig (1%)
Comprehensive Science/ Non-Comprehensive Science	Not sig	-	Not sig
Girls Science/Girls Non-Science	Sig (1%)	Sig (1%)	-
Boys Science/Boys Non-Science	Sig (1%)	Sig (1%)	-
Boys/Girls	Not sig	-	-
Girls Science/Boys Science	-	Sig (5%)*	-

Item 6 Affective Objective: Awareness of the contribution of Chemistry to the economic and social welfare of the community.

Categories compared	Method 1	Method 2	Method 3
Science/Non-Science	Sig (1%)	Sig (1%)	Sig (1-5%)
Comprehensive Science/ Non-Comprehensive Science	Sig (5%)	-	Not sig
Girls Science/Girls Non-Science	Sig (1%)	Sig (3%)	-
Boys Science/Boys Non-Science	Sig (1%)	Not sig	-
Boys/Girls	Not sig	-	-
Girls Science/Boys Science	-	Not sig	-

Item 7 Affective Objective: Interest and enjoyment in Chemistry.

Categories compared	Method 1	Method 2	Method 3
Science/Non-Science	Sig (1%)	Sig (1%)	Sig (1%)
Comprehensive Science/ Non-Comprehensive Science	Not sig	-	Not sig
Girls Science/Girls Non-Science	Sig (1%)	Sig (1%)	-
Boys Science/Boys Non-Science	Sig (1%)	Not sig	-
Boys/Girls	Not sig	-	-
Girls Science/Boys Science	-	Sig (10%)	-

Item 8 Affective Objective: Awareness that a number of variables can influence an experimental situation.

Categories compared	Method 1	Method 2	Method 3
Science/Non-Science	Sig (1%)	Sig (3%)	-
Comprehenisve Science/ Non-Comprehensive Science	Not sig	-	-
Girls Science/Girls Non-Science	Sig (5%)	Not sig	-
Boys Science/Boys Non-Science	Not sig	Not sig	-
Boys/Girls	Not sig	-	-
Girls Science/Boys Science	-	Not sig	-

Item 9 Affective Objective: Commitment to arriving at conclusions from the information, knowledge and understanding available.

Categories compared	Method 1	Method 2	Method 3
Science/Non-Science	Sig (1%)	Sig (1%)	-
Comprehensive Science/ Non-Comprehensive Science	Not sig	-	-
Girls Science/Girls Non-Science	Sig (1%)	Sig (1%)	-
Boys Science/Boys Non-Science	Sig (1%)	Sig (1%)	-
Boys/Girls	Sig (1%)	-	-
Girls Science/Boys Science	-	Sig (1%)	-

Item 10 Affective Objective: Commitment to arriving at conclusions from the information, knowledge and understanding available.

Categories compared	Method 1	Method 2	Method 3
Science/Non-Science	Not sig	Sig (1%)	-
Comprehensive Science/ Non-Comprehensive Science	Not sig	-	-
Girls Science/Girls Non-Science	Not sig	Not sig	-
Boys Science/Boys Non-Science	Sig (5%)	Not sig	-
Boys/Girls	Not sig	-	-
Girls Science/Boys Science	-	Not sig	-

Item 11 Affective Objectives: a) Acceptance of the value of an experiemental approach to problems b) Commitment to apply a scientific approach in other fields of experience.

Categories compared	Method 1	Method 2	Method 3
Science/Non-Science	Sig (1%)	Not sig	Sig (1%)
Comprehensive Science/ Non-Comprehensive Science	Sig (1%)*	-	Sig (1%)*
Girls Science/Girls Non-Science	Sig (1%)	Not sig	-
Boys Science/Boys Non-Science	Sig (1%)	Sig (10%)	-
Boys/Girls	Not sig	-	-
Girls Science/Boys Science	-	Not sig	-

A summary will be made here from the above tables to indicate what are considered to be the most clear indications of attitude trends.

1. The following list includes trends which are indicated by similar results obtained from all three methods employed:

a) Science pupils have a more favourable opinion of the contribution of Chemistry to the full development of the individual (here personified by the scientist) than do non-science pupils.

b) Science pupils see the contribution of Chemistry to the economic and social welfare of the community in a much better light than non-science pupils do.

c) Science pupils take more interest and enjoyment from Chemistry topics than non-science pupils.

2. There are also some indications of attitude trends which are confirmed by the only two methods carried out:

a) Both girls and boys science pupils are more aware of the contribution made by Chemistry to the economic and social welfare of the community than their non-science counterparts.

b) Both girls and boys science pupils take more interest and enjoyment from Chemistry topics than their non-science counterparts.

c) Science pupils are more capable of coping with a

multivariate experimental situation than non-science pupils.

d) Science pupils (both girls and boys) show a greater commitment to arriving at conclusions from the information, knowledge and understanding available than their non-science counterparts.

e) Pupils doing Science in non-Comprehensive schools accept the value of an experimental approach to problems and are more fully committed to apply a scientific approach in other fields of experience than are science pupils in Comprehensive schools.

It should be noted that apart from the indication of a trend in 2)e) above, no differences in affective objective attainment was found between comprehensive science pupils and non-comprehensive science pupils. Very little of significant difference was also discovered between the attainments of female science pupils and male science pupils or in the comparison between all of the boys involved in the survey and all of the girls.

The study of teachers' attitudes showed clearly that almost without exception, the attainment of logical and objective habits of thought by their pupils and an appreciation of the wonder of their surroundings, were high on the lists of affective objectives of the one hundred teachers who replied. The examination of five schools who had shown either extremely good or extremely poor results in objectives concerned with interest in Chemistry and awareness of its important applications, showed very clear indications that the role of the Principal

Teacher in the development of these objectives, both in his staff and his pupils is a dominating factor.

Two caveats must be entered with the above summarised trends:

1. The objectives of the Chemistry course were chosen subjectively. They cannot be supported by a logical deduction that a certain statement should be an objective of a course. Furthermore, the questionnaire used was a subjective interpretation of these objectives and a subjective method of measuring them.

2. It has been accepted throughout that attitudes are learned predispositions. No claim can be made that 'O' Grade Chemistry courses make a major or, indeed, any contribution to this learning process. Attitudes that are exposed by any assessment technique may already be inherent in pupils who select subjects from several options, and their selection may merely confirm attitudes which are already present.

6.2 Suggestions for further work

During the course of the work which is now being concluded, it became more and more meaningful to place the investigations being carried out, the deductions being made and the conclusions being drawn in the context of fundamental questions which served both to moderate and to re-direct the procedures being adopted. The questions were:

what is the purpose of Education and, in particular, what contribution should the study of Chemistry be capable of achieving in order to further the aims of Education? It can be said that the posing of these questions by undertaking work of this nature, is an experience which many practicing teachers should find rewarding in terms of clarifying aims and objectives often obscured by the classroom situation. It may, however, result also in certain frustrations for, as soon as the journey has commenced, unexpected avenues of interest present themselves and limitations of time prevent their exploration. This is particularly so in attitude research and some of these avenues will be listed for what may be the benefit of future journeyers.

The initial formation of attitudes to a school subject cannot necessarily, as has been said in Chapter 6.1, be attributed to the years during which the subject is being studied. Its formation may lie years earlier from environmental or genetic factors over which teachers may have little control. A study of the development of attitudes to school subjects would seem to be a fruitful area for research.

It has been seen that an essential part of any attitude investigation is the production of assessment techniques with proven validity and reliability. A great deal of work remains to be done in this area and the use of several different techniques applied to one specific attitude is

suggested so that, by comparison, the limitations of each, if they exist, can be revealed. Furthermore, if attitude assessment should be in the domain of the classroom teacher, as are many cognitive assessments, reliable and relatively easily administered tests must be prepared for the teacher and in addition, pre-service and in-service training given on the subject. It should be said here that in the school situation it is considered that attitude assessment by teachers is mainly a group function which should be of value in assessing courses and methods of teaching. It would be premature to suggest that it should be applied to individual pupils with the possibility of producing an 'order of merit' of pupils who have apparently achieved desirable affective objectives of their courses.

Should it become possible to measure attitudes with as high a degree of confidence as cognitive attainments are measured, the factors underlying changes of attitudes to school subjects could be usefully explored. This could have far-reaching effects in teaching methods and curricular development. Furthermore, it is considered that comparisons of the above work, where certain trends in attitudes have been revealed, with a previous work already reported where very little by way of trends had been shown for pupils a few years younger than those used in the present work, may suggest that a great deal of much more consequence could emerge from the study of students at a later stage i.e. post secondary education.

Much has been said on the prestigious nature of Bloom's Taxonomy of Educational objectives in the affective domain. A great deal of work remains to be done in verification of this system together with how such systems can be used in the formulation of desirable educational objectives, not only for Chemistry, but for all school subjects. On a practical level the curricula at present being produced for non-certificate pupils at the secondary stage must surely be shown to be relevant to the educational needs of the pupils and to be possible to present in the present educational structure. If, in this area of curricular development, it can be shown that desirable attitude development can be inculcated by school subjects, perhaps in a more integrated form by breaking traditional barriers between subjects, and presented by methods proven to be effective, the study of Chemistry, or for that matter, any school subject could take on new educational dimensions.

To summarise the suggestions for further work, it is considered that research into the affective domain could fruitfully be directed to:

a) the cause of development of attitudes to school subjects;

b) development of further attitude assessment techniques capable of being applied to school groups by teachers;

c) factors underlying changes of attitudes to school subjects;

d) verification of the taxonomy of affective objectives and its application to formulating desirable objectives for all school subjects.

References

1. Allport, G.W.: Handbook of Social Psychology, 1935.
2. Faris, E.: The Concept of Social Attitudes, J. App. Social, 1925, 9, 404-9.
3. Piaget, J.: The Moral Judgement of the Child, 1932.
4. Katz, D. and Stotland, E.: A Preliminary Statement to a Theory of Attitude Structure and Change: in Koch (Ed.) Psychology: A Study of a Science.
5. Heider, F.: The Psychology of Interpersonal Relations, 1958.
6. Eysenck, H.J.: The Structure of Human Personality, 1953.
7. Cook, S.W. and Selltiz, C. in Attitudes: Jahoda and Warren (Eds.).
8. Arastasi, Anne: Psychological Testing, 1961.
9. Edwards, A.L.: Techniques of Attitude Scale Construction, 1957.
10. Lowery, L.F.: An Experimental Investigation into the Attitudes of Fifth Grade Students towards Science: School Science and Mathematics, 1967, 67, 569-579.
11. Lowery, L.F.: Development of an Attitude Measuring Instrument for Science Education: School Science and Mathematics, 1966, 66, 494-502.
12. Hammond, K.K.: Measuring attitudes by error-choice: an indirect method: J. Abn. Soc. Psych., 1948, 43, 38-48.
13. Nedelsky, L.: Science Teaching and Testing, 1965.
14. Butcher, H.J.: The Structure of Abilities, Interests and Personality in 1,000 Scottish Schoolchildren, Brit. J. Educ. Psychol., 1969, 39(2), 154 - 165.

15. Vitrogan, D.: A Method for determining a Generalised Attitude of High School Students towards Science: Science Education: 1967, 51, 170 - 175.

16. Wynn, D.C. and Bledsoe, J.C.: Factors related to gain and loss of Scientific Interest during High School: Science Education: 1967, 51, 67 - 74.

17. Ormerod, M.B.: Social and Subject Factors in Attitudes to Science: June 1973, S.S.R. 54.

18. Dutton, W.H. and Stephens, L.: Measuring Attitudes towards Science: School Science and Mathematics: 1963, 63, 43-49.

19. Brown, S.A. and Davis, T.N.: The Development of an 'Attitude to Science' Scale for 12-14 year olds: Scottish Educational Studies: 1973, 5(2), 85-94.

20. Barker Lunn, J.C.: The Development of Scales to measure Junior School Children's Attitudes: Brit. J. Ed. Psychol.: 1969, 39, 64-71.

21. Mitchell, C.: Do scales for measuring attitudes have any significance? J. Ed. Research, 1941, 34, 444-452.

22. Durcker, K.: on problem solving: 1945. Psychological Monogr.: American Psychological Association.

23. Inhelder, B. and Piaget, J.: The Growth of Logical Thinking from Childhood to Adolescence: 1958.

24. Wrigley, J. and Kerr, J.F.: Attitudes and aims in Science Teaching: 1960, Educ. Rev., 12, 57-67.

25. Meyer, G.R. and Penfold, D.M.: Factors associated with interest in science: Brit. J. Educ. Psychol. 1961, 31(1), 33-37.

26. Lewis, D.G.: The factorial nature of attainment in elementary science: Brit. J. Educ. Psychol.: 1964, 34(1), 1-9.

27. Jones, K.J.: Interest, Motivation and Achievement in Science: J. Expt. Educ., 1964, 33(1), 41-53.

28. I.E.A. Study of Achievement in Mathematics: Ed.: T. Husen (1967).

29. Selmes, C.: Attitudes to Science and Scientists: School Science Review: 1969, 51(174), 7-14.

30. Ashton, B. and Meredith, H.M.: The Attitudes of sixth formers to science: School Science Review: 1969, 51(174), 15-19.

31. Laughton and Wilkinson: The Science Opinion Poll: Education in Science: May 1970, 25-27.

32. Flynn and Murno: Evaluation of a Curriculum: Brit. J. Educ. Psychol.: 1970, 40(3), 271-282.

33. Johnstone, A.H. and Sharp, D.W.A.: Science in a Wooing Mood: Times Educational Supplement: 1970.

34. Lewis, D.G.: Objectives in the Teaching of Science: Educational Research: 1965, 7(3), 186-199.

35. Bloom, B.S. (Ed.): Taxonomy of Educational Objectives: Handbook 1, Cognitive Domain: McKay, 1956.

36. Krathwohl, Bloom and Masia: Taxonomy of Educational Objectives: Handbook 2, Affective Domain: Longman, 1964.

37. Kropp, R.P., Stoker, H.W., and Bashaw, W.L.: The Validation of the Taxonomy of Educational Objectives: J. Expt. Ed.: 1966, 34(3), 69-73.

38. Lewy, A.: The Empirical Validity of Major Properties of a Taxonomy of Affective Educational Objectives: J. Expt. Educ.: 1968, 36(3), 70-77.

39. Mager, R.F.: Preparing Instructional Objectives: Fearon, 1962.

40. Science in Secondary Schools: Ministry of Education Pamphlet No. 38: H.M.S.O.: 1960.

41. Nuffield Chemistry: Introduction and Guide: The Nuffield Foundation: 1966.

42. Curriculum Papers No. 7: Scottish Education Department, H.M.S.O., Edinburgh: 1969.

Bibliography

Bloom, B.S., Hastings, J.T., and Madius, G.F.: Handbook on Formative and Summative Evaluation of Student Learning: McGraw-Hill: 1971.

Hooper, R. (Ed.): The Curriculum: Content, Design and Development: Oliver and Boyd: 1971.

Lewis, D.G.: Statistical Methods in Education: University of London Press: 1967.

Nisbet, J.D. and Entwhistle, N.J.: Educational Research Methods: University of London Press: 1970.

Oppenheim, A.N.: Questionnaire Design and Attitude Measurement: Heinemann: 1966.

Pont, H.B. and Butcher, H.J.: Educational Research in Britain: Second Edition: MacMillan: 1968.

Thouless, R.H.: Map of Educational Research: National Foundation for Educational Research in England and Wales: 1969.

Travers, R.M.W.: An Introduction to Educational Research: Second Edition: MacMillan: 1964.

Travers, R.M.W.: Second Handbook of Research on Teaching: American Educational Research Association: 1973.