AN EXPLORATION OF DIFFERENT OUTLOOKS ON SCIENCE: TOWARDS AN UNDERSTANDING OF THE UNDER-REPRESENTATION OF GIRLS, AND OF MAORI AND PACIFIC ISLAND STUDENTS, IN SCIENCE.

A thesis

submitted in partial fulfilment

of the requirements for the Degree

of Doctor of Philosophy

at the

University of Waikato

by

KEITH ERIC STEAD

University of Waikato

1984

ABSTRACT

The research reported here was undertaken as a supplementary study to the Learning in Science Project conducted at Waikato University (1979-1981) and sought to understand why girls, Maori and Pacific Island students, are under-represented in the sciences. Two distinctive, but complementary, perspectives were developed; one qualitative, the other quantitative, to provide data from which an understanding of the problem was sought.

The qualitative perspective was provided by using a Kelly Repertory Grid methodology and intensive individual interviews with 26 students (and many of their parents) carefully chosen to provide a reasonably heterogeneous sample of students from a variety of different schools, of both sexes, of the three major ethnic groups (European, Maori, and Pacific Island), and from each of the four middle-school form levels (F1 to F4, inclusively).

The quantitative perspective was provided by a series of empirical measures chosen, not only to identify the students for the qualitative sample but also, to investigate particular variables suggested by the literature search to have possible implications for the teaching and learning of science.

The resultant analyses suggested the sex differences in the students' outlooks on science could be accounted for by the existence of a broad based 'gender-related inequality' in the way science is presented to them by the communication media, home,

and school.

Similarly, the ethnic differences in students' outlooks on science could be accounted for by the 'cultural inequality' present in New Zealand society which was identified in the way many of the Polynesian students and their parents, perceived the products, processes, and practitioners of science.

The simplification presented here masks the complexity of the issues involved but, within these two broad postulates, a series of educational recommendations was suggested for affecting current educational practices identified as maintaining (or even creating) the existing under-representation of girls, Maori and Pacific Island students in the sciences.

These included:

(i) Student beliefs about science need to be explored, challenged, modified, and/or extended

(ii) Students' perceptions of other people's views need to be identified, explored, challenged and/or extended

(iii) Teachers' styles of teaching science need to be examined

(iv) Parents' own outlooks on science need to be developed.

This research has emphasised the need to have all students, but particularly girls, Maori, and Pacific Island students, develop positive outlooks on science in order that the current imbalance of girls and Polynesians in the sciences be redressed.

ACKNOWLEDGEMENTS

To my supervisers, Professor Peter Freyberg, Head of Education, and Dr Osborne, Senior Lecturer in Physics (both at Waikato University), I owe much. Their supportive comments and trenchant criticisms throughout this study provided an impetus, a sense of direction, and most important, a confidence that this undertaking would be completed. I value very deeply their contributions and say 'thanks'.

Many other people, knowingly or otherwise, have contributed much to this thesis - in particular, appreciation is expressed for the contributions the members of the LISP team made to my thinking. I sincerely thank Beverley Bell, John Happs, Ross Tasker and Brendan Schollum for this.

This study would not have been possible without the goodwill of the schools, teachers, pupils and their parents who gave me so much of their time and so willingly shared their perceptions of the research problem with me. Thanks go to them too.

Grateful acknowledgement is extended to the NZCER for providing financial support to the study and to Dr Patrick Slater for his advice on the Repertory Grid analyses and for the use of the 'Grid Analysis Package'.

TABLE OF CONTENTS
VOLUME 1

Page

LIST OF TABLES

LIST OF FIGURES

VOLUME 2
APPENDICES

A, kei muri i taku tuara
e pakakō mai ana
ngā koiwi o aku tīpuna
Kei mua e tu mai ana
he kēhua kē, kino kē atu,
Nā te mea he kēhua hou,
Whakaatu mai ana i a au
he kūare ....

And at my back
Crackle
the bones of my ancestors,
In front of me stand
other ghosts more dreadful
because they are new,
Letting me know
that I am ignorant ....
(Arapera Blank, 1974)

CHAPTER ONE

SETTING THE SCENE

> "I conceive it would be one of the greatest boons which could be conferred upon England if henceforth every child in the country were instructed in the general knowledge of the things about it, in the elements of physics and of botany. But I should be better pleased if to these could be added somewhat of chemistry and an elementary acquaintance with human physiology."
> T.H. Huxley, from a speech delivered in 1869.
> (Department of Education and Science, 1980)

1.1 The question.

Considerable advances have been made in science education since Huxley's time in England, in New Zealand, and in most countries of the Western world.

However, whilst every child has, in theory, the opportunity to study science for all his/her school days (and beyond), many children elect to cease studying it beyond the fourth form (F4) or the fifth form (F5) year. In particular, two discernible groups of New Zealand students are choosing not to continue with their studies in science - these are girls and women, and Maoris and Pacific Islanders.

Approximately, 70% of F5 boys take science in New Zealand state secondary schools, as opposed to 50% of F5 girls. At the form six (F6) level, nearly 40% of boys take chemistry and yet just over 20% of the girls do; nearly 50% of boys take physics but only 15% of the girls do. The situation is reversed for biology with 75% of the F6 girls taking it as opposed to 50% of the boys. The form seven (F7) enrolment figures also show a disproportionate representation between the sexes, as do university enrolment figures, where, even in the biological sciences, proportionately more males than females obtain science degrees (further details of science enrolments referred to in this section, together with their sources, are given in Appendix 1.1).

There is a parallel situation as far as ethnicity is concerned. Over 60% of non-Maori F5 students take science as compared with less than 50% of Maori F5 students. Whilst 15% of the Maori F6 students study chemistry, over 30% of non-Maori F6 students take it. The F6 physics proportions are in the same direction (20% Maori versus 30% non-Maori). Only in biology are the proportions similar, with 65% non-Maori students, as opposed to less than 60% Maori students, taking it. The F7 figures show the same relative proportions between these ethnic groups, although not to the same extent. Proportionately more Maori students than non-Maori students leave school at each form level (other than F7) so the convergence of the proportions of the different ethnic groups studying the sciences at higher form levels may simply reflect 'selection pressure'. That is, those Maori students who do stay within the school system may well be those who have accepted, or seek, European educational values (Appendix 1.2 gives the relative proportion of Maori students in New Zealand state secondary schools at each form level for the five consecutive years 1976-1980 inclusively).

Comparable data specific to Pacific Island students in New Zealand schools, are not available but the under-representation of Pacific Island students in senior classes is generally observed.

The central question in this study can thus be stated: "Why are New Zealand girls and women, and New Zealand Maori and Pacific Island students, so under-represented in the sciences?"

1.2 The importance of the question.

The importance of this issue may be illustrated by considering a supplementary question, "Why study science anyway?" Answers would include:

(a) Students who cannot, or will not, learn science are denied a wide range of career possibilities.

(b) In today's scientific workplace, higher pay and higher status frequently accompany scientific and technological prowess.

(c) With the wider choice of subjects within the school system and as a consequence of having a wider choice of careers, the possibility of failure in school or in the workplace should be reduced.

(d) It would be desirable for women, Maoris, and Pacific Islanders to have access to professions which depend on scientific training, since members of the scientific profession control many aspects of today's society and they are at present, as groups, under-represented.

(e) Science contributes significantly to the changes being experienced in contemporary society and all social groups and individuals should be represented in those groups playing a part in directing these changes. Every person needs to have at least sufficient understanding to take an intelligent part in current debates on such topics as environmental conservation, pollution, energy resources, micro-technology, genetic engineering, water fluoridation.

(f) Members of the society without a sense of competency and adequacy in their technological and scientific environment may develop feelings of alienation and powerlessness in their everyday world and become wholly dependent on the technical 'experts' to effect simple repairs to even the labour saving devices and machinery which surround them.

(g) Science provides a way of 'knowing' about the world in a unique and powerful way. It allows for an appreciation, and an understanding, of aspects of the human experience which complements other ways of knowing (such as those gained via an affective, or a spiritual, or a social mode).

In other words, it should be a matter of considerable concern that a large proportion of existing and future New Zealand citizens are scientifically disenfranchised.

1.3 Has the question been asked before?

The original question needs to be broken into two - that concerned with girls and women, and that to do with Maori and Pacific Island people.

Overseas, the issue of girls and women in science has long been one which has promoted comment, speculation, and much research (e.g. in Australia - Keeves & Read, 1974; USA - Cole & Cole, 1973; Britain - Kelly, 1976 ; 1978; 1981a).

In the same year that Huxley made his comments, Becker (1869) raised the question, "Why do students of science among men greatly outnumber those among women?" Whether or not girls had the ability to cope with scientific ideas was an issue of immediate and practical importance to the nineteenth century pioneers of secondary education and was one which confronted the consultative committee of the Board of Education (United Kingdom) in 1923 and its inquiry into the differentiation of secondary school curricula between the sexes (Jenkins, 1980). During the 1950s a concern grew (particularly in the USA and Britain) over the shortage of qualified scientists and science teachers (Manthorpe, 1982) and, in the 1960s, the 'swing from science' further exacerbated the 'manpower' problem. Thus, in these times, the principal reason for encouraging girls to continue with the study of science was that borne out of economic and industrial considerations. An additional argument was that the study of science is an important part of any course of general education which seeks to prepare future citizens for a life in a scientific society.

More recently, whilst the contribution of girls and women to the scientific workforce remains important, other factors are now recognised. One major factor is that of society's increasing awareness of the need to eliminate sex-bias injustices, particularly those which have demonstrable social origins. Considerable research has sought to identify sex differences in ability, attitudes, cognition, and other personality variables, and to relate these to the under-representation of girls and women in science. Some of these studies are reported more fully in the next chapter of this thesis.

Within the New Zealand context, the exploration of the question of the under-representation of girls and women in science has had a shorter history. When high schools for girls were established at the end of the nineteenth century, it was deliberate educational policy to formalise sexual differences in the educational process and to direct girls along the lines they 'ought naturally to go' (Tennant, 1977). It was believed that there were certain courses of study, such as mathematics and the mathematically-based sciences, to which women were simply not adapted, and in which they could not possibly succeed without devoting a disproportionate amount of time, while suffering from 'nervous wear and tear' (Tennant, 1977).

Consequently, at the beginning of this century, the emphasis in girls' education in New Zealand was on preparation for motherhood and houselife, and, with the introduction of 'house science' in the curricula as a compulsory subject for girls in 1917, the continued under-representation of New Zealand girls in the pure sciences was cemented. A report compiled by the Secondary Schools' Association in 1936 confirmed that many girls were handicapped in university study for science and medicine since they had insufficient grounding in the pure sciences (Murdoch, 1944).

More recently, the issue of under-representation of girls and women in science has been raised afresh. An editorial in the New Zealand Science Review in 1975 noted there were only 6 women to 108 men scientists and 3 women to 4,800 men engineers in New Zealand. As recently as 1977, a correspondent pointed out that only 3.9% of the membership of the New Zealand Association of Scientists was female (Fenwick, 1979).

The second part of the original question - 'Why the under-representation of Maoris and Pacific Islanders in science?' - would appear to be a more recent issue.

Whilst inter-ethnic differences in enrolment in science courses have been reported overseas (e.g. Ignatz, 1975), a search of the literature has revealed that no similar research on Polynesian/ non-Polynesian differences in New Zealand with respect to science has been published here or elsewhere. Two particular 'State of the Art' papers given at the 'First National Conference of the New Zealand Association for Research in Education' at the end of 1979 clearly illustrates this dearth of research. One paper (Harker, 1979), surveyed 'research on the education of Maori children' and the other paper (Osborne, 1979) surveyed 'science education research in New Zealand'; from a combined total of over 150 references, not one identified any research done on ethnic differences in science education.

However, considerable work has been done in New Zealand on ethnic differences in a variety of associated fields and Chapter 2 of this thesis will consider those studies which have particular relevance for understanding ethnic differences in science.

1.4 The context of this study.

In February 1979, the 'Learning in Science Project' (LISP) was established at the University of Waikato and funded by the New Zealand Government's Department of Education with the objectives of:

(a) making a study of the teaching and learning of science at the upper primary and lower secondary school (children aged between 11-14 years),

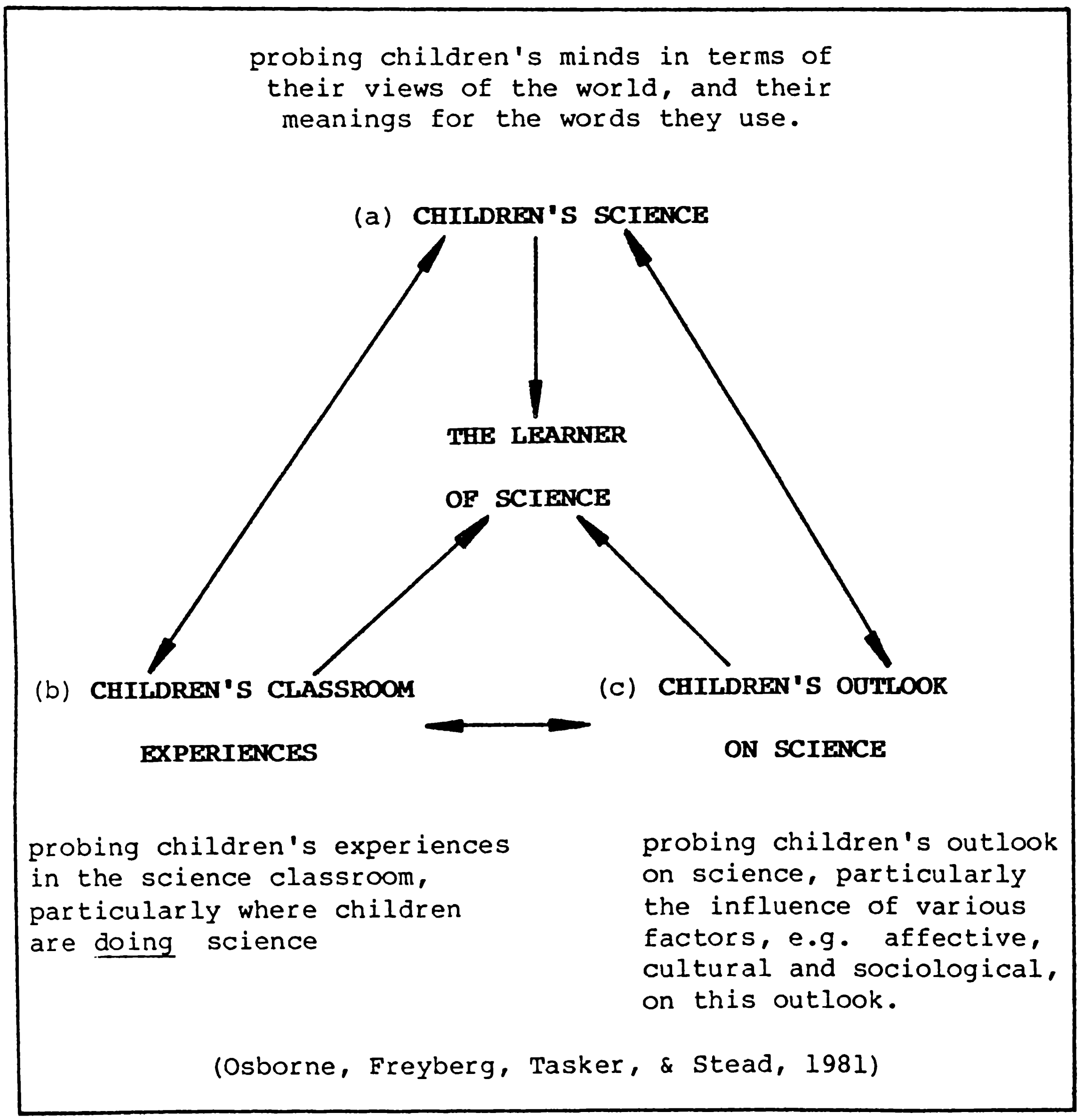
(b) identifying some of the key difficulties experienced by those involved in science at this school level,

(c) suggesting and testing ways of over-coming such identified difficulties.

The project was scheduled to run for three years covering a three-phase programme of research; (i) an exploratory phase in which characteristic difficulties were identified, (ii) an in-depth phase which focused on selected aspects of the difficulties identified in (i), and (iii) an action research phase, based on the preceding phases, which sought to explore, with teachers, strategies and techniques for meeting objective (c) above (see Freyberg, Osborne & Tasker, 1980; Tasker, Osborne & Freyberg, 1979; Tasker, 1980; Osborne, 1980a; , for complete details on the nature, methodologies, and the findings of the Learning in Science Project).

From its inception, the methodological preference was that of naturalistic inquiry (Guba, 1978) in which qualitative, illuminative (Parlett & Hamilton, 1972) data elicited from individuals provided the raw material for analysis, with the emphasis on small-scale, in-depth studies. The second of the three phases outlined above is discussed in more detail as it was within its very broad ambit that the research completed in this thesis was conducted.

Figure 1.1: The three aspects of the in-depth phase of the Learning in Science Project.



Within the in-depth phase, three broad areas of concern (see Figure 1.1) were identified and referred to as:

(a) Children's Science in which the views or perspectives the students held on particular science topics (e.g. 'Gravity', 'Animal', 'Force', etc - see LISP working papers 15-27) were elicited and discussed with teachers, and students, in the attempt to reduce the communicative 'distance' that was discerned when one participant in a learning conversation (Shaw, 1980b; Thomas, 1979) used terms in an 'everyday' sense, and the second participant used the same terms in a 'scientific' sense. For example, in an 'everyday' sense the term 'animal' is not generally used to refer to human beings, (hence the shop sign, 'No animals allowed'), yet it does refer to human beings in a 'scientific' sense (Bell, 1981).

(b) Children's Classroom Activities. In this area, the focus of attention was primarily on the perceptions of the experiences that occur in science classrooms, particularly those of a practical nature (as during science experiments) as acknowledged by (i) the pupils themselves, individually and collectively; (ii) the teacher, before, during, and after, the given lesson; and (iii) the 'participant observer' (Glaser & Strauss, 1967). (See Tasker, 1980; Tasker & Osborne, 1980;1981).

(c) Children's Outlook on Science. The concern here was on those factors which not only affect the views held by the students on particular science topics (see 'Children's

Science' above), but also those which influence the students' affective responses to science. That is, whilst the 'Children's Science' identified specific 'knowledge structures', or the content of understanding in particular areas, 'Children's Outlook on Science' attempted to discern the reasons for the development and maintenance of such views, and explored such dimensions as interest, motivation, aspirations, beliefs, expectations, and values, pertaining to science. Against this wide, seemingly amorphous backdrop, particular emphasis has been directed to the identification of those factors that have a distinct saliency for girls, Maori, and Pacific Island students - that is, the research described in this thesis.

1.5 Outline of the present study.

The research which formed the basis of this thesis will be described in the following order: First, previous studies are surveyed in Chapter 2. Chapter 3 then presents the central argument (the thesis proper) and provides the rationale for the particular research plan adopted. Chapter 4 illustrates the technique used for probing the sample students' 'outlook on science' with two case studies. Chapter 5 provides the qualitative analyses of the data collected from the interiews conducted with students and their parents, while analyses of the quantitative data collected to provide another perspective on the research question are given in Chapter 6. Chapter 7, the final chapter, attempts a synthesis of the qualitative and quantitative perspectives and provides possible answers to the research question before suggesting a series of educational implications arising from the study. It concludes with several brief comments on the methodology and theoretical perspective chosen for the research described in this thesis.

CHAPTER TWO

PRIOR RELEVANT RESEARCH

The research reviewed in this chapter is presented in five sections:

Section 2.1 places the under-representation of girls in the international context by giving a brief account of the science attainment report presented by the International Association for the Evaluation of Educational Achievement (IEA - 1973). This account is followed by a brief review of several studies which provide further analyses of the IEA data.

Section 2.2 summarises the literature on sex differences in science under three general headings. This literature may be summarised in question form:

(i) Attitude studies - do males express more positive attitudes to science than females?

(ii) Cognition studies - do males and females have different cognitive abilities and does science require those abilities more likely to be possessed by males than those possessed by females? A subgroup of biological studies raises the question - have gender differences in science-related fields had an evolutionary 'survival value'?

(iii) Social and societal studies - as society communicates different role expectations according to gender, is science perceived as being more appropriate for males? Two further subgroups of studies are included here:

(a) Political studies - if traditional values have ensured only males have access to political power and status, and if science is seen capable of conferring both on its practitioners, have females been overtly and covertly dissuaded from pursuing it?

(b) Psychological studies - are females more likely than males to fear success, lack self-confidence, and attribute experiential outcomes to factors beyond personal control?

Section 2.3 reviews the literature which may contribute to an understanding of the reason(s) for the under-representation of Maori and Pacific Island students in science. Since very little work has been done in science education in New Zealand, it is not surprising to find no research has been conducted which has been expressly directed at this under-representation. Several possible contributory factors are examined; namely those which arise from studies which have explored ethnic differences in:

(i) Cognition - perhaps scientific thinking requires a particular 'style' of thinking which is one not preferred by the majority of Maori and Pacific Island students?

(ii) Socio-attitudinal research. These studies are considered in three groups; those to do with:

(a) Future time perspectives - perhaps the training time needed to be scientifically competent is considered too long by many Maori and Pacific Island students?

(b) Cooperation and competition - Maori and Pacific Island students' home cultural values may emphasise cooperative interpersonal relationships which are denied them in a competitive school environment. This may be partially responsible for the observed higher school leaving incidence among them and thus, preclude essential preparation for scientific vocations?

(c) Attitudes to school - the function of the school may be perceived solely as 'job preparation' by Maori and Pacific Island parents and students. The tension developed by the competing desires of possible longer schooling and the immediate adult status of the student and of the financial needs of the family may result in an ambivalent attitude towards the school in general.

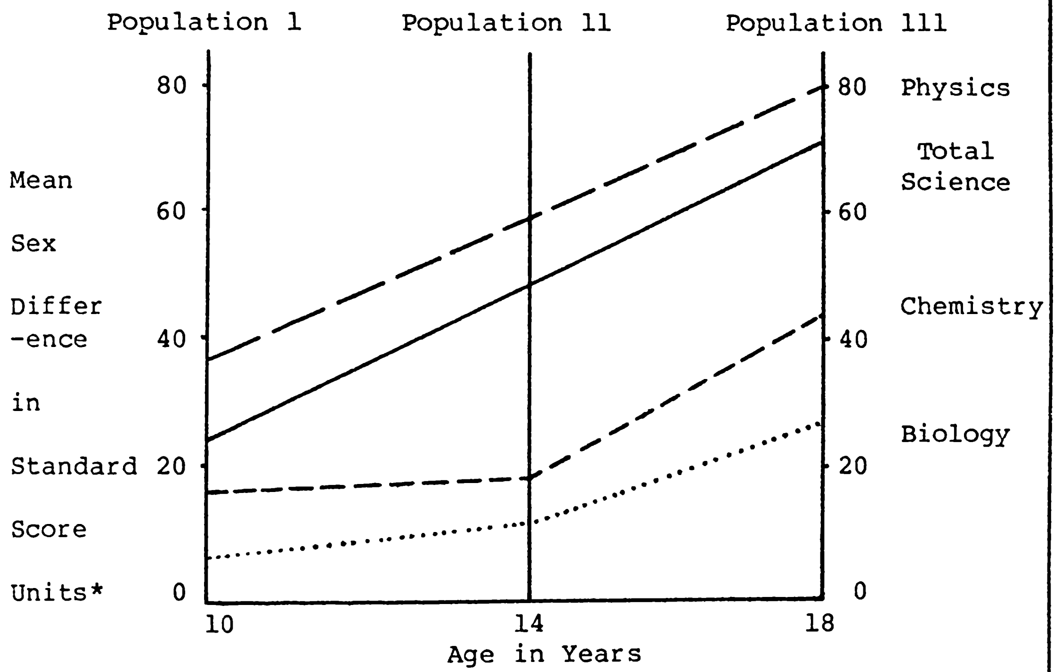
Section 2.4 critically reviews the instruments used in previous New Zealand research in attitudes to science.

Section 2.5 provides the chapter summary.

2.1 International survey results.

Comber and Keeves' (1973) report on the study of science in nineteen countries, although based mainly in Western countries, revealed consistent sex differences. This IEA survey examined science attainment levels for three student populations (at 10, 14, and 18 year old levels) in each country and marked differences between the sexes in the total science scores occurred at each age level, with the magnitude of the difference increasing with student age (see Figure 2.1).

Figure 2.1: Sex differences in IEA Science Scores and Subscores at different ages (after Comber & Keeves, 1973:149).



*Standard Score Units = mean sex differences divided by the average standard deviation for all countries multiplied by 100

At the ten year old level there was considerable uniformity across the countries with boys performing about a quarter of a student standard deviation (mean S.D. = 0.23) better than the girls. At the fourteen year old level, the differences were again relatively uniform, but with the magnitude being nearly half a student standard deviation (mean S.D. = 0.46) in the boys' favour. The differences between the sexes in performance at the eighteen year old level were even greater (mean S.D. = 0.69).

A breakdown of the total science scores into the biology, chemistry, and physics sub-test scores also revealed very consistent trends - not only did all sex differences increase with age, they also increased more markedly in the physical sciences than in biology.

The possibility that the IEA tests may, themselves, have a sex bias, has been examined by Carlson (1976). She showed that most items were apparently neutral and only a few of the sex differences could be explained with reference to specific items. Thus, the overall sex differences could be considered to have accrued from the cumulative effect of small sex differences on many items rather than from a contribution from a few strongly biased items. However, when a multivariate analysis of the item responses in terms of Bloom's (1956) Taxonomy of Educational Objectives was performed by Finn and Kotlewski (1975), this showed that when an allowance was made for sex differences in Information and Comprehension, there was no residual difference in either Application or Higher Processing. This would suggest that boys have a greater knowledge of science but not necessarily have a greater understanding.

Kelly (1978) sought to examine the IEA sex differences by focussing on seven of the developed countries considered in the IEA survey. These were Australia, England, Hungary, Italy, Sweden, Japan, and the United States. She tested three specific hypotheses dealing with the cultural, school, and attitudinal variables but, although not successful in identifying the causes of girls' under-achievement in science, Kelly did come up with some important findings. For example, although boys performed better overall than girls in the countries examined, girls in some countries performed better than boys in other countries. This would suggest that, under some conditions, girls can achieve well in science. In fact, a large percentage of girls from Hungary and Japan achieved scores in the international top five percent. Thus, there was no absolute level of achievement beyond which girls could not proceed. The attitude hypothesis was the only hypothesis able to be supported.

> "Girls did have less favourable attitudes towards science than boys, and there was a connection between attitudes and achievement ... (and) moreover, both girls' attitudes towards science and the standardized sex differences in attitudes varied from country, suggesting the influence of cultural factors and indicating that girls' attitudes were malleable."
> (Kelly, 1978:105. Italics in the original)

2.2 Sex differences and science
2.2.1 Student attitudes to science.

Attitudes to science in general have been extensively reviewed by Gardner (1975a; 1975b; 1975c) and so will not be examined again in detail here. However, a selection of studies which explored or identified sex differences is mentioned to give a general over-view of the nature and variety of research conducted to date in this field.

Some relevant methodological issues concerned with many of the studies (e.g. Gardner, 1975b; Kozlow & Nay, 1976; Munby, 1980;

Vincent, 1980) are raised in Section 2.4.

A distinction is made here between attitudes towards science and scientific habits (Freyberg et al, 1980). An 'attitude towards science' can range from being very positive, through neutral, to being very negative, and refers to the affective response(s) ensuing from a consideration of some aspect of the discipline 'Science'. Such responses as interests, appreciations, values, and beliefs, would be considered within its ambit. 'Scientific habits' are the requisite skills necessary to an individual practising science. Such characteristics as open-mindedness, objectivity, intellectual honesty, curiosity, and a willingness to suspend judgement, would be considered here. The distinction between attitudes towards science and scientific habits is highlighted by considering the individual who may possess the ability to perform particular scientific procedures but may prefer not to use them (Gauld & Hukins, 1980).

Research which examined attitudes towards science includes a study by Rallison (1939) who found that 11 and 12 year old boys asked their teachers nearly twice as many questions classifiable as being 'scientific' as did girls. Ewens (1956) discovered that boys outscored girls on mechanical, computational, and scientific interests (both preferred interests and actual experiences) in a sample of Californian high school students. Sandall (1962) concluded that boys were more interested than girls in practical, scientific, and mechanical matters whereas the girls were more interested than the boys in humane, literary, and social pursuits. This was confirmed by Butcher and Pont (1968) who asked 1100 Scottish high school pupils to rate each of fifteen careers on six separate criteria. Boys rated pure and applied science careers as higher on the 'liking' and 'interest' criteria, whereas girls rated careers involving working with people higher. Brown (1976a,b) found sex differences in only the 'Interest and enjoyment in science' scale of her 5 scale attitude survey administered to 3000 14 year old Scottish pupils. Many studies (Foster, 1967; Clarke, 1972; Sumner & Wilson, 1972; Walberg, 1967) indicate that boys tend to prefer physical science topics, whereas girls tend to prefer biological and social science topics. Sex differences have also been found in such as 'superstitious belief' (Gauld & Hukins, 1980) and 'attitudes to astrology' (Kruglak, 1978).

There have been few comparable New Zealand studies and some are critically examined in Section 2.4. Lai (1977), in finding interest differences between the sexes, proposed a link with socio-economic status and level of parental education:

> "Boys with high interests in science are more likely to have fathers who have obtained higher education. Girls who are highly interested in science are more likely to have mothers who have obtained higher education."
> (Lai, 1977:89)

However, it must be noted that Lai's study was conducted in only a single New Zealand school.

Relatively fewer studies (e.g. Diederich, 1967; Billeh & Zakhairiades, 1975; Kozlow & Nay, 1976) have been specifically directed at sex differences in scientific 'habits'. Hughes (1969) developed a 'scientific habits' test in New Zealand but it appears to have been applied to only one school and no sex differences were reported. Elias and Elias (1976) examined curiosity and open-mindedness and found no significant sex differences (see also Peterson & Lowery, 1972). Similarly, Brown (1976a,b) found no sex differences on measures of objectivity, and neither did Meyer (1970) in his composite measure of 'habits'.

2.2.2 Sex differences in cognitive factors

Maccoby and Jacklin (1974) thoroughly reviewed over 2,000 studies of sex differences and identified several cognitive areas in which differences between the sexes were apparent:

(i) General intelligence - girls perform better on general intelligence tests during the pre-school years, but boys perform better in high school,

(ii) verbal ability - the sex differences were not large but girls do somewhat better in grammar, spelling and word fluency,

(iii) quantitative ability - no sex differences are apparent in the early years, but boys do better at high school age,

(iv) spatial ability - boys consistently score higher than girls from an early age,

(v) field independence - boys and men perform better than girls and women after the beginning of adolescence and the sex differences parallel those in the non-analytical spatial abilities,

(vi) problem solving - when a solution requires manipulation of objects and trying a wide range of approaches, males out-perform females.

Of specific relevance to science education is the suggestion Maccoby and Jacklin make, after reviewing the findings of the Harvard Project Physics (Walberg, 1967), that it would appear that verbal and spatial factors account for some of the variance in science achievement. Physics achievement tests were given to a large sample of high school students. On the portion of the tests calling for visual-spatial skills, the male physics students did better; on verbal test items, female physics students obtained higher scores.

Perhaps even more significant is that in so many studies reviewed so few sex differences of a cognitive nature were revealed. Haertel, Walberg, Junker and Pascarella (1981) drew the same conclusion after analysing data from the 1976 Science assessment of the National Assessment of Educational Progress (NAEP) in which an American national sample of 2,349 thirteen year olds were given a battery of achievement tests. Scales measuring science learning and five related factors (e.g. 'motivation' and 'quality') were related to sex, race, and SES in three-way analyses of variance and covariance. These researchers did notice an age-related sex determinant and concluded:

> "The important conclusion of the present research is the general lack of significant overall differences between boys and girls in science learning and its determinants in early adolescent years in contrast to the highly significant differences between the sexes in science related attitudes, behaviours, and aspirations during the late adolescence, that is, the last two years in high school."
> (Haertel, Walberg, Junker & Pascarella, 1981:339)

However, a recent study from Tasmania by Lynch and Paterson (1980) did identify more widespread sex differences in recognition of simple definitions of concept words in science (atom, gas, proton, compound, volume, mixture, etc). Four consecutive grade levels (7-10) were examined and consistent sex differences in the boys' favour were apparent:

> "Already at Grade 7, half the concept words used in the study produce differences. This suggests that it was not the introduction of scientific terminology in high school which caused differential recognition on the part of boys and girls. These differences are already firmly established in primary school. The concept word 'ion' illustrates this point. Apparently first introduced to pupils in high school, its recognition is very low but it rapidly reaches the score level of other words in the same subparadigm by Grade 10. It is reasonable to assume, then, that both sexes have equivalent exposure to this term, and yet the difference between them in its recognition is already significant at Grade 7 ... Recognition of a concept definition is not necessarily the same as understanding but it is usually a prerequisite to understanding, particularly where language is concerned. Consequently, these results imply differences in achieved understanding between girls and boys."
>
> (Lynch & Paterson, 1980:313-314)

In the light of Maccoby and Jacklin's (1974) findings on the verbal superiority of girls these differences between the sexes in science concept words' definitions are noteworthy. However, some criticism of Maccoby and Jacklin's work has been expressed. For example, Block (1976) noted that the ages of the children in Maccoby and Jacklin's review were not carefully considered and he suggests the sex differences which emerged at particular ages may have been masked by the inclusion of a large number of studies using younger children.

Gray (1981) advances a genetic model to account for the sex differences noted in spatial ability based on cross-species (rats and chimpanzee) and cross-cultural (such as the IEA survey) evidence. He postulates the existence of a single recessive gene for superior spatial ability carried on the X chromosome which requires the presence of testosterone in the neo-natal period. This postulated hormonal pre-condition enables findings on the pronounced impaired ability of individuals with Turner's syndrome to be assimilated into the model. Thus, spatial ability would always be expressed in males, but in females only when the homologous gene (allele) is also recessive. That is, females would demonstrate spatial ability (their phenotype) only when both genes are recessive (genotypically homozygous recessive). In order to predict the likelihood of an individual carrying such a gene, the frequency of it in a population would need to be determined. Gray's model allows for the prediction of specific parent-child correlations (mother-daughter; mother-son; father-daughter; etc) but as the evidence for it is equivocal he offers other support for the biological explanation in terms of sex differences in brain lateralisation of function (spatial functions are principally on the right-hand-side and verbal functions on the left-hand-side) (see also Buffery, 1970; Wittig & Peterson, 1979), and in terms of evolution in the Darwinian sense that the ability to analyse and utilise spatial information has a 'survival' value.

Wittig and Peterson (1979) have reviewed many studies of sex differences in cognitive functioning with respect to various hormones - such as those involved in the menstrual cycle - but research into such factors is still on-going and definite conclusions are yet to be drawn.

2.2.3 Sex differences in social factors

The field of sex-role stereo-typing is vast (Mischel, 1966; Deem, 1978; Unger, 1979; Douvan, 1979) and lies beyond the scope of this thesis, but the prevalent perception that science is a masculine pursuit (Kelly, 1981e; Saraga & Griffiths, 1981; Ormerod, 1981) has direct implications for it.

Kelly (1981a; 1981b; 1981d) argues that low achievement of girls in science is an aspect of the feminine social role. That is, certain learned behaviour is seen as appropriate for girls whilst other behaviour is regarded as more appropriate for boys. Support for this viewpoint is found in research which shows that adults treat male and female children differently from birth and throughout childhood (Lewis, 1982). Boys and girls are given different toys to play with: boys meccano sets, electrical devices, projectile-firing instruments, chemistry sets (toys which expose their handlers to early scientific skills); girls are given dolls, books, and domestic-type toys (which do not require active participation and manipulation). Belotti (1975) questions whether such sex preferences for particular kinds of toys are 'natural':

> "I have seen girls of eighteen or twenty months old spend hours and hours taking a whole lot of little cars, aeroplanes, helicopters, boats and trains from a bag, line them up on a carpet and move them about as little boys. In the same way one can see boys spending the whole morning washing, cleaning the tables and polishing shoes. Later this pattern of play disappears. Children have learnt to ask for the 'right' toy because they know the 'wrong' one will be denied them."
>
> (Belotti, 1975:80)

Previously, Torrance (1963) had noted significant improvement in girls' understanding of the scientific principles involved with particular toys when parents and teachers were made aware of the girls' previous limited experience with them. Schools maintain the impetus towards sex role differentiation generated in the home in many ways (see Deem, 1978; 1980, for comprehensive analyses).

Primary schools are usually staffed by women (Whitcombe, 1979) and the teachers frequently demand 'obedience, silence, passivity and conformity from their pupils - all features of traditional female behaviour' (Sharpe, 1976:145).

> "Girls are praised for being quiet, clean, tidy, helpful, and criticised for being muddy, rough, noisy, lazy, untidy ... On the other hand, boys are praised for toughness, for strength, for leadership, for organisation, for adult behaviour, for initiative and originality. They are criticised for weakness, for 'cissy' behaviour, for rudeness, but not for noise as such."
>
> (Byrne, 1978:83-4)

Consequently, by conforming to femininity, girls are being discouraged from originality and experimentation. What science is taught at primary school is often taught by the few male teachers, or visiting specialists (also male) which further develops the 'masculine' image of science.

The Leeds Literature Collective (1973) reviewed the representation of girls in primary science books, and found that most of the pictures and most of the pronouns referred to males. They concluded:

> "... Most girls already know (by the time they enter secondary school) that science is unfeminine and that their true vocation lies in the home, with unskilled work if they must work, or in the Arts subjects if they are academically successful."
>
> (Leeds Literature Collective, 1973:4)

Recently, the Research and Statistics Division of the New Zealand Department of Education (1980) carried out a similar investigation into the incidence of sex-role stereotyping in school science text-books used in New Zealand schools (6 primary, 4 secondary, and 5 teachers' books were examined) and found:

> "Six times as many *roles* were assigned to males as to females overall. The ratio in reference books and primary text-books was 5:1, in secondary text-books the ratio was 6:1, and in teachers' books the ratio was 7:1.
>
> ... The ratio of the number of *activities* performed by males to those performed by females is 2:1 for primary textbooks and teachers' books, 4:1 for reference books and 9:1 for secondary textbooks.
>
> ... In all groups of textbooks *illustrations* of males outnumbered illustrations of females. Primary and teacher textbooks showed a ratio of approximately 2 males to 1 female while
>
> reference books showed a ratio of 3:1 and secondary textbooks a ratio of 7:1.
>
> ... Reference to *famous people* in total ran heavily (about 19:1) in favour of males. Although people referred to by initial(s) were classed as neutral a more accurate count would probably have included these people as males, for when a female was mentioned her first name was usually used."
>
> (Department of Education NZ, 1980:2-6. Emphases added)

Teachers of science, particularly of physics and chemistry, in secondary schools are also more likely to be male. Assuming that most secondary teachers of science are university graduates, the data depicted in Appendix 2.1, which show the proportion of first degrees gained by women in specific subjects in New Zealand, illustrate this situation. Senior posts in both co-educational and single-sex schools tend to be held by men (Blackstone & Weinreich-Haste, 1980; Department of

Education and Science, 1980). Sharpe (1976) observed such an imbalanced science staff ratio, when compounded with girls' lack of experience and skill in the subject matter of science, that:

> "It is not surprising that many girls have relatively little interest in, or understanding of, scientific or technical subjects. Their lack of experience of these at home, the absence in their characters of the independence associated with analytic abilities, and the apparent non-scientific nature of women's adult role also contributes to this."
> (Sharpe, 1976:148)

It is only in the biological sciences that girls are provided with same sex role models in the teacher and the text. Vockell and Labonc (1981) suggest a girl is less likely to be perceived as being 'deviant' if she expressed an interest in biology, rather than chemistry and physics. Hasan (1975) and Ormerod (1971) suggest that social implications and social desirability play a more important part for girls than boys in selecting or rejecting science as a career. For example, Koelsche and Newberry (1971) noted that girls prefer subjects involving 'living matter', whereas boys are more interested in 'non-living matter'.

Several researchers (Cropley & Field, 1968; Comber & Keeves, 1973; Kelly, 1976; Ormerod & Duckworth, 1975; Osborne, 1980b) have reported that sex polarisation between the biological and the physical sciences is less marked in single-sex schools than in co-educational schools. That is, proportionately more girls study the physical sciences in single-sex girls' schools and proportionately fewer boys study the physical sciences in single-sex boys' schools, than is the case in co-educational schools. Vockell and Labonc (1981) suggest girls in co-educational schools are more likely to perceive the physical science as being masculine than are their counterparts in the single-sex girls' schools. They make the further suggestion that although

> "... it sounds like a good idea to encourage the girls to mix right in with the boys and thereby get rid of the stereotypes, the present study suggests that the exact opposite may be the case: interacting with males may actually increase rather than decrease stereotyping."
> (Vockell & Labonc, 1981:217)

Another perspective, suggested by feminist commentators, involves the perceived association of gender and status in society. As women have been traditionally held to be subordinate to men and that as science has status and power, women are covertly dissuaded from becoming involved with science. Saraga and Griffiths (1981) insist that explanations for the current under-achievement of girls in science are to be found in science's socio-historical context - in spite of claims of equality of opportunity for both sexes - where men are defined primarily in terms of their 'occupation', whilst women are defined in relation to the family.

> "Thus in advanced industrial societies women have a dual role: they are responsible for the production and maintenance of the labour force, at the same time as constituting a part of it. And this dual role means that girls and women are subject to a set of demands for which there is no parallel for men. ... Until the structural basis of women's oppression - in particular, the family - is challenged and changed, women will be unable to take advantage of 'equal' opportunities. They will always be disadvantaged, compared to men, while they carry the prime responsibility for domestic labour and child care." (Saraga & Griffiths, 1981:90)

Consequently, science is viewed by Saraga and Griffiths as male-dominated because (a) men are numerically predominant because of the conservative domestic roles prescribed to women; (b) the personality traits of 'successful' scientists are those which are stereotypically male (Roe, 1951); and (c) science develops in the service of the dominant interests in the society which are primarily economic and military.

The representation of girls taking the biological sciences illustrates this viewpoint. Historically, biology has had lower status and girls have been encouraged to take it, and thereby, they have been encouraged to accept their lower-valued position in the academic hierarchy. Similarly, boys perceived not to be destined for prestige and power, have been 'permitted' to take biology, too, whilst their more highly esteemed 'brothers' have been actively channelled into the physical sciences which traditionally have been able to contribute more directly to the interests of males in society at large. The corollary to this thesis would be that girls who express a determination to take the physical sciences would be perceived as threatening the political basis of power and status enjoyed by male scientists. Also, the contributions that the biological sciences are now making to the interests of both sexes in today's world would suggest the status of biological practitioners would be increasing. That this is occurring would perhaps explain why more men than women are to be found in the higher echelons of biological research and teaching, in spite of fewer numbers of males studying biology at the secondary school level.

Many other 'social' factors have been researched, such as the nature of careers' guidance given in school (Stage, 1976; Stanworth, 1981); the curriculum (Department of Education and Science, 1980; Ormerod, 1975); teacher expectation (Dweck, Davidson, Nelson, & Enna, 1978; Shaw, 1980); assessment procedures (Dwyer, 1979; Harding, 1979; 1980); perceived vocational opportunities (Vetter, 1973; Sharpe, 1976; Phelan, 1979; Fogelman, 1979; Heilman, 1979); parental educational level (Kelly, 1981e); classroom activities (Ebutt, 1981); teaching style (Eggleston, Galton, & Jones, 1976; Galton, 1981); self-concept (Doran & Sellers, 1978), and, whilst such factors have been shown to have some influence on subject choice, they have been concerned with events 'external' to the pupil. Other researchers have proposed 'internal' mechanisms to account for sex differences in achievement situations generally, which have implications for the specific field of science education - three such mechanisms are briefly described here:

(a) Fear of success. Horner (1972) hypothesised that women with high achievement aspirations often deny such aspirations, since they see femininity and achievement as being mutually incompatible. That is, high achieving women find themselves in a conflict situation because they find themselves encouraged to do well academically, yet socially discouraged from doing better than men. Horner found that fear of success imagery increased in girls from junior high school through university, whereas it remained constant for males.

Horner's hypothesis stimulated much research (see Tresemer, 1977, for an extensive review) but the fear of success phenomenon appears not to be as common among women as was first thought, and it is also found in some kinds of male groups (Unger, 1979).

(b) Self-confidence. Women are more likely than men to express low self-confidence in achievement situations (Maccoby & Jacklin, 1974). Lenney (1977) has extensively reviewed the literature in this area and identified three kinds of situational variables that influence women's self-confidence relative to men, all of which have implications for possible explanations for the sex differences in science.

These are: the nature of the specific task; the availability of clear unambiguous information on the individual's ability at the specific task; and the presence and nature of certain social comparison or social evaluation cues. Lenney's conclusion was to suggest that:

> "Women's self-confidence may be more dependent than men's upon the characteristics of the specific person to whom they compare themselves ... the 'problem' for women may in fact be that their self-confidence, far from being consistently low, is instead excessively vulnerable to situational influences."
>
> (Lenney, 1977:11)

If this is so, the relative lack of informal experiences of a scientific kind that girls tend to bring to their science studies would more likely predispose them to feel a lower degree of self-confidence (particularly in co-educational schools where the social comparisons with the boys are readily possible), and hence, prefer to study in other academic disciplines where their self-confidence is perhaps more readily enhanced.

(c) Locus of control (causal attribution). Another line of research which has sought to explain sex differences in achievement has been that in exploring individuals' beliefs about the consequences of their behaviour. Much of this research has been subsumed under 'Attribution Theory' (Heider, 1958) and, as general reviews of this literature are presented elsewhere (De Charms, 1968; Kelley, 1971; Jones, Kanouse, Kelley, Nisbett, Valins & Weiner, 1971; Shaver, 1975), such background information is not presented here. Essentially, Attribution Theory seeks to explain how individuals make causal explanations about events in their world, with particular reference to their explanations of what they perceive as influencing the outcomes of personal events. Where individuals believe there is a causal link between their actions and their outcomes, and that they are responsible for such action, they are said to have an 'internal locus of control'. An 'external locus of control' appears to reflect the belief that one is not in control of one's destiny and that consequences of personal action are results of unstable, chance variables such as 'luck'.

Of particular possible relevance for such an investigation as this present one are the causal perceptions of personal success and failure in academic situations. Weiner and his associates (Weiner, Frieze, Kukla, Reed, Rest & Rosenbaum, 1971) have examined causal attributions for success and failure in terms of four factors: ability, effort, luck, and task difficulty. Each factor is jointly classified as either internal or external, and stable or unstable. Ability and effort are considered internal factors, while task difficulty and luck are external.

In general, males appear to have a more internal locus of control than females, expecially from adolescence onwards (Marks, 1972). Cross-cultural studies (e.g. Detweiler, 1978; Maehr & Nicholls, 1980) also show sex differences in locus of control measures with females having a higher belief in external control over their lives than males. McGinnies (1974) found that of the five countries he investigated (Sweden, Japan, Australia, United States, and New Zealand), New Zealand females scored the lowest of all the females.

Not only does the expectation of a particular consequence of action influence the attribution of cause, but the nature of the consequence of action influences the degree of internality/externality expressed, and sex differences again are apparent. For example, Nicholls (1975) found school girls to switch from an internal explanation when responding to failure (e.g. 'lack of ability'), to an external explanation when responding to success (e.g. 'the ease of the test').

Perhaps the scientist's insistence on searching for identifiable cause-effect relationships before either claiming or disclaiming personal 'responsibility' for his/her actions, is counter-intuitive to many girls? If so, they may well feel, and perhaps express, dissatisfaction with a discipline which actively discourages 'non-rational' explanations for behaviour. The possibility that different preferred 'styles' of thinking may exist in different groups of students is taken up again in the next section of this chapter which now reviews the literature which may contribute to an understanding of the reason(s) for the under-representation of Maori and Pacific Island students in science in New Zealand.

2.3 Ethnic differences

2.3.1 Research on cognitive factors.

Comment has already been made (Section 1.3) on the paucity of research in New Zealand on ethnic differences in science education so the studies presented here are those of a more general scholastic nature than those found in the previous section. More detailed reviews of specific educational studies are to be found in the Hunn Report (1960); Ausubel (1961); Ritchie (1963); Sutch (1964); Watson (1967); Schwimmer (1966); and Foster (1968). Peddie (1974); St George (1977); and Harker (1979) provide reviews which focus on Maori school achievement studies.

Early workers in this field (Lovegrove, 1966; McCreary, 1966; Gustafson, 1967; Du Chateau, 1967) found differences between the Maori and European pupils in a number of intellectual areas such as intelligence test results, listening comprehension, and reading (Harker, 1973). St George (1977) comprehensively reviewed the comparative studies on ethnic differences and noted that studies which used largely non-verbal and/or

Piagetian measures (St George, 1972; Klippel, 1973; Brooks, 1973) revealed fewer significant differences between the groups. He suggested that this might be the result of a greater degree of ethnic commonality now existing in those behaviours and knowledge measured by the researchers' tests than existed previously. However, Reid (1981) reported that during the standardisation of the 'Test of Scholastic Achievement' (TOSCA) (Reid, Jackson, Gilmore & Croft, 1980) consistent differences of between 6 and 7 raw score points between the Maori and European samples occurred even when samples were matched on fathers' socio-economic status. Because very few Maori fathers were in the 'Professional' or 'Managerial' categories of the Elley/Irving socio-economic index (Elley & Irving, 1976), such differences were claimed only for the remaining 'white-collar, skilled, semi-skilled, and unskilled occupational groups'. Consistent differences were also reported between the Pacific Island and European samples, with these differences being larger than the Maori/European differences. In a later analysis of the TOSCA standardisation data, Reid and Gilmore (1983) suggest some interpreters of these data would offer such causal factors as 'language difficulties, experiential deprivation, family size and location, and differing cultural backgrounds and values' to explain the differential performance of the various socio-economic groups on the TOSCA. However, Reid and Gilmore (1983) themselves suggest:

> "... that ability differences revealed by such measures as TOSCA provide an indication of continuing inequalities in our social and school

systems."

(Reid & Gilmore, 1983:29)

The concept of 'cognitive style' has received some attention as a possible implicated variable in ethnic differences in academic achievement (Ausburn and Ausburn, 1978, give a concise overview of the various dimensions involved with cognitive style). Chapman (1973) examined the 'field dependence/field independence' dimension (Witkin & Goodenough, 1981) and found no significant ethnic differences in his sample of adolescent males. Harker (n.d.; 1976) considered the field dependence/field independence dimension to reflect the extent of an analytic ability which, when utilised, is found to a similar extent in both Maori and European students, and suggested the preferred cognitive mode may differ between ethnic groups.

Harker used the Kagan, Moss and Sigel (1963) 'Conceptual Style Test' which provides for a trichotomous classification of cognitive style ('descriptive', 'categorical', and 'relational') and also found no significant ethnic differences, other than those which occurred when the environmental variable of rural/urban location was considered:

> "In general ... it would appear that rural environments tend to favour the production of relational responses while urban environments favour both analytical and categorical responses, with the exception of Maori boys for whom an urban environment is particularly conducive to the production of analytic responses at the expense of categorical ones thus producing an anomalous trend for this group on categorical responses."
>
> (Harker, n.d.:55)

Harker went on to suggest:

> "... the socialisation of sex-roles, at least those aspects of sex role that result in different cognitive stylistic preferences, are qualitatively different in Maori society from that found in Pakeha society."
>
> (ibid. "Pakeha" = European)

However, he concluded:

> "... the findings presented here would not seem to offer much hope that cognitive style could act as an intervening variable to further reduce the direct effect of ethnicity on achievement ... to occur (sic) when environmental variables are statistically controlled."
>
> (ibid)

2.3.2 Research on socio-attitudinal factors.

A variety of studies have been conducted which fit loosely into this category. However, it has not been possible to make the distinction between 'attitudes to science' and 'scientific habits' as in the previous section as no ethnic study has been so specific. Therefore, only those studies which may have connotations to science education in a general way, and can provide an introductory backdrop against which later analyses can be considered, are referred to here.

(a) Future time perspective. The school student who seeks a career in a science-related vocation has to be prepared for a long period of training for the appropriate requisite qualification (such as a 'New Zealand Certificate in Science' issued by the 'Technicians' Certification Authority', or a university degree - both require a minimum of three years post-secondary employment and/or study). This means a deferment of possible immediate returns (usually financial) until some time in the future.

Several researchers have hypothesised ethnic differences on this measure.

Bray (1970; 1971a; 1971b) found Maori/European differences on both future time perspective and delay of gratification, with Maori adolescents having a shorter time perspective and being less able to delay gratification. However, Harker (1979) suggests these studies should be treated with caution as Bray did not control for such factors as family size nor SES. Havighurst (1973) also found the Europeans tend to have a longer time perspective than Maoris and, when SES factors are controlled, he found there was no difference between middle class Maoris and middle class Europeans. Should the proportion of Maoris and Europeans designated 'middle class' increase, the ethnic differences on this measure would obviously disappear. However, because of racial prejudice (St George, 1972), Macpherson (1977) suggests that 'upward' mobility of both Maori and non-Maori Polynesians is not likely to be rapid.

(b) Cooperation and competition. Ritchie (1963; Ritchie & Ritchie, 1978) has drawn attention to the inherent competitiveness of the school environment and suggested it is alien to the Polynesian students' preferred cooperative mode of behaving in a social situation. Graves and Graves (1973) refer to this preference as an 'inclusive' style of behaviour which includes others in an activity, as opposed to the European preferred 'exclusive' style. Consequently, Polynesian students could perhaps find the school a stress-laden conflict situation and hence, tend to remove themselves from it. Such an explanation could account for the relatively few Polynesian students beyond the compulsory school leaving age of fifteen years.

Vercoe(1971) used the Prisoners' Dilemma Game to explore this cooperative/competitive mechanism with eight year old children and found no difference between Maori and European children. Similarly, Thomas (1975), using Madsen Cooperation Boards, found little difference between urban Maori and European children. However, Thomas did find that Cook Island children and rural Maori children were more cooperative than either the urban Maori or Pakeha (European) children. In a later study, Thomas (1978) found that of the three groups of Pacific Island children - Cook Islands, Samoan, and Fijian - the Cook Island children were the least cooperative, and that this second group of Cook Island children were more competitive than the group he had studied previously. He suggested that rapid social change and the role of the school in 'Westernizing' its students might be responsible for the increase in competitiveness.

No work in this area appears to have been done in New Zealand schools with older students, and the possible implications for teachers endeavouring to develop a 'scientific' perspective with their students (both Polynesian and European) has not been explored.

(c) Attitudes to school. Codd and Stewart (1976) examined a group of F3 adolescent girls (121 European and 42 Maori) in a New Zealand single sex school and found that 56% of the

Maori girls disliked doing school work most of the time, as compared to 37% of the European girls. Consequently, 68% of the Maori girls considered their biggest problem to be that of 'how to improve their school work' - this was the 'biggest' problem for only 36% of the European girls. 84% of the Maori girls stated the function of the school was to 'get them a job' - 68% of the European girls stated this, with more of them believing the primary educational function of the school was that of 'preparation for citizenship'. No comparable study appears to have compared Maori and European boys, or any other Polynesian student groups.

Several commentators have mentioned positive Pacific Island parental attitudes to school. For example, Pitt and Macpherson (1974) cite the high regard Samoan parents have for the New Zealand educational system as being a major motive for the migration to New Zealand of many of them, and point out that the parents make many sacrifices to help their children's education. However:

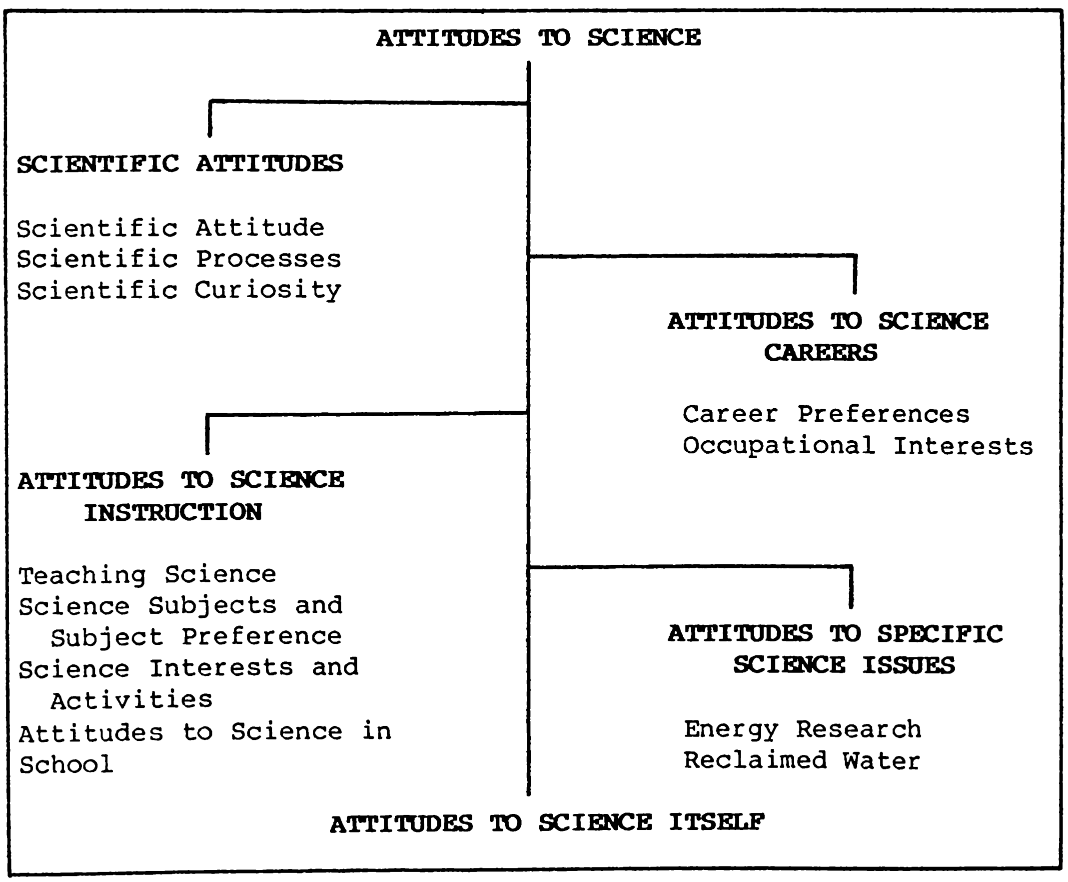
> "Despite parents' great desire to give their children a good education, they may encourage their children to leave school soon after their fifteenth birthday. Some parents do this because they think that at 15 a student has reached an adequate level of education (and many have of course reached a higher level than their parents), but far more important is the family's need for immediate cash to help with high rent or mortgage payments, and the needs of the 'aiga in Samoa ... Most young people respond quickly to the suggestion that they should leave school. Besides signifying adulthood, a job gives them money and independence."
>
> (Pitt & Macpherson 1974:107.
>
> 'aiga = the extended family kin group)

Schwimmer (1968) noted a similar ambivalency in Maori parents in a small rural community he taught at in the 1960s, where the parents valued the pragmatic outcomes of education (those of preparing pupils for the modern world with pre-vocational qualifications and knowledge of European forms of behaviour) but he sensed a conflict with traditional Maori values and life style. However, Fitzgerald (1970) found that Maori graduates in his study did not perceive such a conflict and, as Harte (1971) points out, such findings would suggest that not all Maoris (nor all other Polynesian groups) do find a discrepancy between the values of the home and of the school. The suggestion, made by several writers (e.g. Kerr, 1971; Harker, 1979), that socio-economic status must be taken into account when analyzing variations between groups, should be noted in this connection.

2.4 Attitudes to science - some methodological issues.

Different cognitive abilities themselves are possibly influenced by prior socio-attitudinal (and 'cultural') factors (e.g. such as particular child rearing practices - Belotti, 1975; Sharpe, 1976) and may be partially expressed as different cognitive (or conceptual) 'styles'. Logan and O'Hearn (1982) make the suggestion that different life styles do give rise to different 'thought styles' in their explanation for the apparent increasing difficulty experienced by students of science in mastering the 'abstract' subject matter and reasoning processes of the sciences. They observe that as the broad cultural background (which provides the context for thinking) has undergone immense changes as Western society has progressively moved from a 'peasant' through a 'new world' and into a 'post-affluent' society, so too have 'thinking styles' moved from a 'pre-ordained' through an 'analytic' to a 'holistic' style. This latter form, they claim, is prevalent in today's self-seeking, individualistic, creative world and is inimical to productive science. If their argument is accepted, it may be suggested that different micro-cultures (ethnic groups, the sexes) may also influence the development of different cognitive styles.

Figure 2.2: Factors, variables, or attitudinal targets of instruments identified in 204 science attitude studies by Munby (1980)



Therefore, in addressing the problem of how best to explore such socio-attitudinal factors, the previous literature was critically reviewed in relation to types of instruments conventionally used. The most relevant research has been that on 'attitudes to science'. The ambiguity of the term 'attitudes to science' has already been raised (Section 2.2.1) and it is further highlighted when the range of instruments used to measure these 'attitudes' is examined. Munby (1980) analysed 204 instruments which purported to measure 'attitudes to science' and found these could be conveniently grouped into several broad areas. These are diagrammatically illustrated in Figure 2.2. In this section the instruments used in five New Zealand 'science attitude' studies are examined. These show several methodological weaknesses and provide indigenous evidence for the need to clearly identify the focus of the researcher's concern.

(a) Hughes (1969) sought to develop a test 'to measure the scientific attitudes of High School students' and produced an instrument which was administered to pupils of three different ages (13, 14, and 15 year olds) in a co-educational school in Auckland. This instrument, although stated to resemble a Likert approach, differed in that the assumptions regarding the number of underlying dimensions involved in the attitude were not examined. Furthermore, a multiple-choice format was adopted rather than the usual Likert response requirement of placing a given statement into one of (usually) five categories.

The scale, as administered to the students, comprised 20 items chosen to cover the 'characteristic scientific attitudes' referred to in the 1968 New Zealand Science Syllabus (such as 'intellectual honesty'; 'recognition of the uncertainty of Man's knowledge'; 'recognition of the tentative nature of theories'; and 'respect for the place of reason in human affairs'). An example of an item taken from the scale follows:

> "Jim and some of his classmates were arguing about capillary action. Jim said that all liquids would rise up a fine tube against gravity just like water does. He did some experimenting at home and found that mercury would not rise up the tube. He realised that he had been wrong and wondered what he should do about it when the subject came up again. What do you think he should do?
>
> (a) Change the subject to avoid embarrassment.
> (b) Only tell his close friends about his experiments.
> (c) Not say a word about his experiments to anyone.
> (d) Tell the group that he had changed his mind.
> (e) Still keep to his old opinion."
>
> (Hughes, 1969: Appendix)

Hughes provided a split-half reliability coefficient (0.75) and claimed high content validity (by referring to the concordance between the raters of the multiple choice items - all concordance coefficients were significant beyond the 0.01 level). However, although he acknowledged there were at least six constructs tapped by his scale, he totalled the response values given to each item and based his subsequent analyses on the total raw scores. This is an example of the major weakness of many such tests noted by Gardner (1975b):

> "To add up the weight, the number of doors, and the number of cylinders in a motor car to produce a single number would have little meaning. Yet many would-be attitude researchers do the equivalent all the time. Instruments have frequently been constructed which contain two or more logically and psychologically distinct variables; the distinctions are not perceived, or ignored, and all the item responses are summed to yield a single score."
>
> (Gardner, 1975b:13)

(b) Jenkins (1973), as part of a broad study which investigated 'expectations' as well as 'attitudes' towards science in several teachers' college student groups at a primary teachers' college, devised a Likert scale to examine 'attitudes to science and the teaching of science'. The final scale consisted of forty items which were able to be placed into one of six categories:

> "1. Social implications of science.
> 2. Scientific attitudes - attitudes such as curiosity, rationality, suspended judgement, open-mindedness, critical-mindedness, objectivity, honesty, humility, and also such attitudes as enthusiasm, perserverance, etc.
> 3. Science interest - any interest related to science as a study or activity. i.e. reading about science, watching science on T.V., doing experiments, etc.
> 4. Science as an activity - refers to the *enterprise* of science - the method of inquiry as practised in scientific investigations.
> 5. Science knowledge - the body of *information* resulting from scientific investigation.
> 6. Teaching science - items relating to classroom practice and ways of teaching science."
>
> (Jenkins, 1973:52. Italics in the original)

Jenkins did not provide reliability coefficients but claimed validity on the basis of having a group of science teachers score each item by selecting the category to which they considered it belonged. In analysing the results, each item was treated separately and significant differences between specific student groups sought (e.g. between the 'science' and the 'non-science' student groups). Thus, no overall measure of 'attitude' was attempted and so Jenkins avoided the pitfall mentioned above. However, no student numbers are given (although for staff/student comparisons, a total of eight staff members were used) and the statistical method for identifying 'significant differences' between groups was not specified. As the analyses were based on frequency counts for each item-response option, it is assumed a Chi-square was used. Jenkins did give a descriptive account of those items which discriminated between the groups. e.g.

> "Item 1 The progress of mankind is the progress of science. This item elicits the strong divergence of opinion which the statement was intended to bring out. Science students strongly agreed with it and the non-science groups disagreed, especially first year art ...
>
> "Item 18 The work of scientists will eventually result in a dehumanised and automated world. Surprisingly, this item gained its significance from differences expressed between first and third year students, and not between science and non-science groups. First years were strongly in agreement with the statement."
>
> (Jenkins, 1973:61-2)

She concluded that the investigation 'was successful in revealing differences between staff and students in their attitudes towards science and to the teaching of science' but she did not attempt to relate the results to the six criterion groups used to specify the components of the 'attitude' originally. However, to be fair, it is possible for the reader to refer to the table which gives the science teachers' assessment of each statement's grouping, together with Jenkins' descriptive analysis of the discriminating items (as above), and deduce the underlying construct on which particular groups of students held differing 'attitudes'.

(c) Thomas (1976) developed a questionnaire which was composed of 10 sentence completion items and 15 Likert scale items to explore 'the development of attitudes towards science'.

This was administered to a sample of 211 F3 and F4 students in several coeducational schools in Auckland and the data generated were used to examine a series of hypotheses concerning the effects of such variables as teacher effectiveness, pupil achievement, form level, parental influence, personal motivation, sex, and socio-economic status, on the development of attitudes towards science. The sentence completion items were scored +1, 0, or -1 ('depending on whether or not that attitude expressed was positive, neutral, or negative') and the 'algebraic sum of these scores is the measure of the pupil's generalised attitude towards science'. The Likert-type items were scored so as to give four separate scores, one for each group of questions deemed to be tapping into a common construct. For example, the following three items purport to ascertain 'parental influence':

"3. My parents encourage me to take an interest in science

8. My parents are not interested in science

13. I would like to talk about science with my parents"
(Thomas, 1976:86-7)

(d) Lai (1977) constructed a 'Science Interest Inventory' which contained a questionnaire designed to measure students' degree of feeling towards science activities or their degree of participation in science activities. No definition of 'science interest' was provided. His sample consisted of 134 F4 students from a single co-educational high school in Auckland. The first part of his measure used Likert-type items such as:

"1. I like to visit an exhibit of laboratory (sic)
2. I would like to belong to an astronomy club
3. I like to read articles about scientific things
4. I like to hear talks on Chemistry or Physics."
(Lai, 1977: Appendix C)

The responses to be made were the usual Likert 'disagree strongly'; 'disagree'; 'no opinion'; 'agree'; 'agree strongly' type. A total of 18 items were provided but, once again, the individual scores from each item were summated to give a total raw score for the 'interest in science' measure. No consideration of the possible variety of underlying constructs was made; no reliability figures were given; and no mention was made of validity. It would appear to be a very weak measure indeed.

(e) Vincent (1980) modified a 60 item forced choice (Likert) inventory of science attitudes developed by Moore and Sutman (1970) and applied it to several classes from three Christchurch secondary schools to test the prediction that there would be a difference in mean scores on the scales between classes and between schools. Vincent defined the term 'scientific attitude' as:

> "An opinion or postion taken with respect to a psychological object in the field of science ... A scientific attitude inventory is an instrument which assesses some elements in each division of the universe of scientific attitudes."
> (Vincent, 1980:2)

Thus, Vincent acknowledged the existence of several 'scientific attitudes' and keyed each item to one of six attitudinal scales. Each scale had ten items keyed to it in such a way that five items represented each end of a continuum within the scale. Thus, as each scale was scored separately, a 'profile' of scientific attitudes was built up. The scales were:

"1. Value placed on the facts, principles and theories of science
2. Orientation towards scientific data and the nature of scientific explanations
3. Orientation towards the nature of the scientific mode of enquiry
4. Appreciation of the role of scientific activity
5. Attitude towards the relation of science to society
6. Attitude towards and interest in science as a career."
(Vincent, 1980:12-13)

Although Vincent did not give reliability coefficients for his version of the scales, Moore and Sutman had done so (test-retest reliability = 0.93). Vincent was sensitive to the question of validity and, by using a group of student teachers to key the items to the scales, and by trialling the rewritten items for comprehension by a group of 12-13 year olds, it would appear that he had produced a valid version for use with his experimental sample. Whilst his analysis may be considered to be rather simple (only histograms were provided showing the distributions of each class's responses on each scale, together with the means and standard deviations for each class and each school in the sample), the instrument itself would appear to be sound.

All these instruments purported to measure some aspect of attitudes to science (or 'science interest') but only Thomas (1976) endeavoured to ascertain the degree of influence which significant other people (in this case, parents) had on the development of students' attitudes. If, as has been suggested in the literature, the social component is an important variable in the development of an individual's attitude, an attempt to find out its effect is imperative.

However, in spite of the apparent wide range of available instruments overseas and the development of several in New Zealand, none appeared to be appropriate for this investigation. The general lack of agreement on the meaning of the term 'attitude', the limitations of existing instruments which measured 'attitudes', and the insights gained by this investigator in the research on attitudes for the Learning in Science Project (Stead, 1980a), suggested the use of another term. The term 'outlook', as used in the expression 'Outlook on Science', was adopted and used in this investigation to refer to such general orientations towards, or away from, the study of science as expressed by any, or all, of an individual's beliefs, attitudes, intentions, behaviours, opinions, values, etc. This expression thus embraced the social, cultural, cognitive, psychological, and behavioural factors identified in this literature survey but raised the methodological problem of how best to gain an understanding of the 'outlooks on science' held by the various groups of students. This problem is addressed in the next chapter.

2.5 Summary

The research reviewed in this chapter indicated the under-representation of girls and women in science to be a world-wide phenomenon and that it appeared to be influenced by sociological factors, such as sex-role stereotyping. Boys, more than girls, tended to participate in science activities from an early age and develop positive attitudes towards it. Science, covertly and overtly, is depicted in the home, school, and media as a masculine pursuit. The possibility is also raised that spatial ability, more often higher developed in males than in females, is another contributing factor to the disproportionate representation of the sexes in the sciences. However, the sex differences in spatial ability may also be linked with social factors.

The under-representation of Maori and Pacific Island students in the sciences is also influenced by sociological factors. The noted cognitive differences between the ethnic groups would appear to disadvantage Polynesian students. However, the suggestion (Reid & Gilmore, 1983) that these differences may be a consequence of social and educational inequalities predisposes this investigator to examine socio-attitudinal factors behind the under-representation of Maoris and Pacific Islanders in science.

The apparent importance of students' outlooks on science for explaining the under-representation in the sciences of both girls and of Maori and Pacific Island students, has provided a convenient, specific focus for this thesis.

CHAPTER THREE - TOWARDS AN UNDERSTANDING OF STUDENTS' OUTLOOKS ON SCIENCE

> "When one construes another person's outlook, and proceeds to build an experiential cycle of his own upon that construction, he involves himself, willy nilly, in an interesting way. He can test his construction only by activating in himself the version of the other person's outlook it offers. This subtly places a demand upon him, one he cannot lightly reject if his own experience is to be completed. He must put himself tentatively in the other person's shoes. Only by enacting that role can he sense the impact of what happens as a result of taking the point of view he thinks his friend must have."
>
> (Kelly, 1966)

It was suggested at the end of the previous chapter that the reasons for the under-representation in science of particular student groups were to be found in the different outlooks on science these groups held. Two fundamental questions arise from this suggestion:

(a) What <u>are</u> the outlooks on science held by the different student groups?

(b) What <u>influences</u> the development and maintenance of these students' outlooks on science?

It was recognised the answers to these questions needed to be sought within an explicit theoretical framework (Guba, 1978) and instrumental techniques, consistent with the theory, would be required to collect the requisite data. Prior research was reconsidered with these requirements in mind and, as already noted (Section 1.4), within the LISP preference for a 'qualitative' approach, rather than one wholly 'quantitative'. Thus, particular importance was placed on the requirement of being able to work alongside individual students and to have them express their outlooks on science in a way that was personally meaningful to them and that which could later be communicated to their teachers, and other interested educational audiences.

The Glaser and Strauss (1967) 'Grounded Theory' had been influential in shaping the overall LISP approach to its qualitative research (Osborne, 1980a) but this researcher (Stead, 1980b) felt it might generate explanations ('models') of student behaviour too context-specific to be of widespread value to science education, and to research in general, in other settings. Kelly's (1955) Personal Construct Psychology (PCP) was beginning to be used in qualitative science education research in England (Pope, 1981; Pope & Shaw, 1981; Watts, 1981) and, as the investigator had had previous exposure to it (Stead, 1973), he realised it could meet the theoretical, the instrumental, and the qualitative requirements. Thus, it was decided to use PCP as the theoretical basis for the study and its 'repertory grid' as the basic instrumental technique primarily for seeking answers to the first question above. The theory and technique are described and discussed in <u>Section 3.1</u>.

It was anticipated that the demand on time of the qualitative research would be considerable and, with a small student sample, however carefully selected, there was always the possibility that idiosyncratic responses would not be recognised as such, and that a <u>quantitative</u> perspective (to complement the <u>qualitative</u> PCP approach) was also required. Since relatively large numbers of students were available to the project it was decided this requirement could be met, and answers to the second question above sought, by using Ajzen and Fishbein's (1980) Theory of Reasoned Action (TRA). Essentially, this theory provided for the development of a questionnaire which tapped into students' beliefs about science, their intentions whether to study science or not, and the values they placed on the study of science. The rationale for choosing this particular theory is described in Section 3.2.

In addition to the PCP and TRA approaches, the selection of the sample of students for the individual interviews enabled the use of several other quantitative measures, chosen:

(a) to provide a means of identifying a sample of students reasonably representative of their peers in terms of their scholastic ability and their responses to some aspects of school science across the variables of sex, ethnicity, form level, and school type, and

(b) to allow for an examination of several ideas raised by previous research which seemed to this investigator to suggest possible ways of explaining some of the sex/ethnic differences in aspects of science in ways consistent with those provided by the PCP and TRA approaches. The rationale for the choice of each measure is discussed in Section 3.3.

Thus, Section 3.3 presents the overall research plan for the investigation, describes how the sample of students was selected for the qualitative interviews, discusses the rationale for the choice of the quantitative measures, and finally, proposes two empirical hypotheses, framed in 'null' form, to facilitate a statistical analysis of the data generated by the quantitative measures.

Section 3.4 provides the chapter summary.

3.1 Personal Construct Psychology

3.1.1 PCP application and theory.

Personal Construct Psychology (Kelly, 1955) has been developed in many diverse fields sinces its inception in a clinical context. For example, Reid and Holley (1972) examined students' choice of university; Riley and Palmer (1976) explored attitudes towards seaside resorts; Hudson (1974) investigated students' images of grocery stores in Bristol (Chalmers & Taylor, 1978, did a similar study in Hamilton, New Zealand); Honikman (1976) applied PCP in a study designed to explore architects' perceptions of their clients' needs; Ryle and Breen (1974) investigated British social-work students' construing of their roles and how their perceptions changed in the course of their two-year training programme (Lifshitz, 1974, did a similar study with social-work students in Israel); Du Preeze (1975) applied PCP to the analysis of political debates on internal African affairs; Childs and Salmon (1978) examined elements of effective property management with a group of South West Queensland farmers (Bock, 1976, had conducted a similar study in South Australia).

Within the general field of 'education' various applications of PCP have been explored. For example, teacher training (Adams-Webber & Mirc, 1976; Pope, 1977; Hopwood & Keen, 1978; Olson, 1979); curriculum change (Olson, 1980); learning processes (Shaw & Thomas, 1979; Thomas & Harri-Augstein, 1977); developmental processes (Salmon, 1969; Applebee, 1975);

educational theory (Salmon & Bannister, 1974; Yorke, 1978); computer assisted learning (Perrott, Applebee, Heap & Watson, 1976; Shaw, 1980a; 1980b; Shaw & Thomas, 1978); reading (Reid, 1976; Thomas & Harri-Augstein, 1976); pupil/teacher interactions (Nash, 1973; Hargreaves, 1977; Blease, 1978; Clift, Cyster, Russell & Sexton, 1978); and education in general (Pope & Keen, 1981).

Of direct relevancy to this investigation has been the application of PCP to science education - Gonzales (1979); Pope (1981); Pope & Shaw (1981); Watts (1981).

The essence of PCP is stated in a fundamental postulate and eleven corollaries (see Appendix 3.1) making it one of the most explicit theoretical systems in psychology today (Fransella, 1972). Bruner (1956) described it as 'the single greatest contribution of the past decade to the theory of personality functioning'. Kelly's analogy to explain human behaviour was that of man the scientist. Each human being was seen as a personal scientist, classifying, categorising and theorising about his world, anticipating future events on the basis of his theories and acting on the basis of his anticipations. That is, according to Kelly, man's behaviour is not determined by an innate set of instincts (as in psychoanalytical theory) nor is it determined by schedules of reinforcement and associations between stimulus and response (as in behaviouristic theories).

> "For Kelly, man is essentially a scientist; he is in the predicting business. He is perpetually seeking to try and guess what happens next by reconstruing his universe."
>
> (Bannister, 1966a)

Consequently, man is not at the mercy of the moment since he carries around with him a system of constructions which he has developed over the years and has tested against recurring events and has come to use to predict the future. The constructions are validated to the extent that a successful prediction occurs or they are revised should the prediction not be successful. Thus, most, if not all, interpretations of events are subject to continual revision and ultimate replacement. It also follows from this viewpoint that reality is not revealed directly to the individual but is that which is perceived via the constructions he imposes on reality. That is, the mental representational model of the world constructed by each individual defines reality for that individual.

> "Man looks at his world through transparent patterns or templets which he creates and then attempts to fit over the realities of which the world is composed. The fit is not always very good. Yet without such patterns the world appears to be such an undifferentiated homogeneity that man is unable to make any sense out of it. Even a poor fit is more helpful to him than nothing at all. Let us give the name <u>constructs</u> to these patterns that are tentatively tried on for size. They are ways of construing the world."
>
> (Kelly, 1963:8-9. Italics in the original)

Kelly's personal 'templets' might alternatively be considered as particular 'cognitive styles'. For example, an individual who is described as being 'field independent' (Witkin, Ottman, Raskin & Karp, 1971) may prefer to use <u>fewer</u> constructs, and be more likely to use superordinate constructs, than might a 'field dependent' individual (such a person could also be possibly described as using a 'categorical cognitive style' (Kagan, Moss

& Sigel, 1963) when higher order linkages between two sets of construct systems are suggested).

Reference has already been made to a possible link between noted sex and ethnic differences on science-related measures and particular 'cognitive' factors. Within PCP such factors are interpretable with reference to identifiable features of construing (such as the <u>nature</u> of preferred constructs, or the preferred <u>articulation</u> of particular constructs).

However, not only are 'cognitive' factors able to be explored but so too are the 'affective':

> "(Kelly) rejected the compartmentalism which was found in psychological writings of his time and, in seeking to take a holistic view of the person, he argued that the splitting of human functioning into intellectual/cognitive and affective components was inappropriate."
>
> (Pope, n.d.:9)

This rejection of 'compartmentalism' echoes the viewpoint which gave rise to the expression 'outlook on science', and the preference to seek socio-attitudinal factors to explain the under-representation of particular student groups in science.

It is not intended to give a detailed description of PCP as this may be found in many fundamental texts on 'personality' but, in order to provide the rationale for the 'instrumental technique' (the repertory grid) associated with PCP, five essential characteristics of 'constructs', the elementary units of PCP, are enumerated here:

(i) Constructs are bipolar, single dimensional scales. For example, 'weight' would be the scale 'light-heavy'. 'Shape' is generally not a construct as it is not bipolar and thus, if an individual was asked to sort a groups of objects according to shape, he/she would need to produce appropriate constructs (such as 'smooth-jagged') to help him/her to do so (<u>note</u>: an individual could use a construct ' with shape - shapeless'!).

(ii) Constructs have a limited range of convenience. The construct of weight gives no help in sorting objects according to size; a new construct of size is needed to do this.

(iii) Constructs are related to each other by other constructs. For example, the constructs of weight and size are related to each other by the construct of density.

(iv) Constructs are modified, discarded, developed, or whatever, in the light of experience with a changing world.

(v) Constructs are used to predict the future and anticipate future events. For example, a scientist may use the construct of density to predict whether an object will sink or float, and a person in the everyday world uses his/her 'personal' constructs (c.f.'scientific' constructs) to predict whether the book he/she sees on the library shelf will satisfy him/her or not. <u>Note</u>: scientific constructs are consensus constructs determined by and shared by scientists (working in the same 'paradigm' - Kuhn, 1970); personal constructs are personal to the individual and are usually not so carefully and explicitly defined.

Thus, the idiosyncratic representational model of the world constructed by each individual is made up of a collection of these constructs organised into a particular system, and it is this system of constructs which determines the rationale for the individual's behaviour. Therefore, for an observer to understand why an individual behaves in a certain way, or holds particular predictions (for example, what would be the outcome if he/she were to continue with a study of science), the observer would require access to the individual's construct system. The technique developed within PCP to provide access is the Repertory Grid.

3.1.2 The Repertory Grid technique

> "A scientist's inventions assist him in two ways: they tell him what to expect and they help him to see it when it happens. Those that tell him what to expect are theoretical inventions and those that enable him to observe outcomes are instrumental inventions."
> (Kelly, 1969)

Personal Construct Psychology is a 'theoretical invention'; Repertory Grid techniques are 'instrumental inventions'. Over the years, since Kelly's first 'Rep. Test', many different forms of the grid have been developed. Bannister and Mair (1968) and Fransella and Bannister (1977) describe a number of these, the latter authors pointing out that lack of imagination is the limiting factor in the development of novel approaches to grid methodology. Although Kelly originally called his technique the 'Repertory Test', it is now accepted (Fransella & Bannister, 1977) that the grid is better viewed as a method - a method for exploring personal construct systems.

Essentially, three issues are identifiable which recommend the repertory grid approach as being appropriate to this investigation. First, is its integral association with PCP; second is the philosophical preference of the investigator towards 'naturalistic' (Guba, 1978), as opposed to wholly 'empirical', research paradigms. The repertory grid method allows for an exploration of an individual's phenomenological world in terms of his/her own peculiar subjective dimensions (constructs), rather than those of the investigator's, and provides objective measures of the relationship between these dimensions. That is, the grid method allows for a flexible blending of subjective and objective exploration of the personal construct system under investigation. The third issue is that of practicality. The task of completing a grid is readily accomplished by school pupils and it is not too time consuming (This is an important consideration when several interviews with individual pupils are to be conducted within school time). Note: A discussion of the reliability and validity of the repertory grid, and some of the practical problems associated with its administration and subsequent interpretation, is to be found in Appendix 3.2.

Comprehensive presentations of grid methodology, analyses, and evaluation, are available elsewhere (Bannister & Mair, 1968; Fransella & Bannister, 1977; Adams-Webber, 1979; Pope & Keen, 1981). However, a brief description of the commonly used forms of the repertory grid, and how they may be analysed, will be useful at this point.

(a) Repertory grid formation. A repertory grid is essentially a rectangular matrix (see Appendix 3.3 for an example) comprised of a set of stimuli, known as 'elements', usually rated (e.g. on a 1 to 5 scale), but occasionally ranked, across a series of constructs. These constructs represent the identified set of discriminatory dimensions which enable the elements to be compared and contrasted with each other.

In its original form, as the 'Role Construct Repertory Test', Kelly (1955) used a set of role titles (e.g. Self, Mother, Father, Brother, Sister, Spouse, Best Friend, Threatening Person, Ethical Person, Successful Person) as elements. The set of elements chosen establishes that subsystem within an individual's total construct system which is the focus of scrutiny, and it need not be centred on people, as Kelly's original grids tended to be. When the Rep Test was administered, the subject was asked to supply the name of a person who would fill that role in the subject's life and this name was written either on a separate card or on a list alongside the appropriate role title. Constructs were elicited from the subject by the experimenter successively selecting a group of three cards (e.g. Father, Best Friend, Ethical Person) and asking the subject to suggest a way in which two of these people are alike, and yet different from the third. The process of selecting groups of three cards continued until no new constructs were suggested. This technique became known as the 'triadic' system for eliciting constructs and is based on Kelly's definition of a construct:

> "In its minimum context (a construct) is a way in which two elements are similar and contrast with the third."
>
> (Kelly, 1955:61)

The set of constructs, so elicited from each subject individually, reflects the idiosyncratic nature of each person's construct system and it is the relationships betweeen these constructs in the set, and the dispersion of elements across these constructs, that is of primary interest to the investigator. The element dispersion is determined by the subject as he/she rates each element in turn across each construct. The completed matrix, in which there is a separate column for each element and a separate row for each construct, defines a 'raw' grid.

The particular construct subsystem to be explored is determined primarily by the choice of elements, which must therefore be representative of the individual's set of elements within the subsystem. These elements are most often chosen by the investigator and then discussed with the interviewee who may wish to delete some or add others to the element pool. If inter-grid comparisons of element dispersion in construct space are to be made, a core of common elements is necessary.

The choice of constructs, particularly with children, is less unequivocal. Kelly (1955) has provided six variations of the triadic method. However, these variations may be too complex for certain groups of people; may be too time consuming (particularly if every possible triadic combination of many elements is considered); and may produce some superficial constructs of dubious utility.

Considerable discussion in the literature has developed over whether supplied constructs produce the same sorts of grid responses as elicited constructs (see Pope & Keen, 1981, for a review). Purists emphasize the centrality of the <u>personal</u> construct system being explored and argue for the individuality of the respondent to be maintained. However, many pragmatic factors may intervene to deny such an absolute approach with certain groups (such as respondent 'shyness', inarticulation, or an inability to extemporaneously identify salient constructs during the interview). Fransella and Bannister (1977) suggest a variety of alternative methods for eliciting constructs and those used in this investigation are discussed in Section 3.3.

Kelly's original method used a dichotomous form of grid development in which the respondent placed each element on one or the other of the two poles of each construct (each placement was usually represented by a tick in the appropriate cell of the matrix). In order to allow for greater response sensitivity in discriminating between elements, two alternative methods of grid formation have evolved, the 'ranking' and the 'rating' methods

(Bannister & Mair, 1968; Fransella & Bannister, 1977; Pope & Keen, 1981). In the ranking method, each element is arranged in order of its perceived 'distance' from each construct pole (e.g. on the construct 'boring/interesting' each element is ordered from being the 'most boring' to that being the 'most interesting') on each construct and given a corresponding ranking value (e.g. 'most interesting' = 1; 'most boring' = 10, if 10 elements are ranked). Difficulties arise with this method when large numbers of elements are to be ranked, and when tied ranks are considered.

With the rating method, each element is assigned a rating value which reflects its position on a particular construct. A 5-point or 7-point scale is usually employed and this allows for finer discriminations to be made than is possible with the dichotomous method and yet avoids the difficulties possible with the ranking method. For example, as each construct is identified, one pole is the nominal '1' value and the contrast pole becomes the nominal '5' value, with intermediary positions receiving the intervening values. The value '3' may be used for those elements 'half-way' between the two poles, or, with those elements for which the construct appears to be inappropriate (blank cells are generally not admissible in most grid analyses). Thus, as each construct is responded to with each element and the corresponding value noted, the raw grid is systematically built up - see the flow diagram in Appendix 3.4. This raw grid is then able to be analysed.

(b) Repertory grid analyses. Several techniques for analysing the mass of data contained with repertory grids to reveal the inherent structure and pattern are now available. These range from the simple hand analyses (Bannister, 1965; Taylor, n.d.) to complex statistical analyses which require computer facilities (Shaw & Thomas, 1978; Slater, 1976; 1977; Shaw, 1980a; 1980b; Keen & Bell, 1980). Some of these computer techniques are interactive and enable the user to 'converse' with the computer and, in so doing, allow for the progressive development of a repertory grid usually accompanied by a commentary on the patterns in the responses (e.g. PEGASUS - Shaw, 1980a; 1980b).

In general, the statistical methods used may be grouped into four broad categories:

(i) principal component analysis (Hope, 1968; 1969; 1970; Slater, 1972; 1974; 1976; 1977);

(ii) cluster analysis (McQuitty, 1957; Goodge, 1979; Shaw, 1980a; 1980b);

(iii) multidimensional scaling (Kruskal, 1964); and

(iv) the D^2 (non-metric - in which only ordinal properties of the data are assumed) method of analyses (Kelly, 1955; Osgood, Succi, & Tannenbaum, 1957), or other methods (both metric and non-metric) (Cronbach, 1955).

The relative merits of these different methods have been well argued (Yorke, 1978; Rump, 1974; Humphreys, 1973; Slater, 1974; Hope, 1970) and no consensus of opinion has yet emerged. It would appear there is no single analytical method for all types of possible application - the grid user must use that method which is best suited to his/her own needs.

The main aim in these analyses is to simplify the data in the grid as much as possible without incurring distortions of the original patterns and structure. All of the above techniques tend to base the simplification on the computation of 'similarity matrices' or 'correlation matrices' (Coombs, Dawes & Tversky, 1970). These matrices preserve the relationships between the rows of constructs and columns of elements (expressed as 'vectors').

Detailed descriptions of the alternative methods of grid analysis may be found in Pope and Keen (1981), Fransella and Bannister (1977), and Adams-Webber (1979). As appropriate computer facilities and programmes were available, this investigation used the principal component analysis method.

Slater (1972; 1974; 1976) has been the strongest advocate of this method. The 'Grid Analysis Package' (GAP) (Slater, 1977) has a variety of computer programmes for analysing grids in a variety of forms. The analysis of a single grid (or a series of individual grids) is possible with INGRID. The output from Ingrid produces sets of tables defining the relationships between constructs; between elements; between elements and constructs in terms of direction cosines (these are mathematically equivalent to correlation coefficients); elements and construct vectors and loadings on the derived principal components; and various options such as the Bartlett's test (which determines whether the remaining variation within the transformed grid after a given number of the principal components has been extracted is randomly distributed over the remaining components). The output also provides the polar coordinates of the elements and constructs (in component space) to enable a spherical geometrical representation of element/construct relationships to be displayed. That is, the first three principal components may be represented by a set of orthogonal diameters of a hypersphere as may be plotted on a geographer's globe. Each construct is represented as a diameter of this hypersphere and each element is located on its surface (see Hope, 1969; Slater, 1977, for detailed descriptions). Comprehensive descriptions of INGRID may be found in Slater (1977) and Pope and Keen (1981).

3.2 The Theory of Reasoned Action

Ajzen and Fishbein (1980) have based their theory on the assumption that:

> "... human beings are usually quite rational and make systematic use of the information available to them. We do not subscribe to the view that human behaviour is controlled by unconscious motives or overpowering desires, nor do we believe that it can be characterized as capricious or thoughtless. Rather, we argue that people consider the implications of their actions before they decide to engage or not to engage in a given behaviour. For this reason we refer to our approach as a "theory of reasoned action"."
>
> (Ajzen & Fishbein, 1980:5)

According to Ajzen and Fishbein's Theory of Reasoned Action a person's <u>intention</u> to perform a behaviour (e.g. to study science) is made up from two relatively independent components:

(i) a person's <u>attitude</u> to that behaviour (e.g. 'I enjoy studying science') and,

(ii) their perception of what others will think about them performing that behaviour (e.g. 'most people think I should study science') - this perception may be called the perceived social standard.

A person's attitude to that behaviour is influenced primarily by a set of objective beliefs. The set of objective beliefs constitute all those personal opinions held by a person about the consequences of performing the behaviour in question. For example, a student may believe studying science will enhance his/her career opportunities, would provide intellectual satisfaction, and give a feeling of control in a technological environment. Such a student is likely to evaluate positively, the action of studying further science at school. In contrast, the student who believes studying science is a waste of time because of its dubious relevancy in his/her life, believes it to be difficult, and suitable only for students who can afford university study, is likely to hold an unfavourable attitude towards further science study.

Associated with a person's objective beliefs that a given behaviour leads to certain outcomes are his/her personal evaluations of these outcomes (e.g. 'studying science would enable me to obtain a place in a tertiary institution in the city but I cannot see myself as a tertiary student').

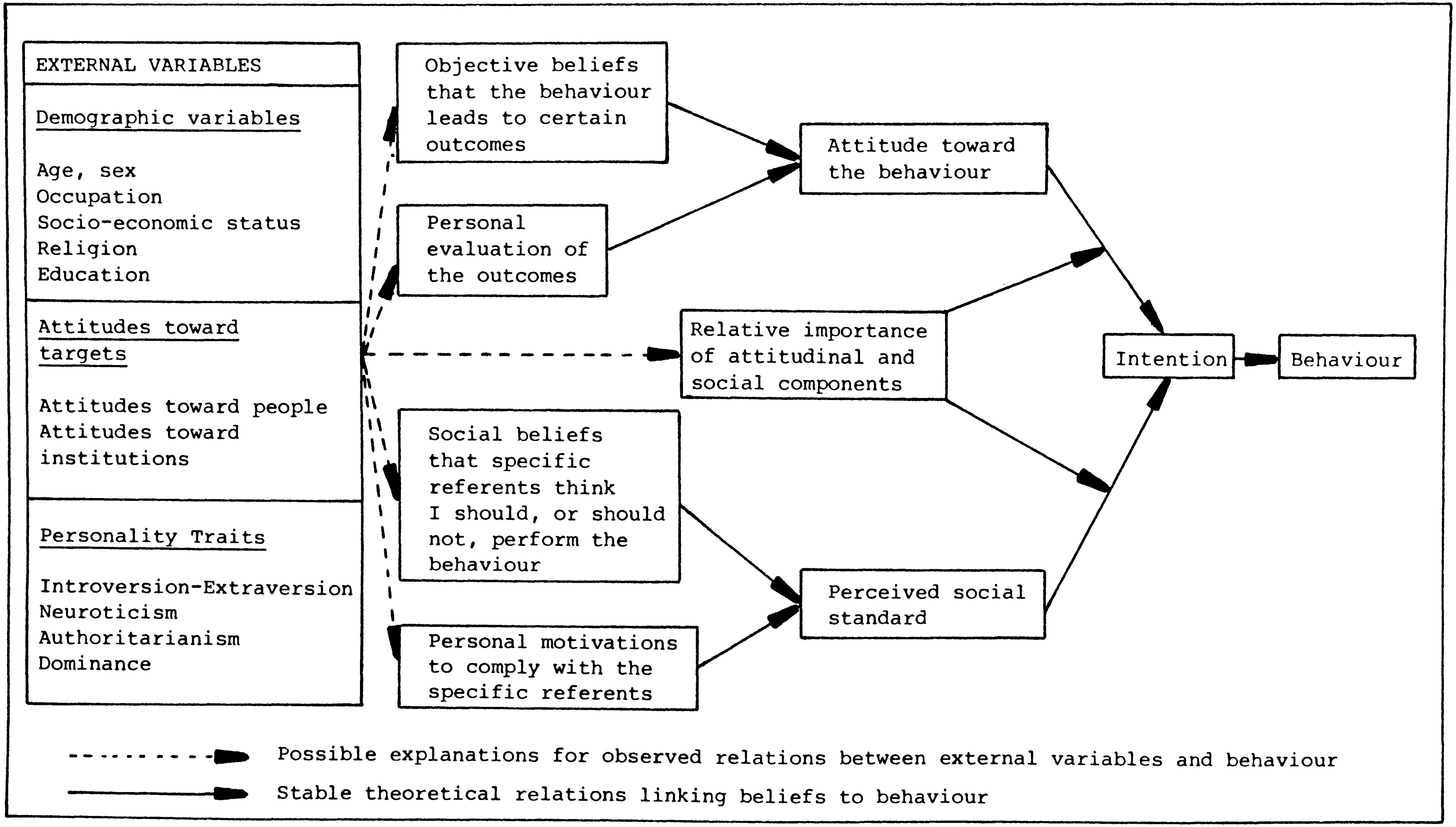
Similarly, a person's perceived social standard is influenced primarily by a set of social beliefs. These social beliefs are those associated with specific individuals or groups of people important to the person (e.g. 'Dad thinks I should study science - Mum thinks studying science would be a waste of time').

Associated with these social beliefs are the person's motivations to comply with the perceived wishes of significant people around him/her (e.g. 'If my folks disagree, I usually do what Dad wishes, rather than Mum').

How the two major components of the Theory of Reasoned Action (the attitudinal and the perceived social standard), and their determinants, relate to a person's intention to perform a behaviour, is shown in Figure 3.1.

Ajzen and Fishbein use 'Path Analysis' (Osborne, 1976; Wolfe, 1980) to assign relative weightings to each of the two components of intention. This increases the explanatory value of the theory. For example, two F4 students, A and B, may express positive attitudes towards studying science at the F5 level and both may perceive social standards to be such that they should not study science any further. The outcomes of these conflicts between their attitudes and their social standards could be predicted by knowledge of the relative weightings each student gives to these two components of intention. That is, the different intentions, of to study (e.g. student A) and not to study (e.g. student B) science at the F5 level, would follow if student A's intention was determined primarily by attitudinal considerations, and if student B's intention was primarily under the control of his/her perceived social standard.

Figure 3.1: Factors determining behaviour according to Ajzen and Fishbein's (1980) Theory of Reasoned Action



Finally, Ajzen and Fishbein claim that although 'external' factors such as sex, age, social economic status, education, and various personality traits, may well influence behaviour, they do so indirectly and only if they are related to one or more of the variables specified by their theory.

The Theory of Reasoned Action therefore seemed appropriate for this study because it provided a theoretical rationale for directing specific research attention to the socio-attitudinal factors, identified from the literature search and in the preliminary LISP work, as being suggestive of providing answers to the research question.

Of substantial interest was the role of beliefs (both 'objective' and 'social') in the theory because it was suspected that (a) male students would have a more extensive set of <u>objective beliefs</u> about science than female students (and, to a lesser extent, European students would have a more extensive set of objective - scientific - beliefs than Maori and Pacific Island students) due to their greater informal exposure to scientific processes, principles, and products in their leisure time activities (Torrance 1963; Belotti, 1975), and (b) girls (Saraga & Griffiths, 1981), and Polynesian students (Graves, 1974; Pitt & Macpherson, 1974; Ritchie & Ritchie, 1978), would have a more extensive set of <u>social beliefs</u> than boys, and European students.

For many students in New Zealand schools, the decision whether or not to continue with a study of science is made during their second year at secondary school. This decision is made following often a total of only four or five secondary school terms of science so the influence of their sets of objective and social beliefs would be of considerable importance. Thus, the Theory of Reasoned Action focussed attention on the nature and range of beliefs held by different student groups.

Other questions were raised by the theory too, such as: Is there a 'characteristic' differential weighting of the attitudinal and social components for the different student groups? Are there particular beliefs (stereotypes?) held by particular student groups? Which people influence students' intentions (arents? Science teachers? Peers? Potential employers?).

As well as providing quantitative socio-attitudinal data to complement the qualitative data from the PCP approach, it was anticipated the Theory of Reasoned Action would provide the educator with the material from which to fashion specific teaching and 'diagnostic' techniques which would enable student <u>intention</u> to be identified, explored, and perhaps altered. For example, if the most salient of a student's objective beliefs were factually erroneous (e.g. 'You need to study chemistry only if you're going become a chemist - pharmacist') and that his/her intention not to study science was determined by such beliefs, an appropriate teaching episode would challenge and, hopefully, modify and extend his/her set of objective beliefs, and thereby provide for a possible change of intentionality. It would follow that <u>if</u> the under-representation in science of particular student groups <u>was</u> related to such intentionality, and if these intentions could be altered, perhaps this current under-representation could, in turn, be redressed?

3.3 The research plan adopted in the investigation

The Learning in Science Project provided access to a wide variety of schools, of which eight were chosen as giving representative coverage of ethnic compostion (Maori, European, and Pacific Island) and type (single sex, coeducational, rural, primary, intermediate, and secondary). A summary of the characteristics of the eight schools used in the investigation may be found in Appendix 3.5.

Discussion with the schools' principals (or headmasters), heads of departments of science (where applicable), guidance counsellors (in two schools) and with classroom teachers (Tasker & Osborne, 1981), enabled the purpose and nature of the investigation to be discussed and access gained to a total of 20 classes (from F1 to F4 inclusively) which were deemed to be reasonably representative of their school. A descriptive analysis of the twenty classes chosen may be found in Appendix 3.6.

From these classes, in consultation with the school personnel involved with the students, 26 students were selected for the intensive individual interviews. These students were selected on the bases of their representativeness on the school and form variables; their responses on the quantitative measures (see the following subsection); their 'Progressive Achievement Test (PAT) scores and report grades; the likelihood of consent from their parents; their ability to converse freely with an adult; and their accessibility to the investigator in the following school year. A summary of the characteristics of these sample students is found in Appendix 3.7.

Following the individual interviews, based on the repertory grid approach, unstructured interviews with the parents of the students from the sample were sought and convened. Finally, questionnaires designed to produce data for the Theory of Reasoned Action analyses were administered to the F4 and F5 classes - these classes were essentially the same as those on which the initial quantitative measures were used but in the following school year when all the students had moved up a form level.

3.3.1 The description of, and rationale for, the quantitative measures used.

In order to select the sample of students for the repertory grid interviews two particular quantitative measures (the 'Science Questionnaire' and TOSCA' - see following) were employed. As the application of these measures required access to entire classes of students the opportunity was taken to apply three further quantitative measures which the search of the literature indicated might shed more light on the question of why certain groups of students turned away from the sciences. The discusssion on the rationale behind the selection of each measure considers how each measure may be viewed from a PCP perspective.

This discussion follows:

(a) The Science Questionnaire. This questionnaire was devised by the investigator in an attempt to produce a 'science measure' which would indicate something of the student's thinking about certain words and topics in science. It was hoped the measure would discriminate between those students who preferred to give intuitive, 'everyday' explanations of the words and topics, and those able to give more 'scientific' explanations. It was conjectured that the former students may be those with less developed, or 'poorer' outlooks on science and that the nature and range of their personal constructs used to respond to concepts and events of a scientific kind would be distinguishable from the latter students. For example, students with positive outlooks on science might tend to use many more objective constructs in a more systematic fashion and use fewer affective-type constructs than might students with less developed outlooks on science. Thus, this measure was used, in part, to provide a convenient method for identifying particular students for subsequent repertory grid formation and analysis.

Also, of particular statistical importance was the need to have a reliable and valid instrument to explore several of the possible mechanisms, suggested within the literature survey, for explaining the under-representation in science of particular student groups. That is, the 'science measure' needed to be able to provide empirical data sufficient for correlational analyses to be conducted with the data obtained from the other quantitative measures.

Thus, several criteria were adopted in the development of the measure. These were:

(i) The measure should be reasonably independent of school science so as to avoid the possibility that students would recall and present responses based on their previous school science experiences.

(ii) It should embody the LISP findings that students' responses to questions on scientific phenomena are influenced by their existing 'cognitive frameworks' and that these frameworks may be described as those of 'children's science' or of 'scientist's science' (Gilbert, Osborne & Fensham, 1982). See Appendix 3.8 for further details.

(iii) It should not disadvantage students who have reading difficulties or whose understanding of the English language is weak.

(iv) It should be able to be answered by all students in each of the four form levels under investigation and yet discriminate between individual students.

(v) It should be in a form convenient to administer to entire classes at a time and be readily scored.

Several trial versions were tested and evaluated before the final form was produced with three sections (see Appendix 3.8 for the questionnaire and specific administration details).

<u>Section one</u> was of a multiple-choice answer format

and investigated the students' concepts of LIVING, ANIMAL, LIGHT, GRAVITY, FRICTION, and FORCE.

Section two consisted of four questions, once again with multiple-choice answers, raised by four separate demonstrations performed by the investigator. These were designed to explore the nature of the students' concepts of the PARTICLE NATURE OF MATTER in such a way as to directly confront the students visually with problems not necessarily dependent on previous science teaching.

Section three was of a Likert-scale format in which ten provided statements (e.g. "I enjoy doing science experiments") were to be responded to by indicating a choice from five alternatives (strongly agree; agree; undecided; disagree; strongly disagree). This section was devised to provide an initial general measure of affective ('attitudinal') response and to provide the basis for the initial interviews with the selected students. No attempt was made to include the responses made on this section with the scores derived from Sections one and two. That is, the 'science measure' did not include the measures made in this Section three.

A scoring system was devised for the first two sections which allowed for a weighting of the alternative responses in such a way so as to reveal differences between 'children's science' and 'scientists' science' responses (these weightings are included alongside each alternative response option in Appendix 3.9).

Thus, the possible range of scores on this measure was ± 60 (with x = 0.9; s.d. = 14.2; being obtained from the final trial based on four classes - one each of F1, F2, F3, and F4; n = 109). Thus, in gross terms, a positive score would suggest a 'scientists's science' view was held by the student whilst a negative score would suggest he/she held a 'children's science' view. A test-retest reliability coefficient (a Pearson product-moment correlation derived from the final trial classes referred to above, given the measure a second time after an interval of between three and four weeks) of 0.79 was obtained.

A group of experienced science teachers associated with the LISP examined the measure and were in agreement that those items in the final version of the questionnaire tapped into part of the general area of 'science'. Thus, face validity was assumed.

Each question, with the accompanying illustrations and verbal explanations, was presented to each class by the investigator on a portable over-head projector and the students recorded their responses on the pre-prepared response sheet (Appendix 3.9).

(b) <u>The Test of Scholastic Ability</u> (TOSCA) (Reid, Jackson, Gilmore & Croft, 1980). The primary reason for using this test was to obtain a relatively objective measure of the 'representativeness' of each class, and ultimately, of each student chosen for the individual interviews. Whilst it was desired that each student so chosen would have similar scores to each other on this measure, some variation was to be expected and would be regarded as a possible contributory factor in differences in 'science ability' and/or science outlook which might be subsequently identified.

TOSCA is a pencil-and-paper group measure of:

> "... a comprehensive range of learned or developed abilities which involves the manipulation of the verbal and numerical symbol systems of our culture. The abilities tapped are intended to be school-related rather than curriculum-specific and generally do not involve skills of the kind taught specifically in the classroom. Performance on the test as a whole ... (provides) a guide to a student's current status in broad language and numerical reasoning abilities and give an indication of his standing in relation to his age peers on the range of scholastic tasks sampled." (From the 'Teacher's Guide' notes given to principals and teachers involved in the standardazation procedure for TOSCA in 1980).

Equivalent forms of the test ('A' and 'B') are produced and arranged in three broad levels: Primary (Norms range: 9.0 - 12.5 years); Intermediate (Norms range: 10.6 - 14.5 years); and Secondary (Norms range: 12.6 - 14.11 years).

> "Each test comprises 70 objective items (multiple-choice and completion) graded in difficulty. The tests are non-overlapping; no items are repeated in tests at adjacent levels. Abilities are sampled in the ratio of one numerical item to five verbal items."
>
> (Reid, Jackson, Gilmore & Croft, 1980:6)

A time limit of 30 minutes is given for the completion of the test. The investigator administered the test to each class during normal school time; students in F1 and F2 were given the Intermediate Form B and students in F3 and F4 were given the Secondary Form B (examples of these forms are to be found in Appendix 3.10). Each protocol was marked by the investigator and the raw scores noted for possible inter-class comparison. For inter-student comparisons percentile ranks were derived.

(c) Cognitive Style measures The term 'cognitive style' is used to refer to an individual's customary way of perceiving and processing information. Since science requires of its practitioners particular cognitive skills (Karplus, Karplus, Formisano & Paulsen, 1977) the possibility arose that those students who 'naturally' possessed these skills would not be disadvantaged in the study of science in the way those students without them might be.

The notion that individuals develop particular identifiable cognitive styles in responding to events provided the suggestion (Section 3.1.1) that these styles may be interpreted as being characteristic of particular personal construct systems. A fundamental assumption adopted in this investigation was that individual outlooks on science are determined by the individual's personal construct system. Therefore, the opportunity to explore this assumption from a quantitative perspective was provided by the 'Hidden Figures Test' and the 'Conceptual Style Test'. Both measures may be considered to explore different, but complementary, aspects of cognitive style.

(i) Hidden Figures Test (Ekstrom, French & Harman, 1976). The Hidden Figures Test was taken from the Kit of Factor-Referenced Cognitive Tests (Ekstrom et al, 1976) and, although primarily a test of Thurstone's factor 'flexibility of closure', this version of the test was developed as part of a study of field-independence, and a number of studies have shown that a close relationship exists between these two 'constructs' (Gardner, Jackson & Messick, 1960: Witkin, Dyk, Paterson, Goodenough & Karp, 1962).

The field independent-field dependent dimension may be considered to be one of at least nine dimensions to be found under the term 'cognitive style' Messick, 1970). It has been extensively described and researched by Witkin and various associates (1962; 1971; 1977; 1981), and is essentially a bipolar continuum from field independent, where a person is able to 'focus' on a single component in a complex field without being distracted, to field dependent, where the surrounding complex field influences the perception of the person such that a single component in the field may not be recognised.

This dimension emerged from the literature survey as being one which discriminated between the sexes after the beginning of adolescence (Maccoby & Jacklin, 1974), the period of time when the IEA studies (Comber & Keeves, 1973) show the disparity between the sexes on measures of science attainment to increase. If Harker's (1976) suggestion that this dimension reflects the extent of an analytic ability - an important component in scientific thinking - is tenable, a partial answer to the research question would be suggested. In particular, the use of the Hidden Figures Tests provided for an examination of the suggestion that a field independent person may prefer to use fewer personal constructs, than might a field dependent person. That is, a qualitative assessment appeared possible with this measure.

The Hidden Figures Test is a group administered test which assesses the ability to see simple figures in complex designs. The test consists of two parts. Each part requires the subject to locate one of five simple figures in as many of the 16 complex designs as he/she can in 12 minutes. The score is the sum of the correctly identified figures. An example of this test is given in Appendix 3.11

The investigator administered the test to each class during normal school time and subsequently scored and coded the responses for computer analyses.

(ii) The Conceptual Style Test (Kagan, Moss & Sigel, 1963). This measure appeared to offer a way of ascertaining how individuals actually used their personal constructs and thus, provided a complementary perspective to that provided by the Hidden Figures Test which appeared to focus primarily on the structure of personal constructs systems.

The Conceptual Style Test (Appendix 3.12) provided the situation in which groups of three stimulus pictures (triads) were presented in booklets to the students who were instructed to select two from each group which "are alike or go together in some way" and to record the reason(s) for their choice on a pre-prepared response sheet. Thus, 'conceptual style' may be defined as the preferred mode of categorisation in a situation where alternatives are possible (Sigel, Jarman & Hanessian, 1967).

The 'mode of categorisation' was indicated by the written responses and classified according to the scoring criteria adapted from Kagan, Moss and Sigel (1963) by Archer (1970).

These criteria may be found in Appendix 3.13. The resulting three scores were separately summed to give a measure for each of the categories: 'descriptive', 'categorical', and 'relational'.

The set of 25 triads were those used by Archer (1970) and Harker (1976) so as to facilitate inter-study comparisons. The test was administered to each class during normal school time by the investigator who also categorised the responses collaboratively with a graduate student to ensure consistency of scoring. Each respondent's score on each of the three categories of conceptual style was recorded separately.

(d) Test of Intellectual Achievement Responsibility (Crandall, Katkovsky & Crandall, 1965). This test provides a scale for assessing students' beliefs that they, rather than other people, are responsible for their intellectual-academic successes and failures. That is, the test provides a measure of perceived 'locus of control' (refer Section 2.2.2c) in an intellectual-academic context and it was selected to provide another perspective on, and further quantification of an aspect of, the possible social influences on student behaviour as suggested by Ajzen and Fishbein's (1980) Theory of Reasoned Action.

The possible importance of the locus of control dimension for this study was noted during the literature survey which revealed consistent sex and ethnic differences on it. For example, the Coleman Report (Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld & York, 1966), based on a large-scale study of United States children, suggested differences shown by minority groups (read ethnic) on this dimension could be very significant for academic achievement. This report concluded:

> "A pupil attitude factor, which appears to have a stronger relationship to achievement than do all the "school" factors together, is the extent to which an individual feels that he has some control over his own destiny ... The responses ... show that minority pupils, except for Orientals, have far less conviction than whites that they can affect their own environment and futures."
>
> (Coleman, et al, 1966:23)

Support for this viewpoint has been strong (see Phares, 1976; Bar-Tal & Bar-Zohar, 1977, for literature reviews on the relationship between perception of locus of control and academic achievement).

Therefore, it was anticipated that _if_ students' personal construct systems showed they tended to perceive the study of science as particularly academic, and _if_ students' loci of control did play an important role as mediators of academic behaviour, an investigation of their locus of control beliefs might well provide yet another insight into their outlooks on science - particularly if sex and ethnic differences were evident on this dimension. Furthermore, it was anticipated the TRA analyses would provide for possible identification of specific social groups perceived by students with high _external_ loci of control as influencing their intentions to study, or not to study science beyond F4.

Several scales have been developed to measure locus of control orientation (e.g. Crandall, Katkovsky & Crandall, 1965; Rotter, 1966; Levenson, 1972) but the Crandall et al (1965) measure was chosen for this study because it was readily available; it appeared to have been carefully designed and trialled; and it had generated a considerable body of published research against which the findings of this current study could be examined.

It consists of 34 forced-choice items. Each stem describes either a positive or a negative achievement which regularly occurs in students' daily lives. This stem is followed by one alternative stating that the event was caused by the student and another stating that the event occurred because of the behaviour of someone else in the student's immediate environment (Appendix 3.14). An equal number of positive and negative events are provided and the scale is so constructed that, in addition to a total I (internal or self) responsibility scores, separate subscores may be obtained for beliefs in internal responsibility for successes (I+ score) and for failures (I- score). Thus, a student's I+ score is obtained by summing the positive-event items; a student's I- score is obtained by summing the negative-event items; and his/her total I score is the sum of his/her I+ and I- subscores.

For comparable samples, the reliabilities of the two subscales for the IAR are reported by Crandall et al as .66 for I+, .74 for I-, and .69 for total I. In order to obtain more appropriate reliability measures for the current study, a test-retest procedure (with four classes, one each of Forms 1, 2, 3 and 4, tested twice over an interval of between three and four weeks) gave reliability coefficients (N=108) I+ = .57; I- = .68; total I = .63.

Minor alterations to four items of the published version (Crandall et al, 1965) were made to remove American expressions (e.g. "If a teacher passes you to the next grade ..." became "If a teacher moves you to the next higher class or form ...") by the investigator to remove possible response uncertainty.

The test was administered to each class by the investigator during regular class times. Each student was given a questionnaire booklet and a separate response sheet. The instructions on the front cover of the booklet were read to the class by the investigator, as was each item (to minimise possible reading difficulties) and the students encouraged to work at a common rate. After completion, the test was marked by the investigator and the I+, I- and total I scores recorded.

(d) Other measures. Where possible, measures derived by the schools, such as the New Zealand Standardised Achievement Test (PAT) scores (reading, listening, mathematics, study skills), 'intelligence' scores (e.g. Otis; Raven's Progressive Matrices), teacher-constructed test results, and school examination marks, were collected to assist in providing the investigator with as complete a scholastic profile of each class (and student) as possible in the time available. However, these data were not to be included in the statistical analyses because they were not uniformly available from each school, and where available from different schools, the wide variation in administration, testing, and scoring conditions associated with each reduced the confidence that could be accorded them.

For the purpose of a statistical analysis of the general question of possible sex and ethnic differences, two broad hypotheses were framed in the null form:

Hypothesis 1: No sex differences will be found on the
(a) Science measure
(b) Test of Scholastic Ability
(c) Hidden Figures Test
(d) Conceptual Style Test and the
(e) Test of Intellectual Achievement Responsibility.

Hypothesis 2: No ethnic differences will be found on any of the above measures.

3.3.2 The individual interviews with students

Once the students had been chosen for this phase of the study and their, and their guardians', agreement obtained, an initial interview with each individual was made to obtain general background data such as parents' names and occupation(s), data on siblings, family position, student's interests and vocational aspirations, 'favourite' school subjects, etc, (the 'Background Data Sheet' is included in Appendix 3.15). The purpose of this initial interview was also to arrange times for future interviews (each secondary school student was asked to provide the investigator with a copy of their personal school timetable); to fully explain the nature and purpose of these subsequent interviews; and to begin developing a rapport between the student and the investigator.

Each interview was conducted away from the student's class in a separate room (such as a laboratory preparation room, an 'interview' room, the staff-room, an unused classroom and, occasionally, out-of-doors) with an audio tape recorder running.

The emphasis in these interviews was to develop 'conversations' (Thomas & Harri-Augstein, 1977) based around the repertory grid technique.

(a) Elicitation of constructs. Each student was interviewed individually about his/her responses to each of the ten Likert-type statements given with the Science Questionnaire. Each interview was audio-taped and later transcribed. The transcriptions were scrutinised and the personal constructs used were listed. The individual lists consisted of between eight and fifteen bipolar constructs; some of which were supplied by the investigator where the existence of implicit, unstated constructs were suggested (e.g. "More for Maori kids/more for Pakeha kids").

(b) Elements consisted of the various school subjects studied by each student; a selection from his/her main 'hobbies', interests, sports, vocational interests (where known) and occasionally, a stereotyped adult role (e.g. 'being a housewife', or 'doing Dad's job').

(c) Grid completion. Each element was written on a small card, together with an identifying alphabetical character, and the entire set of elements, in random order, was given to the student. A wooden 'rule', 1 metre in length, with a one-to-five scale clearly marked on it, was positioned on the desk in front of the student. This rule had provision for placing each construct pole (also written on a card) and the qualifiers 'very', 'fairly', and 'inbetween' on it.

In random order, each construct was displayed on the rule and the student instructed to place each element card in front of the rating he/she considered to be most appropriate to it. On completing this task for each construct, the student read aloud the identifying character corresponding to each element and rating to enable the investigator to record the student's judgement of a prepared blank response sheet (Appendix 3.3).

The administration of the grid was completed by asking the student to suggest any other constructs that could have been used. When these were suggested, construct cards were prepared and added to the grid. The triadic approach suggested originally by Kelly (1955) and often used by others, was found to be too time consuming and often produced trite or superficial constructs of doubtful utiltity and so was not adopted by this investigator.

(d) Grid analysis. The data from each grid were computer analysed using INGRID (Slater, 1977. See Section 3.1.2b). The construct and element loadings on each of the first three (and occasionally the first four) principal components were recorded in order to provide the requisite co-ordinates for locating the position of each element, and one pole of each construct, in three dimensional space.

(e) The Kitset Model. In order to provide for greater insight into each student's personal construct system, and to enable the students the opportunity to comment on the analyses, a portable kitset was constructed by the investigator which allowed for convenient construction of a 'model' of each individual student's personal construct system.

Basically, the kitset contained two sets of small plastic spheres (12mm diameter), each set of a different colour, to represent the set of elements, and the set of construct poles. Each sphere was marked with an appropriate character (an alphabetical character for the elements, and a numerical character for the construct poles) and drilled to accommodate the end of a single length of wire (20SWG). A set of pre-determined lengths of wires, corresponding in length to the possible range of loadings on the third component, was located in one half of the kitset carrying case (alongwith the plastic spheres). The other half of the carrying case comprised the baseboard made of 'particle-board' and drawn up as a two-dimensional graph to accommodate the loadings on the first and second components. This 'particle-board' base was soft enough to readily allow for holes to be made in it with a needle, and yet, firm enough to support the wire lengths each topped with a plastic sphere. Appendix 3.16 gives an illustration of the kitset model.

The students were interviewed individually with 'their' constructed model before them and their responses to it audio-taped. The investigator's initial comment was, "I've made this model up from what you've told me on previous visits and how you shuffled those bits of card-board around last time I saw you. But I'm not sure if this is my model, or is it really yours, so I want you to carefully criticise it."

Their attention was then directed to the element spheres ("The yellow ones") and the identity of each established with reference to the original completed grid response sheet and the explanation given that 'those which are close together might appear to you to be similar to each other in some way, but those which are widely separated, might appear to be quite different', and the students was asked to explain why this might be, or not be, so. On completing an examination of the elements, attention was drawn to the construct poles (these corresponded to those on the right-hand side of the grid response sheet) and the discussion continued. This allowed for the verification of previously elicited constructs and the elicitation of those previously unexpressed, as well as the identification of any elements or construct poles anomalously positioned.

The discussion was then directed to exploring yet other constructs, usually higher order constructs (i.e. 'superordinate constructs'), which may be applicable, as well as other elements. Likewise, some of the original constructs and elements were able to be discarded from this developed discussion when their saliency was found to be low. In some cases, a second grid (and occasionally, a third grid) was composed, analysed, and discussed during a subsequent interview.

As these individual interviews with the students were conducted, it became apparent to the investigator that much of what was being revealed by the conversations during the repertory grid formation and on the kitset construct models had hitherto never been expressed nor even recognised by the students. Many ideas, expressions and beliefs appeared to be largely intuitive and previously sublingual. They seemed possibly to have originated from the student's own parents' beliefs and values. That is, the students' outlooks on science being articulated in these conversations, appeared to have developed beyond the students' school experiences. Thus, it became imperative that the possible origin of such outlooks be explored by seeking contact with the students' parents.

3.3.3 Interviews with the students' parents.

A letter (see Appendix 3.17) was sent to the parents of each student still within the the individual-interview sample at this time giving a brief explanation of the purpose of the proposed visit and notification that the writer would make telephone contact to confirm acceptance, or otherwise, of the proposal and to arrange a meeting time. Eighty seven percent of the parents agreed to and kept the appointments so arranged.

In all cases, the meetings were held in the family home usually in the evening, or during the weekend. Each meeting usually lasted about an hour, with the range being between about 45 minutes and 4 hours (!).

An attempt was made in these informal, unstructured interviews to reveal the parents' attitudes and beliefs about schooling in general, and about science in particular. Also, information was sought on the degree of support given to their children's school-work; sex differentiation in rearing their children; and beliefs about the degree of control they felt they had in determining the outcomes of their lives. That is, as well as exploring the possible origins of the students' outlooks on science, an attempt was made to obtain insights into the possible origin of particular 'conceptual styles' and 'locus of control' beliefs as revealed by the initial class measures. All interviews with the students' parents were audio-taped for later transcription and analysis.

3.3.4 The development of the TRA questionnaires.

The data for the TRA analyses were produced by a questionnaire designed to provide values for each of the various factors shown in Figure 3.1. In this study, the development of this questionnaire occurred in two stages; an open-ended 'preliminary' stage, and a 'closed' final stage.

(a) Stage one - the preliminary questionnaire. This first stage sought to collect a variety of student-held beliefs ('objective' and 'social') about the three branches of science usually taught in New Zealand secondary schools (biology, chemistry and physics) and about the influence of significant others in their school science subject choice by providing a sample of 111 F4 and F5 students (none of whom had been previously associated with any aspect of this study) with an open-ended questionnaire (see Appendix 3.18).

For example, question one asked, "What are the advantages, for you personally, in studying science in the Fifth form?" Question six asked, "What are the reasons why you might not want to study Chemistry in the Sixth form?" Question nine directed the students to "Think hard about the people, or groups of people, who are most important to you in your life (perhaps relations, friends, teachers, possible employers, etc). List those who you believe would think science is an important subject for you to study."

The responses to this preliminary, stage one questionnaire were categorised and used to provide the items for the final, stage two, closed-format questionnaire.

(b) Stage two - the final questionnaire. Two parallel questionnaire forms were developed; one for use with F4 students and one for F5 students. This parallelism enabled questionnaires to be responded to by not only the classes in the initial class surveys (conducted during the previous academic year), but more particularly because it was felt that it was at these form levels that real, personally meaningful decisions about next year's school science subject options were being made and that more valid responses could be expected. However, the results of only the F4 version are provided in full in the text of this thesis; the F5 results will be provided in Appendix 6.5.

The final 'Science Attitude Questionnaires' (SAQ4 and SAQ5, for the F4 and F5 respectively) so developed, were presented with two parts, Section A and Section B. Each item within Section A provided data for a particular component of the TRA model (see Appendix 3.21) and followed the general format of the sample questionnaire provided by Ajzen and Fishbein (1980). A 5-point Likert scale response was required for each item.

Each response to each item was scored on a one-to-five basis and entered into a computer file for subsequent linear transformation to provide the composite measures for each TRA model component. The transformations used with both questionnaires may be found in Appendix 3.19.

Section B of the SAQs was provided to obtain other quantitative data on:

(i) how likely it is that any science option would be studied in F6, with reasons,

(ii) what careers the students had in mind (if any),

(iii) who, or what, helped the students with their choice of subjects,

(iv) the subjects the students perceived to be most important in the following year.

These data were sought to provide additional, broad-based material to help provide a more comprehensive overview of the context in which students' outlooks on science were held.

3.4 Summary

To provide the investigation with a theoretical basis (Guba, 1978), Personal Construct Psychology (Kelly, 1955) was chosen because of its comprehensiveness (Bruner, 1956), its recent application in science education research (Pope, 1981c; Watts, 1981), its emphasis on the individual, and for its provision of a technique - the repertory grid - for exploring <u>individual students'</u> outlooks on science.

A second theoretical perspective, that provided by the Theory of

Reasoned Action (Ajzen & Fishbein, 1980), was used because of its emphasis on both attitudinal and social components of students' intentions to study, or not to study, science in subsequent years. This second approach also provided an instrumental technique (the questionnaire), but one which focussed on groups of students' intentions. Therefore, as such, it was seen to complement, rather than compete with, the PCP perspective.

Finally, because the literature survey indicated several mechanisms which could contribute to an explanation for the under-representation of girls, and of Maori and Pacific Island students, in the sciences, the opportunity was taken to explore four of these (field independence, conceptual style, locus of control, and scholastic ability) using an empirical, quantitative approach.

Thus, it was hoped the combination of individual and group, idiographic and nomothetic, qualitative and quantitative, theoretical and instrumental, approaches would provide for a comprehensive analysis of the research question.

CHAPTER FOUR - TWO CASE STUDIES ILLUSTRATIVE OF THE REPERTORY GRID METHOD

The repertory grid technique is essentially idiographic and the condensing of information into summary form, which is necessary before even tentative generalisations can be made, does not do justice to its richness. To illustrate this richness, only two studies will be presented in the interests of brevity.

These case studies, one of a European F1 girl (Leanne), the other of a Maori girl (Aroha), were chosen for the girls' representativeness of their sex, age, and ethnicity on most of the empirical measures in the class surveys (refer Appendix 3.4). However, the repertory grid analyses revealed their outlooks on science to be very different from each other. Therefore, these particular case studies not only illustrate aspects of the repertory grid technique but also, in revealing the influence of social factors, highlight the importance of the outlooks on science held by significant people in the students' lives.

<u>Note</u>. Although the students in all the individual interviews were chosen initially from F1 to F4 inclusively, the development of the repertory grids and the interviews with parents were carried out in the first school term of the following year when each student had moved up one form. All demographic data cited are those collected at the commencement of the study.

4.1 Leanne

Leanne, aged 12.5 years, was the second of two adopted children in her family - her older brother was in F3. Her father was a mechanic for a large motor company and her mother worked as an office clerk in the same company. Leanne's F2 teacher described her as:

> "She's a bit of a busy-body! At times she gets a bit funny, like most of us females (laughs)! She soon gets over it - she's (got) a cliquey group of friends and tends to be led a bit by them - no I guess she's pretty influential - oh - I'd put them all on a par. She's a likeable kid ... pretty average - she'll do okay in life - not brilliant, not by a long shot - just typical of that sort of girl."
>
> (F2 teacher - middle aged, female)

Table 4.1: Leanne's elements and constructs used in the repertory grid analysis.

Elements		Constructs*	
A.	Hairdressing job	1.	I dislike
B.	Doing science	2.	I find easy to understand
C.	Working with computers	3.	I find enjoyable
D.	Reading books	4.	Is encouraged by my parents
E.	Studying animals	5.	What Mum is not interested in
F.	Playing netball	6.	I know nothing about
G.	Watching TV	7.	What Dad is (or might be) interested in
H.	Doing homework	8.	Is important
I.	Reading comics	9.	I think is a girl's thing
J.	Studying plants	10.	What I am not (or won't be) good at
K.	Doing office work	11.	Usually for kids
L.	Studying insects	12.	Don't talk about at home
M.	Doing maths		
N.	Doing a science job		
O.	Drawing		
P.	Doing jig-saw puzzles		

* Only the right-hand poles are provided above but the contrast pole was always identified in the formation of the raw grids with the students, and the orientation of each construct was entirely arbitrary. That is, either pole of each construct could just have easily been used as the 'emergent' pole.

Leanne expressed interest in doing jig-saw puzzles, drawing and playing netball. She claimed science to be her most difficult subject and languages (Maori and French were taught in 'cultural' periods run one hour each per week within the school). Table 4.1 gives the elements obtained in the initial interviews and the right hand poles of the constructs used in the formation of Leanne's repertory grid.

The raw grid was analysed as described earlier and the kitset model, depicting the element and construct loadings on the first three principal components simultaneously, was presented to Leanne. Graphical representations of these loadings are shown in Figure 4.1.

4.1.1 Construct analyses

Table 4.2 provides the means and variations of Leanne's constructs. The low proportion of total variation recorded by constructs 1,4,8,9,10 and 12 indicated these did not discriminate markedly between the elements. For example, the 'high' mean of 3.7 for construct 4 revealed that Leanne perceived most of the elements to be encouraged by her parents (element C 'working with computers' was the notable exception). Similar interpretations may be applied to the other constructs with low variation and a mean displaced from the mid-point. Note: the arbitrary left-right orientation of the construct poles influenced the direction of this displacement.

Thus, Leanne perceived most of the elements to be 'likeable' (construct 1); to be those which she considered herself to be reasonably good at (construct 10); but which were not discussed much at home (construct 12). The mid-range means on constructs 8 and 9 suggest Leanne perceived the elements to be neither particularly important nor particularly unimportant, nor had she perceived them as having any particular association with either sex. An alternative interpretation of the significance of a mid-point mean is that Leanne may have found the constructs not to apply well to the set of elements - the elements may have fallen outside the 'range of convenience' (Kelly, 1955) of the constructs.

Table 4.2: Leanne's construct means and variation

Construct	mean	variation	as percent
1. dislike	2.6	11.9	4.9
2. easy	3.6	25.8	10.5
3. enjoyable	3.6	25.8	10.5
4. encouraged by parents	3.7	13.4	5.5
5. mum not interested	3.3	31.4	12.8
6. know nothing about	2.7	27.4	11.2
7. dad interested	2.3	29.0	11.8
8. unimportant	2.9	16.9	6.9
9. girl's thing	3.0	2.0	0.8
10. I'm not good at	2.3	21.0	8.5
11. for kids	3.1	29.8	12.1
12. don't talk about at home	3.3	11.4	4.7

Constructs 5, 11 and 6, show the greatest variation and suggest Leanne's perception of her parents' interests (constructs 5 and 7), her perceptions of different activities usually performed by children and adults (construct 11), and her perceptions of her own knowledge (construct 6), were the most powerful discriminatory dimensions in her personal construct system.

Table 4.3: Correlations between Leanne's constructs

CONSTRUCT	2	3	4	5	6	7	8	9	10	11	12
1 I Dislike	-0.7**	-0.8**	-0.2	.3	.5	.2	-0.2	-0.2	.7**	-0.1	0
2 I find easy to understand		.9**	.5	-0.2	-0.6*	.2	.3	.6	-0.8**	.4	0
3 I find enjoyable			.4	-0.2	-0.6*	.2	.2	.4	-0.8**	.3	-0.1
4 Is encouraged by my parents				-0.3	-0.5	.3	-0.3	.4	-0.4	.5	-0.4
5 What Mum is not interested in					.4	0	.4	-0.1	.5	-0.1	.4
6 I know nothing about						-0.1	.1	-0.4	.7**	-0.7**	.7**
7 What Dad is (might be) interested in							-0.1	-0.3	-0.2	.1	-0.1
8 I think is unimportant								0	0	.1	.7**
9 I think is a girl's thing									-0.5	.3	0
10 What I am not (or won't be) good at										-0.3	.2
11 Usually for kids											-0.5
12 Don't talk about at home											

For two-tailed tests of significance * = $p < 0.05$
** = $p < 0.01$
df = 10

The redundancy in Leanne's personal construct system is reflected in the high correlations between several constructs (Table 4.3). For example, a major cluster consists of constructs 1 ('I like/dislike'), 2 ('I find easy/hard to understand'), 3 ('I find boring/unenjoyable'), 6 ('I know a lot/nothing about') and 10 ('What I am/am not good at'). Other than several pairing of constructs (e.g. 6 and 12 - 'I know a lot/nothing about', and 'Do/do not talk about at home'; and 4 and 11 - 'Is not/is encouraged by my parents' and 'Usually for adults/kids') most remaining constructs were relatively independent of each other.

4.1.2 Element analyses

Table 4.4 presents the sums, the sum of the squares, and the sum of squares as percentages of the total variation for Leanne's elements. The most salient element in Leanne's grid is readily identifiable from this table as C - 'working with computers', and it was distanced markedly from any other element (see also Table 4.5). A possible explanation could be found in terms of 'sibling rivalry' - Leanne appeared not to want to be closely identified with her elder brother:

Leanne	He likes science a lot, and that. He wants - he likes computers - he likes working with computers, and they've got a computer at the school and he goes over there after school - and he's got his own programme and that. He likes computer games, just that sort of thing.
I	Would that interest you?
Leanne	No, not really. Cos I don't know about them.

The least salient elements were L ('studying insects'), E ('studying animals'), and J ('studying plants'). That these elements should be those usually associated with aspects of school science is worthy of note. Thus, from this analysis, it would appear that Leanne was indifferent to these 'science' elements - at the time the raw grid was constructed she had not developed clearly determined responses to them. It would be conjectured that because of her 'indeterminancy' with respect to these elements, their positioning in her personal construct system would be shown to vary in subsequent grid analyses.

Table 4.4: Leanne's element measurements

Element	Total	Sum of squares	As per cent
A	-1.70	0.68	5.7
B	-0.09	0.62	5.1
C	-0.05	2.24	18.6
D	-0.56	1.05	8.8
E	-0.76	0.19	1.6
F	1.59	0.83	6.9
G	-0.41	0.56	4.6
H	-0.53	0.77	6.4
I	1.31	0.61	5.1
J	-0.12	0.27	2.2
K	-0.66	0.96	8.0
L	-0.47	0.18	1.5
M	0.02	0.34	2.8
N	1.88	0.98	8.2
O	1.10	0.79	6.6
P	-0.56	0.95	8.0

An examination of Table 4.5 reveals element B ('doing science') was seen by Leanne to be relatively closely associated with E ('studying animals'), H ('doing homework'), J ('studying plants'), L ('studying insects') and M ('doing maths'). Element N ('doing a science job') was not perceived by her as being particularly close to any other element - the closest being I ('reading comics')!

Table 4.5 : Standardised distances between Leanne's elements

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	1.1	1.6	1.0	.7	1.0	.7	1.0	.9	.8	1.0	.8	.9	1.0	1.0	.8
B		.9	1.0	.7	1.0	1.0	.8	1.1	.5	.9	.6	.7	1.1	1.2	1.3
C			1.7	1.1	1.7	1.6	1.5	1.5	1.0	1.1	1.1	1.3	1.3	1.7	1.8
D				1.0	1.2	.7	.8	1.1	1.1	1.3	1.0	.6	1.3	.9	1.1
E					.9	.8	.7	.9	.4	.7	.2	.6	.9	.9	.8
F						.9	1.0	.7	.8	1.1	.8	1.0	1.0	.9	.9
G							1.0	.7	.9	1.2	.8	.8	1.0	.6	.7
H								1.1	.8	1.2	.7	.6	1.4	1.0	1.0
I									.8	1.2	.9	1.0	.9	.4	.7
J										.8	.3	.7	.9	1.0	1.1
K											.7	.9	.9	1.4	1.3
L												.6	.9	1.0	.9
M													1.0	.9	1.0
N														1.1	1.2
O															.7
P															

4.1.3 Component analyses

The first three components extracted by the principal components analysis accounted for 72% of the total variance (this proportion accords with Slater's 1977 observations). See Table 4.6 and Figure 4.1.

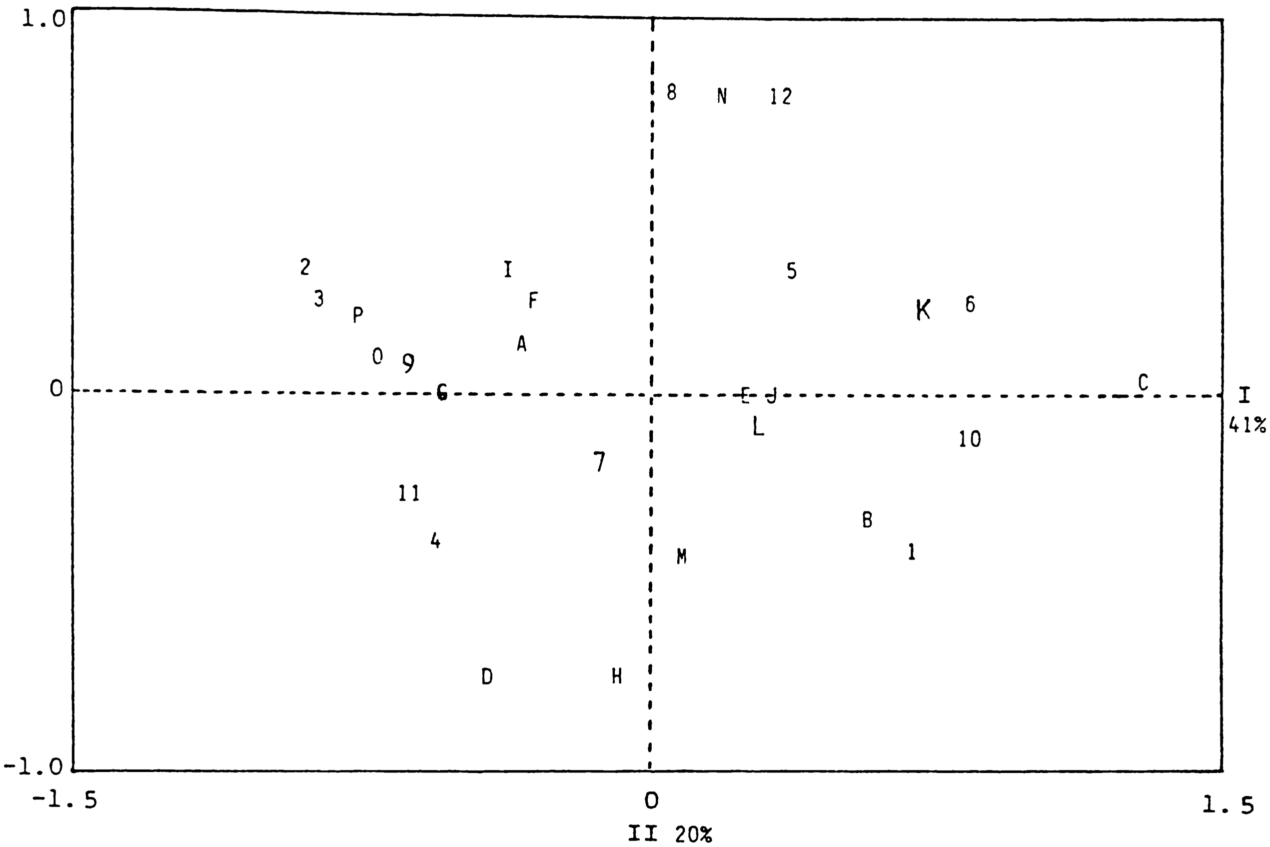
Table 4.6: The first four latent roots of the principal components of the variation recorded in Leanne's grid.

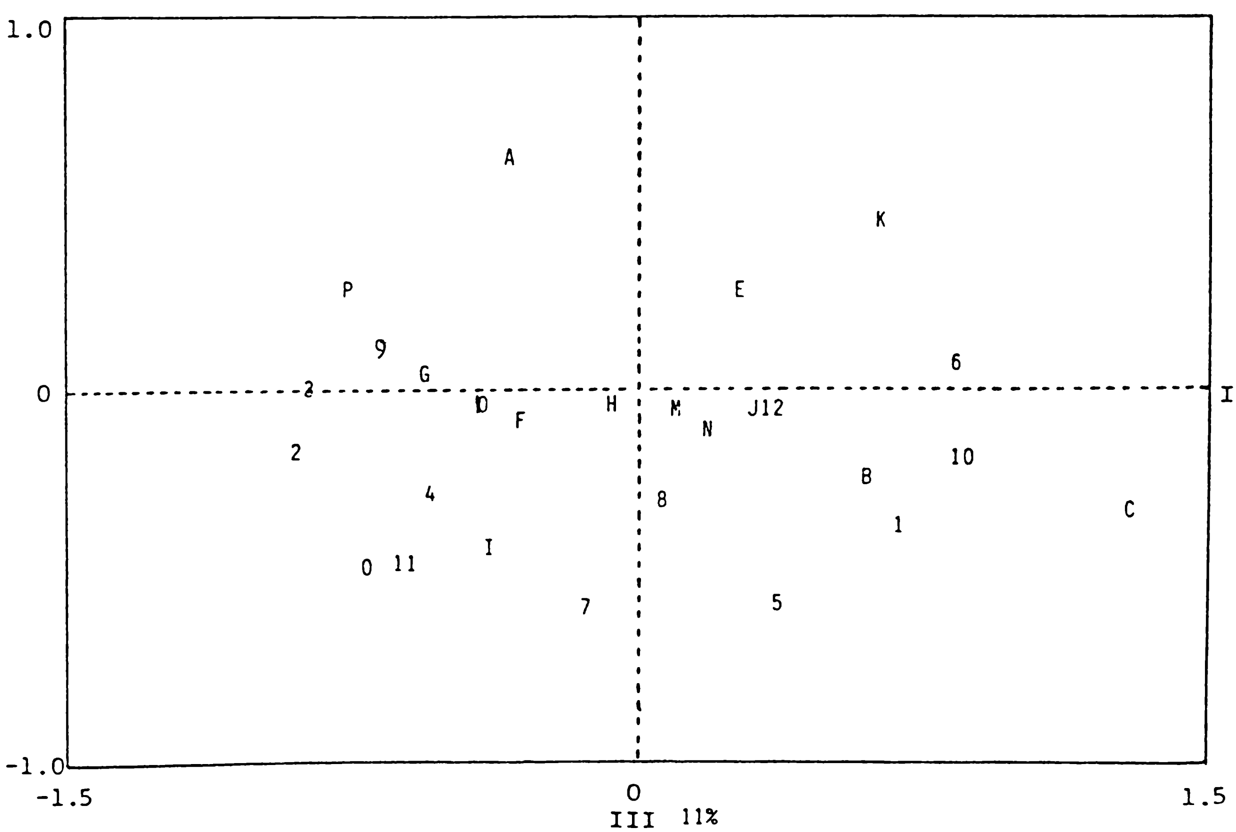
Component	Root	As a percentage of the total variation
1	5.0	41
2	2.4	20
3	1.3	11
4	1.2	10

The several constructs (1,2,3,6 & 10) which correlated highly with each other (see Table 4.3 above), and the saliency of elements C ('working with computers'), O ('drawing') and P ('doing jig-saw puzzles') have influenced the positioning of the first component (this component accounted for 41% of the total variance). The constructs reflected a composite of an affective dimension ('I like/dislike'; 'I find boring/enjoyable') and a perceived difficulty dimension ('I find easy/hard to understand'; 'What I am/am not good at').

The second component (20% of the total variance), with high loadings on it from constructs 8 ('I think is important/unimportant') and 12 ('What we do/don't talk about at home'); a positive loading from element N ('doing a science job'); and negative loadings from elements D ('reading a book') and H ('doing homework'), identif it as being a value dimension. That is, elements with the greatest

Figure 4.1: The dispersion of Leanne's elements and constructs in component space as represented by the first three components





perceived value are positioned to the bottom of the upper graph in Figure 4.1. Leanne's value perceptions were obviously influenced by the values expressed at home:

Leanne "I'm always getting told to read more and do my homework."

The <u>third component</u> (11% of the variance) reflected a 'child/adult' dimension. Constructs 5 ('What Mum is/is not interested in'), 7 ('What Dad is/is not interested in'), 11 ('Usually for kids/adults') and, to a lesser degree, construct 4 ('Is/is not encouraged by my parents'), influenced this component, as did elements A ('hairdressing job'), K ('doing an office job'), O ('drawing'), and I ('reading comics').

The positioning of the science-related elements was such that B ('doing science') was perceived as not being particularly liked and somewhat difficult. It was something which would (or might) be of interest to 'Dad' but not to 'Mum'. Leanne perceived it as being relatively closely associated with 'studying animals' (E), 'doing homework' (H), 'studying plants' (J), 'studying insects (L) and 'doing maths (M). 'Doing a science job' (N) was not perceived as being particularly close to any other element, but was particularly associated with the emergent construct poles of 12 ('What we <u>don't</u> talk about at home') and 8 ('Things that are <u>un</u>important').

Leanne I don't like science all that much.
I Hmmm, what sorts of jobs need to have science?
Leanne Um - no quite sure - if you want to be a - if you want to learn more about computers, or something like that. If you - I don't know really.

I	Do you need to know much about science just for everyday living outside the job scene?
Leanne	No, not really - I don't think so.

These comments corroborated the positioning of construct 6 ('I know a lot/nothing about'), particularly with respect to elements B ('doing science') and C ('working with computers') - this construct and these elements all load high on the first component and illustrate a possible interpretation of the phenomenon under investigation: a paucity of early science experiences may predispose an individual to develop negative attitudes towards actual, or possible, subsequent like experiences. If girls' sex-role socialisation patterns, rather than boys', lack these early science experiences, then girls will be more 'at risk' than boys in this regard. That is, when events are perceived to be beyond the range of convenience of one's construct system (such as when adequate constructs are not available), anxiety occurs (Kelly, 1955) and this anxiety may be expressed as a 'negative' attitude toward the target experiences.

The following extracts from conversations with Leanne illustrate this possibility. The first came from an earlier interview when the discussion explored her response to watching TV science programmes:

I	Okay, what is it that you don't like about some of the science programmes?
Leanne	Boring, usually, to me.
I	And what makes them boring?
Leanne	Probably because I don't know much about them.

And the second illustration arose from the discussion concerning the positioning of construct 9 ('I think is a girl's/boy's thing'):

I	And working with computers, that the boy's thing? ... So that makes good sense?
Leanne	Yeah.
I	Why do you say that? Why do you think that science is slightly more for boys than girls?
Leanne	I don't know, except boys like mucking around with things and fixing things, and sort of because my brother is interested in computers, and science, and that.
I	I see. Does that put you off an interest in science yourself, because you think it's a boy's thing?
Leanne	No.
I	No? You can still see that you could follow it through?
Leanne	Yeah, if I wanted to.
I	If you wanted to, but you don't really want to?
Leanne	No
I	Why not?
Leanne	I don't think it would interest me.

Leanne's belief that she did not know much science must be viewed within the context of her school experience. Her F1 teacher was responsible for all the F1 science in the intermediate school and, although very enthusiastic, he was perceived by this observer to be over-confident and very domineering in his relationships with his students. He tended to 'brow-beat' them by such as constantly firing a series of scientific 'facts' at them during any class period, irrespective of the particular lesson topic being presented! It is possible that even though Leanne may well have been exposed to more school 'science' than had many comparably aged students, she still felt her knowledge to be inadequate alongside that of her male peers and her F1 male teacher, and that an intuitive male-science association developed at this time. This association would have been reinforced by her brother's expressed interest in science; her perception of her father's interest; and her mother's lack of interest. It is also possible that a degree of antagonism had developed between Leanne and her F1 teacher and, in rejecting him, she tended to reject his values too - such as rejecting of his placing an obvious value on the importance of studying science. This rejection would not have been challenged by her current (F2) female teacher who openly professed:

> F2 Teacher "I know nothing about science and I'm too old to start learning about it now. The kids'll get all the science they'll need next year across at the high school."

Leanne's parents felt they were unable to give any guidance in science and probably had communicated their own value perceptions of science to Leanne:

I	Have you felt that maybe you've been handicapped by not having more science?
Father	Oh, I'm not fully aware of what science, you know, how big a field science covers now. I don't know about science but, you know, education in general, I would've been better possibly to have stayed on at school longer and that sort of thing. But with regard to science, I don't know ...
Mother	Oh, my concept of science at school was where we had two periods a week and that was in the laboratory and that was it. You know, I sort of - I work in an office so, you know, I suppose I don't really - I don't really know whether - I don't really know what field science covers, really.

Leanne's father, perhaps inadvertently, nicely expressed his own sex role stereotypic perception of science when asked to rank the school subjects in order of importance - he placed science third behind mathematics and English:

I	And what about science then? Coming back to that again, why would you put that third?
Father	Well, expecially for a boy, I think, possibly science will possibly come into, you know, into jobs - well science covers a pretty big field doesn't it? And if, you know, different parts of it, could be associated with it quite a bit.
I	You mentioned 'especially for a boy', why that?
Mother	(laughing) I was going to pick him up on that one!
Father	But there again, I think it's possibly the - you think of, you know, science is more - you think of as a boy being involved in it more than a girl. But then, nowadays it's - girls and that, you know, are getting into more.

Both parents perceived science as being a particularly academic subject to be taken only by the most intelligent students:

I	So you've passed comment there that it would be a brainier person (who would study science) - so you see science as being a fairly academic, or a fairly abstract sort of subject?
Mother	Yeah.
Father	Hmmm (affirmative).
Mother	Yes, somebody, as you say, the real, the bright - the brighter ones. I couldn't really see Leanne in that category, could you (turning to her husband)?
Father	Not at this stage.
Mother	No, to me, she's just an average student - I couldn't really see her going into depth into science, or anything like that.

Leanne's mother had a clear, but restricted, view of the kind of person a scientist may be:

I	What sorts of people become scientists?
Mother	You said 'scientists', you know, I sort of think of professors, or something like that.

Disregarding obvious media-influenced stereotyping, Leanne's own perception of scientists was not too dissimilar:

I	If you had to make up a story about a scientist, how would you describe that scientist?

Leanne	Someone who's crazy and does lots of weird things and usually - usually evil - sometimes - in the (TV) programmes, and that.
I	And is it usually male or female?
Leanne	Male usually.
I	Could it be female?
Leanne	Yeah.
I	... What sort of people become scientists? Let's say, what sort of kids become scientists? You think of some of your class mates.
Leanne	Usually kids that are pretty brainy and that.
I	Hmmm, do you think that you could become a scientist, if you wanted to?
Leanne	No.
I	No? Why not?
Leanne	I don't know.
I	Do you think you're brainy enough?
Leanne	(Shakes head).

Leanne's father commented several times about the way he candidly encouraged his son with scientific activities - these activities were supported by his wife:

I	You talk about your son being keen on electronics, and so on, is this something that he, perhaps, has picked up from your interests and hobbies?
Father	Well, we've always sort of, you know, had gadgets or that sort of thing. We've always - well we made up a board a few years ago - we had lights that he had working and electric aerials working and this sort of thing - you know, he's always been interested in the electrical side.
Mother	His father comes home and finds that he's wired up four speakers to a radio in the garage, and this sort of thing.
Father	Yes, anything that, you know, he can get in that is in that line I picked up an - we had a microfiche (reader) at work, it wasn't working and they were going to throw it out so I grabbed that, the other week, and he's got that out in the shed and he's found out where the problem is and he's just got to fix that, and whether he can get any use out of it, but - it's quite a big one.
Mother	At least he can see how it works and what happens.

Support of a similar kind did not appear to have been offered to Leanne, possibly because:

Mother She wouldn't be - um - interested in learning how it all worked and that sort of thing - settling her mind to it, would she (turning to her husband)? She's sort of -

Father No, she'd -

Mother She can't sit down and figure things out, you know. She would probably not apply herself to anything like that.

It would not have been 'diplomatic' of the interviewer to suggest to the parents that perhaps they were not so concerned with providing Leanne with experiences which may challenge, develop, extend her skills of observation, exploration, problem solving, in 'things' scientific, as they appeared to be for their son. They appeared to accept Leanne's more passive behaviour in this field to an extent unlikely to have been accepted in Leanne's brother. The effects on the outlooks on science both their children would develop as a consequence of their parents' beliefs were not readily assessable but it is suggested they would be considerable.

4.1.4 Leanne's outlook on science

By the beginning of her F1 year Leanne had developed an outlook on science which included the following components:

- Science is boring
- Science is difficult and therefore studied only by 'brainy' people (and I am not brainy)
- Science is unimportant in my life (my parents and my current teacher would agree with me)
- My parents, brother, teachers (last year's and this year's) and my friends imply science is more for boys than for girls.

- I don't know much about science, I don't want to know much about science and, to be a hairdresser, I don't need to know much about science
- I don't know any scientists but I believe they are 'strange' people
- I have had only limited contact with science but I know I'm not good at it
- My parents don't encourage me to work hard at science the way they encourage me with my maths and reading
- I don't like doing science, I don't like reading science books and I don't like watching science programmes on TV
- I will probably stop studying science as soon as I can.

It may be suggested these components of Leanne's outlook on science developed in a particular social context which never, or rarely, identified the relevancy of science for people in their everyday world but, instead, nurtured the belief that science is an esoteric discipline of value to only a small group of people (intelligent males?) in society.

Leanne's TOSCA ranking (69th percentile) would indicate she was scholastically able to successfully study science and her Science Questionnaire score of -12 was close to the mean of all F1 students in the sample (x = -10.94). Also, her preferred 'conceptual style' was the 'descriptive' (with a score of 17; F1 mean = 8.9) - that which is now known as the 'analytic' style (Harker, 1976). However, Leanne did find the Hidden Figures Test, the measure of field independence, which was suggested (Section 3.3.1) might reflect an analytic ability, somewhat difficult and scored only 3 (compared with a F1 mean of 5.73).

Even before embarking on any secondary school level science studies, it seems that Leanne had developed a resistance to science which could lead her to discontinue with a study of it beyond the school core requirements - that is, beyond F4. Leanne's outlook on science, even though it had developed in an apparent ad hoc fashion, if not challenged and transformed, was going to be very influential in determining her future subject choices, her possible vocational plans and the nature of a wide set of subsequent beliefs and attitudes about science. Leanne appeared a likely science 'drop-out', even as a F1 student, who would contribute to the under-representation of girls in science in higher forms.

4.2 Aroha

The second illustrative case study is offered as a contrast to Leanne's. Aroha was a Maori girl whose outlook on science was such that, contrary to the norms for her sex and ethnicity, she was continuing with a study of science beyond F4 and intended to study it at tertiary level.

At the time of the individual interviews, Aroha was a fifteen year old F5 student at a rural co-educational high school studying six subjects for School Certificate (English, science, mathematics, technical drawing, art and, Maori). The first interview, based on her responses made at the end of the previous year to the ten statements from the third section of the Science Questionnaire, allowed for an initial exploration of her outlook on school in general:

- "I think a lot of my friends turn away from school because of their parents ... Some parents think that school is a waste of time and they don't encourage their kids to do their homework and try to work as hard as they can."

- "I find science programmes on TV quite interesting. Especially the David Attenborough, and things like that."

- "The only reason I'm taking science is so, next year, I can take physics to try and reach the goal of being an architect."

- "Science is one of those things that helps you understand more about your environment."

- "I think I can still keep up my Maori customs ... and preserve the culture and hand it down to my children."

- My parents want me to do well in school ... they encourage me to take science ... but most of the time they don't know what I'm talking about 'cos it's new to them."

Table 4.7: Aroha's elements and constructs

Elements		Constructs (right-hand poles only)	
A.	Studying physics	1.	Obscure - difficult to understand
B.	Studying chemistry	2.	Things I feel I do not need to know much about
C.	Studying biology		
D.	Working as an architect	3.	Things I find interesting
E.	Studying engineering	4.	Things that do not (or will not) help me in my life
F.	Studying woodwork		
G.	Studying tech drawing	5.	Things that challenge me
H.	The school system	6.	Things that are not encouraged by my parents
I.	Studying English		
J.	Studying mathematics	7.	Do contribute to an understanding of my own environment
K.	Working as a teacher		
L.	Studying Maori	8.	What I am not (or will not be) good at
M.	Studying art		
N.	Playing sport	9.	Contributes to our Maori culture
O.	Doing craftwork	10.	Things that are important
P.	Religion	11.	Things that most people think are feminine
		12.	Important from a religious viewpoint
		13.	Things that I consider are feminine
		14.	Things that do not help when relating to others

An analysis of the transcript of this interview provided an initial list of thirteen bi-polar constructs and several elements (e.g. 'Working as an architect'). Other elements were provided by taking her six School Certificate subjects (with 'Science' being split into the separate elements of biology, chemistry and, physics). See Table 4.7.

On completion of the raw grid (as outline above) Aroha suggested the sixteenth element 'religion' and the fourteenth construct 'Things that help/do not help when relating to others'. These were incorporated into the grid data and the completed grid analysed by INGRID.

4.2.1 Construct analyses

Table 4.8 provides the means and variations of the constructs.

Table 4.8: Aroha's construct means and variation

Construct	mean	variation	as per cent
1. difficult	2.3	27.0	13.1
2. needn't know	2.3	21.0	10.2
3. interesting	4.3	7.4	3.6
4. not helpful	2.0	16.0	7.8
5. challenging	4.5	8.0	3.9
6. not encouraged	2.1	31.8	15.5
7. environment	4.3	11.0	5.4
8. I'm not good at	2.5	24.0	11.7
9. Maori culture	4.3	7.4	3.6
10. important	4.0	16.0	5.8
11. feminine (others)	2.5	12.0	7.8
12. religious	4.1	2.9	1.4
13. feminine (self)	2.3	11.0	5.4
14. don't relate others	3.0	10.0	4.9

Constructs 3,5,7,9 and 12 have high means and little variation which reflected Aroha's high rating for all elements and that these constructs did not discriminate markedly between the elements. That is, Aroha believed all the elements were 'interesting' and 'challenging'; that they 'contributed to an understanding of her environment' and her 'Maori culture'; and that they were 'important from a religious viewpoint'. Construct 4, with its low mean, complements this cluster by indicating most of the elements were also viewed as 'being useful' (had this construct had the poles reversed, its mean would have corresponded to those above).

Constructs 6,1,8 and 2 show the greatest variation which suggested that parental encouragement, perceived difficulty, own ability and personal relevance were the most powerful discriminatory dimensions in Aroha's personal construct system. It is noted that construct 12 ('Not important/important from a religious viewpoint') discriminated least, indicating a high religious commitment.

The correlations between the constructs are given in Table 4.9.

Construct 6 ('Things that are/are not encouraged by my parents') emerged as a cogent construct in that not only does it show the greatest variation (Table 4.8) but it also correlates highly with several others (i.e. 2,3,7,8,10,14). Thus, Aroha's parents influenced her perception of those things which she saw as being necessary to know about; would help her in her life; contributed to an understanding of her environment; those that she believed herself as being good at; and being important; and which help when relating to others.

The only other high correlations, outside this cluster, occurred between constructs 11 and 13; 'Things most people think are masculine/feminine' and 'Things I consider are masculine/feminine' (r = 0.9). Although Aroha professed to be

Table 4.9 : Correlations between Aroha's constructs

CONSTRUCT		2	3	4	5	6	7	8	9	10	11	12	13	14
1	Obscure - difficult to understand	-0.1	-0.2	0.1	0.4	0.1	-0.2	0.5*	0.0	0.1	0.1	0.8**	-0.2	-0.1
2	Things I feel I do not need to know much about		-0.2	0.4	0.1	0.5*	-0.4	0.5*	0.1	-0.9**	0.1	-0.2	0.2	0.3
3	Things I find interesting			-0.5*	-0.2	0.0	0.0	-0.3	0.3	0.3	-0.2	0.2	0.0	0.1
4	Things that do not (or will not) help me in my life				0.5*	0.7**	-0.4	0.8**	-0.1	-0.5*	-0.6*	-0.2	-0.5*	0.3
5	Things that challenge me					0.3	-0.2	0.6*	0.1	-0.2	-0.4	0.1	-0.3	-0.2
6	Things that are not encouraged by my parents						-0.5*	0.8	0.2	-0.5*	-0.4	-0.1	-0.2	0.6*
7	Do contribute to an understanding of my own environment							-0.4	-0.6*	0.5*	0.0	-0.2	-0.1	-0.4
8	What I am not (or will not be) good at								-0.1	-0.4	-0.5*	-0.1	-0.5*	-0.4
9	Contributes to our Maori culture									-0.2	0.3	0.4	0.5*	0.0
10	Things that are important										-0.1	0.2	-0.2	-0.3
11	Things that most people think are feminine											0.1	0.9**	-0.4
12	Important from a religious viewpoint												0.1	-0.2
13	Things that I consider are feminine													0.3
14	Things that do not help when relating to others													

For Two-tailed tests of significance - df = 12

* = $p < 0.05$

** = $p < 0.01$

able to distinguish between these constructs, the analysis revealed she tended not to and disclosed the existence of only a single psychological dimension despite the two, apparently different, construct descriptors.

4.2.2 Element analyses

Table 4.10 gives the sums, the sum of squares and the sum of squares as percentages of the total variation, for the elements.

Table 4.10: Aroha's element measurements

Element	Total	Sum of squares	As per cent
A	0.37	0.67	4.8
B	-0.69	0.33	2.4
C	0.38	0.58	4.2
D	-0.87	0.74	5.3
E	0.88	1.74	12.4
F	1.02	1.48	10.5
G	-0.98	0.63	4.5
H	-0.96	1.10	7.9
I	-1.67	0.92	6.6
J	-0.47	0.43	3.1
K	0.68	1.01	7.2
L	-0.27	0.85	6.1
M	1.57	0.64	4.5
N	0.34	0.61	4.3
O	0.30	0.96	6.9
P	0.37	1.32	9.4

The most salient elements are E ('studying engineering') and F ('studying woodwork'), followed by P ('religion'). B ('studying chemistry') is the least salient element and is viewed indifferently. Several clusters of elements in construct space become apparent when Table 4.11 is scrutinized. Element A ('studying physics'), B ('studying chemistry') and J ('studying Mathematics')make up one cluster; C ('studying biology'), L ('studying Maori'), M ('studying art') and O ('doing craftwork') constitute a second cluster;

Table 4.11 : Standardised distances between Aroha's elements

ELEMENT		B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	Studying Physics	0.5	1.0	0.8	1.3	1.2	0.8	1.0	0.9	0.6	1.1	1.0	0.1	0.8	1.2	0.9
B	Studying Chemistry		0.8	0.8	1.2	1.1	0.7	0.9	0.7	0.5	0.9	0.9	0.8	0.7	1.0	0.9
C	Studying Biology			1.0	1.2	1.1	1.0	1.0	0.9	0.8	0.9	0.7	0.7	0.9	0.4	1.1
D	Working as an architect				1.1	1.1	0.3	1.1	0.9	0.8	1.2	0.9	1.1	1.0	1.2	1.0
E	Studying Engineering					0.8	1.1	1.2	1.3	1.3	1.2	1.5	1.2	1.0	1.2	1.6
F	Studying Woodwork						1.0	1.3	1.4	1.3	1.0	1.4	0.9	1.0	1.1	1.5
G	Studying Technical Drawing							1.1	0.9	0.8	1.1	0.9	0.9	1.0	1.1	1.0
H	The School System								1.0	0.9	1.1	1.1	1.1	0.8	1.1	1.3
I	Studying English									0.5	1.2	0.6	1.2	1.1	1.1	1.1
J	Studying Mathematics										1.0	0.5	0.9	0.9	1.0	0.8
K	Working as a Teacher											1.2	0.8	0.8	0.9	1.1
L	Studying Maori												1.0	1.1	0.9	0.8
M	Studying Art													0.7	0.7	1.0
N	Playing Sport														0.9	1.1
O	Doing Craftwork															1.3
P	Religion															

D ('working as an architect') and G ('studying technical drawing'), another cluster; with E ('studying engineering') and F ('studying woodwork'), a fourth cluster. The remaining elements are more or less independent of others.

4.2.3 Component analyses

In some respects, Aroha's construct system was not typical in that four components, rather than three, were found to be significant (according to the Bartlett's test given as an option with INGRID), although 66% of the total variance was accounted for by the first three components. See Table 4.12.

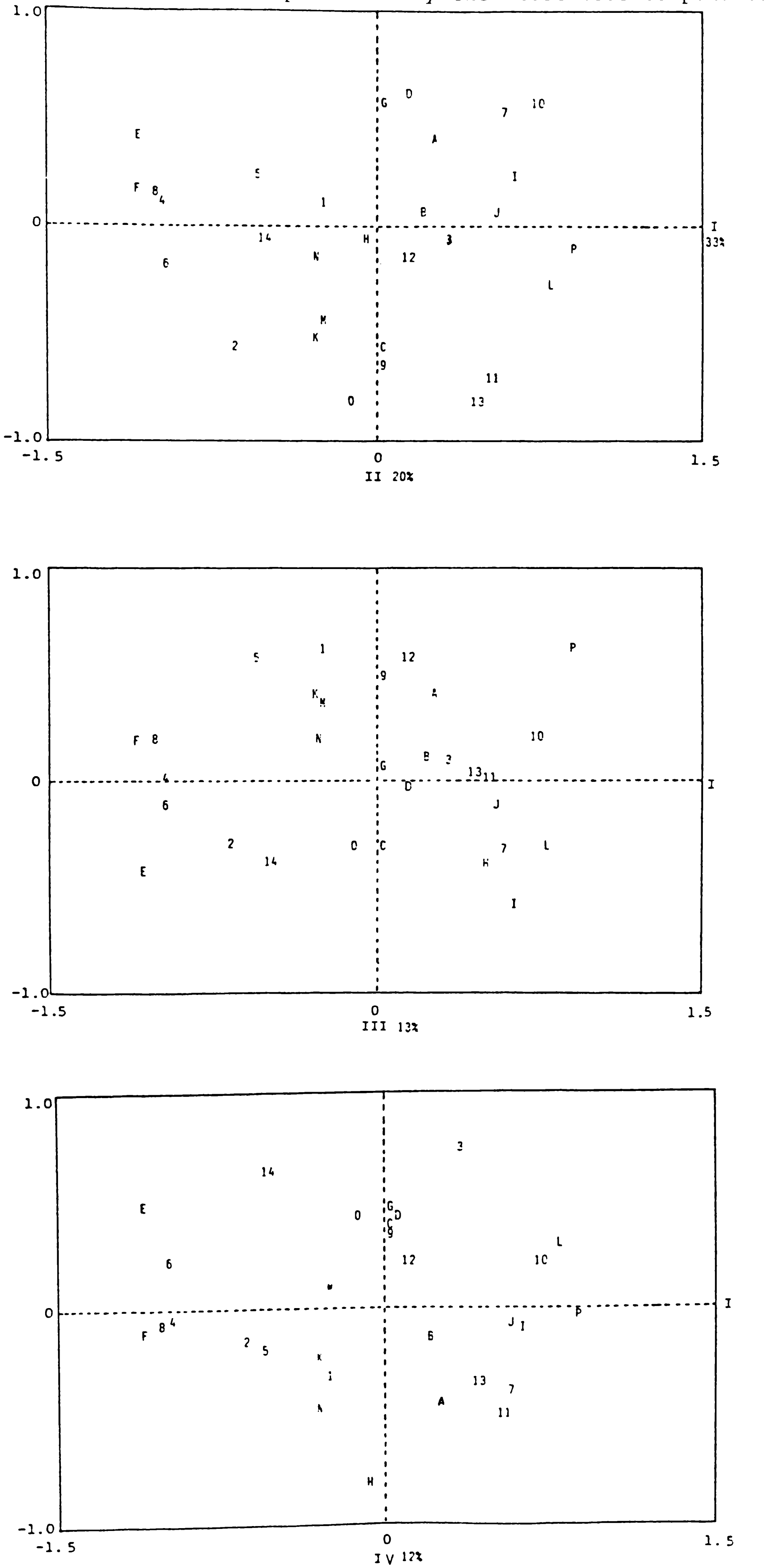
Table 4.12: The first four latent roots of the principal components of the variation recorded in Aroha's grid.

Component	Root	As percentage
1	4.6	33
2	2.8	20
3	1.8	13
4	1.7	12

The loadings of the constructs and the elements indicate the psychological meaning of the components and two-dimensional diagrams, representing the planes of the first component and the second, third and fourth components, in turn, are shown in Figure 4.2 (Aroha was presented with the kitset model which displayed the loadings on the first three components simultaneously).

Discussion with Aroha established the first component to be a value dimension as manifested by such comments as, "Ah, I don't know anything about woodwork or engineering so I don't consider them very important at all, but I consider religion extremely

Figure 4.2: The dispersion of Aroha's elements and constructs in component space as represented by the first four components



important because it affects the way I act, the way I think, and the way I live."

This had been alluded to in the foregoing presentation of the construct and element data and the inter-element distances are more readily visualised in this graphic mode. The saliency of the elements 'religion', 'studying Maori', 'studying English' and 'studying mathematics', at the positive end, and of 'studying engineering' and 'studying woodwork', at the negative pole, is very distinctive. Similarly, in considering the second component, the element cluster of 'working as an architect' and 'studying technical drawing', was almost diametrically opposite to that of 'doing craftwork' and 'studying biology'. The most cogent constructs loading on this second component related to gender (constructs 11 and 13).

Component 3, in accounting for only 13% of the total variation, was not so readily interpretable. Element P ('studying religion') and constructs 1 ('Obscure - difficult to understand'), 12 ('Important from a religious viewpoint') and 5 ('Things that challenge me') load relatively high positively on it; whilst elements I ('studying English') and H ('the school system'), load negatively. To this investigator this component appeared to reflect an abstract-obscure/worldly-clear psychological dimension.

Finally, component 4, in being positively influenced by construct 3 ('Things I find interesting') and negatively influenced by elements H ('the school system') and N ('playing sport'), was identified as reflecting an affective dimension.

The kitset model clearly identified the cluster of science elements consisting of A ('studying physics'), B ('studying chemistry'), J ('studying mathematics') as being relatively near to the two elements D ('working as an architect') and G ('studying technical drawing'). Aroha expressed agreement with this element dispersion:

Aroha Cos I'm pretty concerned about my career and the subjects that I'm taking for it.

She noted element C ('studying biology') was distanced from the first cluster of elements because:

Aroha ... they're subjects that you have to get to be an architect. You don't need biology. There's nothing wrong with having biology in School C but - um - you have to get physics and maths in School C if you want to be an architect. That's probably why biology is on that end (of the model) .

The construct poles which lay close to these elements were 2 ('Things I feel I need to know much about'), 6 ('Things that are encouraged by my parents') and 10 ('Things that are important'). These constructs, as well as reflecting Aroha's vocational concerns, drew attention to the influence her parents had on her outlook on science - comment has already been made (Section 4.2.1) that this construct (No 6) recorded the greatest variation and hence provided for the strongest element discrimination.

Another aspect of her parents' influence surfaced when the source of Aroha's information concerning subjects necessary for pursuing her chosen career was queried and she replied:

Aroha I hear that a lot of people don't like physics and my father's got a friend who urges girls to take physics even though they don't want to, and he's said that it was the only subject that really helped him in his life ... so, I'll take physics.

The influence of her father's informants was very apparent:

Aroha Dad's friend, he was a draughtsman and he took me to look at his things ... and it was quite neat so I though I'd like to be an architect, or something.

Aroha's mother was not able to be interviewed but Aroha's father, a primary head teacher, explained that he had sought information about school subjects from knowledgeable friends:

Father I have taken her to some of my friends who have had training in architecture and other things. We have invited an architect here to talk to us about the particular things that she needs to be aware of in preparation for that particular goal again. We've done - I think we've done the best we can with the limited amount of knowledge that we've got about it - the field of architecture.

Aroha had clearly resolved not to be deterred by social pressure to conform to the peer norm and avoid the science subjects. Her response to the interviewer's suggestion that friends' attitudes to her taking subjects usually taken by boys might make it difficult for her to do as she wished, was:

Aroha I think I've got used to it - taking tech drawing and being the only girl in the class - so I've got used to it ... and I've had to try and face the fact that I might be the only lady architect for a little while, or something, or there might only be a couple of us (laughs). So, it doesn't really worry me about that I'll probably be the only girl in the class.

This motivation to be academically successful was evident in Aroha's family background:

Father I suppose we're fortunate in a way, our family - I have two brothers with degrees and they've been through the university and they've got an idea of what it's all about. I haven't been through university but I've been through teachers' college.

He went on to describe his own attitude to Aroha's studies:

Father She is required to do a certain amount of time on homework at night and I expect that she'll do it and I expect that she maintain a high standard at all times. It's my own attitude about achievement anyway and they've got to knuckle down to it. We all have to work hard ... as far as I'm concerned with expectations for my children, I expect them to do the best they can in all things.

This attitude to school studies expressed by Aroha's father possibly reflects a trait characteristic of his socio-economic status, rather than any disconfirmation of traditional Maori values (see Kerr, 1971; Harker, 1979, for further elaboration of this point). However, it was an attitude evidently communicated to, and accepted by, Aroha.

Aroha's father professed no particular knowledge of science but expressed a regret that he wasn't a science teacher in a secondary school because:

Father I like being analytical - I like sort of evaluating things and finding out - posing problems and working things out for myself.

When asked why he considered the study of science to be important, he replied:

Father Gosh, well, we're surrounded with - gosh, it's everywhere around us, isn't it? We have living things all around us - we need to be aware of what's going on around us. Surely we take an interest in why things happen, how do they happen, why is this different to

> something else, why is this bigger, larger, thinner, heavier?

In response to a similar question, Aroha had given a similar reply:

Aroha	Oh, as I've gone on in life, there's things that come up and you wonder why they happen and why this moves, and this thing goes, and why it goes. Oh, I've found that in science that it's answered a lot of those little questions. It's made things a lot clearer and easy to understand. It's good when you understand something and - um - it's not something that's one whole big confusing thing. If you know a little bit about something, I find that I need to know - to get to know - a bit more about it and then I can sometimes find interesting things about things.

When her perception of a 'scientist' was explored she explained:

Aroha	I think, when I think of a scientist, I always think of a person with a white coat on and he works in a laboratory. But it's not always that way, is it? Um - I don't think I do know somebody who is a scientist, except science teachers, and the people you see on TV and things like that.
I	You seem to use the word 'he'. When you think of a scientist you think of 'him' - as being a person wearing a white coat?
Aroha	Oh, it's not always a 'he' but usually it is a man.
I	Why is this usually a male?
Aroha	I don't know. Um - oh, maybe it's that - sex discrimination thing again - I don't know - um - what did I call it? Where girls are expected to do one thing and not to do boys' things, and vice versa.
I	Hmmm, sort of role stereotyping?
Aroha	Yeah, stereotyping, that's what I mean, yeah.

Obviously Aroha's perceptions of science were not so clearly differentiated as her father's and she acknowledged that it had been only relatively recently that she had perceived any personal relevancy of science - primarily only in a vocational sense:

Aroha I thought (previously) that the only jobs I really knew that deals with science was probably a scientist or marine biologist, or something like that and it (science) sort of didn't really appeal to me at the time - but architecture does include science - physics anyway.

4.2.4 Aroha's outlook on science

Thus, it would appear Aroha's vocational plans had markedly determined her outlook on science and these plans had developed under explicit guidance from her parents (it is assumed her mother shared Aroha's father's educational values). It would also appear that Aroha was still in the process of differentiating the school subject known as 'Science' into its constituent elements. That is, Aroha had discerned the importance of physics (assisted by her father's friend's comments), and biology appeared to be lessening in value as its perceived contribution to her vocational plans waned. Chemistry was still somewhat of an enigma for her as she had little knowledge, or experience, with which to clearly identify its value to her plans - hence the centrality of the corresponding element within Aroha's construct system.

Therefore, whilst the investigator's focus of interest lay primarily with the science elements, these could not be isolated from Aroha's total construct system in which elements such as 'religion', 'working as an architect', 'studying technical drawing', 'doing craftwork', 'studying woodwork' and 'studying engineering' contributed so much. However, with these non-science elements providing the backdrop, several general observations on the way Aroha perceived her science could be made:

(i) Physics was seen as not having as great a personal value as Religion, Maori, English and Mathematics, yet it was more valuable than the remaining elements. It was seen as being somewhat masculine, difficult and was seen clearly as being necessary for her chosen career, although it was found to be somewhat boring.

(ii) In not loading particularly high on any of the first four components, Chemistry was not perceived as being particularly salient. Thus, the value of Chemistry, in terms of personal relevancy, had not been discerned; it had not been identified as either 'masculine' or 'feminine'; it was not found to be particularly difficult nor particularly easy; and it aroused no strong feelings either for or against it.

(iii) Biology was seen as having some value although it was neither strongly supported nor rejected by Aroha's parents; it was seen as a girl's subject; it was easily understood, and it was found to be fairly interesting. In terms of overall significance, the study of Biology was not seen as being able to contribute to Aroha's goal of becoming an architect although it was perceived as being able to contribute to an understanding of her environment and culture and so was allied with non-career type pursuits such as craftwork, Maori and art.

Aroha's F5 science teacher described her as:

Teacher ... a conscientious hard worker. She rarely asks questions in class but prefers to swot the text and any written material given out. She'd be one of our better students but I guess in a city school she'd be only average - perhaps slightly above average. She's given a lot of support at home by her parents - they're both teachers, I think.

This teacher's assessment of her scholastic ability was supported by her ranking on the TOSCA subsequently administered along with the other empirical measures. Her TOSCA ranking on the 54th percentile suggested she was a scholastically 'average' student, but her Science Questionnaire score of +26 was well above the mean for F4 students (mean = 3.3) as too was her Hidden Figures Test score of 13 (F4 mean = 9.3). Her scores on the other measures, the 'Conceptual Style Test' (subscores: 'Categorical' = 10; 'Descriptive/analytical' = 8; 'Relational' = 7); and the Intellectual Achievement Responsibility scale (I+ = 11; I- = 11) were within one standard deviation of the F4 means.

These data raised the possibility that Aroha, although not an academically 'gifted' student, did have a specific ability in dealing with particular types of problems, such as those found in the Science Questionnaire and in the measure of Field Independence (a possible association between these particular measures is explored in a later chapter) and, that an intuitive recognition of this ability predisposed her to continue with her studies in like fields.

However, the analysis of Aroha's construct system seemed to indicate that she believed physics to be difficult, chemistry not so difficult and biology relatively easy - a ranking in the opposite order to her perceived value of each. Consequently, the alternative explanation based on career plans, with a mirroring of her parents' values, would be more tenable. That is, her desire to be vocationally successful as an architect, a discipline demonstrably encouraged by her parents, enabled her to score well in pre-requisite areas.

4.3 Summary

The influence of 'significant others' in the development of Aroha's outlook on science would thus be paramount and may be compared with that of Leanne's. Leanne's outlook on science, whilst diametrically opposed to that of Aroha's, was influenced in a similar fashion by particular people - in Leanne's case, unwittingly by her older brother, as well as by her parents.

The familial influence on Aroha's outlook on science was overt - she was explicitly advised to continue with a study of science (particularly physics) and she was prepared to do so. The familial influence on Leanne's outlook on science was covert - science was not perceived by her parents to be particularly relevant for Leanne, but she was neither explicitly encouraged nor discouraged from taking an interest in it. Her brother was explicitly encouraged to take an interest in science, particularly with regard to computers. It might be suggested that as no explicit cues concerning science and herself were given to Leanne from her parents that the default option may have been to respond to perceived cues from within the school context. These cues would possibly have been those from her F1 and F2 teachers, neither of whom appeared to communicate any encouragement, or to provide appropriate role models, for the development of positive outlooks on science, to Leanne.

Whilst Aroha's teachers, at the F1 and F2 level similarly, may not have explicitly encouraged her, because of the greater exposure to familial cues, the default option would not have been triggered. The contribution of various people to students' intentions to continue with a study of science is examined with the TRA questionnaire to be discussed in a subsequent chapter.

CHAPTER FIVE - INSIGHTS INTO OUTLOOKS OBTAINED FROM THE REPERTORY GRID, AND INDIVIDUAL INTERVIEW, ANALYSES

This chapter presents the overall findings which resulted from the repertory grid analyses and individual interviews with the student sample and their parents. The material presented here is primarily descriptive. Only the analyses from the final grids (out of up to 4 obtained from each student) are presented here, as they proved to be the most stable.

The chapter is organised into four sections: Section 5.1 focusses on possible sex differences within the repertory grid analyses; ethnic differences will be discussed in Section 5.2; interview data from the students' parents are presented and discussed in Section 5.3; and Section 5.4 provides an overview of the various qualitative insights into the students' outlooks on science gained.

It is suggested the reader refers to Figure 1 in Appendix 5.1 whilst reading Section 5.1 as this figure provides a visual overview of both sex and ethnic personal construct systems (with respect to science elements) and enables the contribution of each 'aspect', referred to in the detailed analyses to follow, to be more readily observed. This figure may be scanned horizontally to note possible ethnic differences, and scanned vertically to explore possible sex differences, between the student groups. Note: the 'Polynesian' division is made up of the Maori and Pacific Island students in the sample. As only the first two components extracted from the INGRID analyses are represented here, simplification of the students' personal construct systems is inevitable, especially where a considerable proportion of the total variation within the repertory grids was not accounted for by these first components. Similarly, with the omission of the complete sets of elements and constructs from these graphical representations, much information essential for a fuller interpretation is not available from this figure - the complete graphical representations are to be found in the succeeding figures of Appendix 5.1.

5.1 Repertory grid analyses of girls' and boys' outlooks on science.

5.1.1 Element analyses

Table 5.1 gives a breakdown of all elements provided by the sample students in their final grids. It can be seen from this table that the nature of the elements was similar for both boys and girls; this being due in large part to the element elicitation procedure used. Thus, just over 30% of both the girls' and the boys' elements within the construct systems explored in these analyses were science-related.

A Chi-square test analysis (Appendix 5.2) on the distribution of these elements across the school associated and the possible career linked categories revealed no statistical significant difference between the two student groups (Chi-square = 0.3; 3dF). Note: As 'expected' frequencies of less than 5 (Popham, 1967) were anticipated in the 'recreational element' cells, these were omitted from the contingency table.

In order to test whether there were overall sex differences in regarding these science-related elements they were further analysed by calculating a 'composite saliency' score from each final grid according to the formula:

$$\text{composite saliency score} = \sum_{e=1}^{n} \sqrt{X_e^2 + Y_e^2 + Z_e^2} \Big/ n$$

where X_e^2 = the square of the loading of a given element, e, on the first component of the INGRID principal component analysis

Y_e^2 = the square of the loading of the same element on the second component

Z_e^2 = the square of the loading of the same element on the third component

n = the total number of science-related elements in the grid

Table 5.1: Categorisation of all elements taken from the final grid of each student distinguished by sex.

Categories	BOYS (N=10) No. of elements	BOYS (N=10) % of total elements	GIRLS (N=15) No. of elements	GIRLS (N=15) % of total elements
School associated elements:				
(a) science related	33	20	59	25
(b) non-science related	59	36	81	34
Recreational elements				
(a) science	2	1	2	1
(b) non-science related	32	20	43	18
Possible career linked elements				
(a) science related	16	10	16	7
(b) non-science related	22	13	37	16
TOTALS	164	100	238	101 rounding error included

In essence, this score produced a mean element-origin distance for all the science-related elements in each student's grid. The saliency of an individual element reflects its significance in a person's construct system "whether his attitude towards it is consistently favourable or consistently unfavourable, or favourable in some respects and unfavourable in others" (Slater, 1977:94). Conversely, an element lying close to the origin would be one not clearly perceived (and thereby quite likely not to be consistently rated on subsequent grid administrations - see the discussion on grid reliability, Appendix 3.2. The same principle was applied here with groups of elements and, in order to determine statistically any possible sex difference, a t-test calculation was performed on the resultant composite saliency scores - see Appendix 5.3.

The calculated t value of 1.41 indicated no statistical sex difference had been demonstrated between the composite saliency scores. That is, the t-test analysis suggested the apparent strengths of response to the science-related elements considered together, was (statistically) similar in both girls and boys. In terms of a postulated construct 'indifference/intensity', boys and girls would tend to rate the science-related elements similarly (although the mean composite salience scores suggest the boys would rate them more 'intensely' than the girls).

However, such a composite analysis does not take into account the nature of the 'axes' used to locate these elements, nor does it indicate the direction in which the elements lie from the origin. Two students may use similar axes and locate a particular element equidistant from the origin but hold diametrically opposite views on it. This point is best illustrated by Figure 1 (Appendix 5.1). For example, Peter and

Sandra, were F3 students with very similar first and second principal components ('axes'), namely, 'important/unimportant' and 'easy/hard', and both used the element 'working with chemicals' and both positioned it a similar distance from the origin (Peter 0.86 units and Sandra 0.85 units). That is, both students expressed quite strong responses to this particular element (it was a 'salient' element for them) yet, when one student's graphical representation of his/her personal construct system is superimposed on that of the other student's, these two elements are seen to be quite opposed.

5.1.2 Construct analyses

Table 5.2 shows a breakdown of the three constructs found to discriminate most between the elements of each final grid completed by each student. The discrimination 'index' was derived from the degree of variation recorded against each construct by the INGRID analysis (see Tables 4.2 and 4.8 for illustrations based on Leanne and Aroha's constructs).

In discriminating maximally between the various elements in any one grid, these constructs provide expressions of the essential student-perceived differences between the grid elements in the student's own terms. That is, they are the 'psychological dimensions' preferred by the student when determining contrasts between all the elements of the grid considered simultaneously. Note: Conversely, when the elements are compared, and similarities sought, the constructs with the lowest recorded variation and with recorded means displaced from the mid-point indicate high consensus responses to the elements.

Table 5.2.: Categorisation of the three most discriminating constructs taken from the final grid of each student distinguished by sex.

Construct Categories	BOYS (N=10) No. of constructs	BOYS (N=10) % of total	GIRLS (N=15) No. of constructs	GIRLS (N=15) % of total
Career considerations	5	17	2	4
Affective associations	5	17	17	33
Social status - parents	9	30	12	24
- peers	1	3	1	2
Perceived difficulty	7	23	11	22
Personal relevancy (other than career)	3	10	6	12
Miscellaneous			2	4
TOTAL	30	100	51*	101 rounding error included

* This total includes tied rankings which occurred when constructs showed the same proportion of the total variance.

Several sex differences are immediately apparent from Table 5.2. In this sample, four times as many boys as girls expressed discriminatory constructs based on career considerations. For example, Russell (a F2 student) provided the constructs "I think will be/will not be necessary for a career', and 'Useful/useless for making a living' (these correlated: r = 0.9). The kitset model interviews allowed for elaboration of this. For example, in responding to a query about the position of the element 'Studying music', Russell replied:

Russell "I'm not very good at music... You just sort of don't really take an interest in that sort of thing ... You just sort of feel that it's not going to be of too much use in life.

I	I see. So looking through all the school subjects that you do have, which one's do you think will be of greatest importance to you, in later life?
Russell	Probably maths and English.
I	Hmmm, why do you say those two?
Russell	Well maths, you need it for, you know, you're always coming across problems, if you're a technician you're going to have to find about certain things to do with maths. And English, you know, you've got to be able to explain yourself to other people, and you've got to be able to communicate because if your vocabulary's limited you can't - sort of - tell other people what you're thinking.
I	Okay, so maths and English - are there are other ones up there?
Russell	The others are not terribly important - they are important but they aren't as central."

In describing his responses to elements representing his 'out-of-school' interests (playing soccer, and playing war games with model soldiers), he again expressed the vocational/non-vocational construct:

Russell	"You can't make a living out of them. They're good for taking time - they're good to take an interest in but you can't really go into full-time, sort of thing."

When the science elements were specifically examined Russell did not perceive them as being of particular value to him - they were considered to be 'not terribly important'. Thus, Russell's responses to his school subjects in general were fairly typical of many boys in the sample and reflected a marked emphasis on the perceived possible benefits in terms of vocational application.

An interesting comparison and contrast with Russell's perceptions is provided by Andrew (a F4 student). Andrew also expressed a highly discriminating vocation/non-vocation construct: 'Necessary/not necessary for a job', but expressed a more pragmatic, shorter-term, very specific reason for considering science to be important:

Andrew "Every subject suddenly becomes important in the fifth form because of School C ... without School C you haven't got much chance of getting a good job, cos that's becoming more important ... It's good to do chemistry and biology because if you need it later on - if you wanted to change your job - you've got a background to it and you can go and specialise in it."

Several girls did express such vocational/non-vocational constructs but, other than the two exceptions revealed in Table 5.2, they did not emerge as being highly discriminatory. An example, Lynda (a F4 student) expressed the construct 'useful/not useful for a job' but did not use it to discriminate markedly between the elements on her grid. This was illustrated by her responses when asked to account for the clustering of science elements around the origin on the kitset model. Although the context of the discussion would have suggested a vocational/non-vocational continuum, the affective dimension was obviously dominant:

Lynda "I don't find it (science) easy - there's some parts I like and some I don't.
I Do you think it's going to be useful for you in your life?
Lynda Some of it - I suppose the chemistry will be.
I Why is that?
Lynda For hair-dressing ... I suppose biology for general knowledge."

An analysis of Lynda's constructs showed the affective construct 'Things I am/am not confident with' - one similar to that suggested in the extract above (I like/don't like') - to be most discriminating between the elements.

Lynda's responses were typical of many of the girls in the sample in that, even when careers or future jobs were being discussed, their elements were twice as likely as the boys' to be distinguished from each other on the basis of affective constructs rather than the vocational/non-vocational dimension. In fact, the affective construct was the most 'popular' type used by the girls (refer Table 5.2).

Other examples of such affective constructs used by the girls included: 'Things I find dumb/Things I find neat' (Susan, and Mihi); 'Things I am/am not keen on' (Janis); 'Things that turn me on/turn me off' (Jackie L); 'Boring/exciting' (Amanda); 'I think are good fun/I think are serious' (Louana); and 'Things I can/can't get involved in' (Sharon). Whilst the boys often expressed similar constructs they were less likely to be the most discriminating ones.

For boys, the most discriminating constructs were those associated with their perceptions of their parents' beliefs and opinions. For girls, such constructs were also important, but these were second to the affective constructs. The following excerpts taken from interviews with both girls and boys are illustrative of this:

Sharon "My parents don't take an interest in stuff I'm pretty good at - they nag at me for maths - Mum does anyway - and about typing, Dad does, because that's mainly to get jobs with. Being a nurse - Dad wants me to be a nurse - that's what they nag me about ... Mum doesn't ask me how I'm doing in English, social studies, or science, whereas she asks me a lot about maths because she knows I'm hopeless at maths, but I have to encourage her to talk to me about science because I like science and I want her to ask me what we did that day in science."

Janis "My parents say, "Science is alright - it's a worth while subject - it's better than typing ... you could get degrees in science."

Peter "My mum and dad encourage me with all my school work."

Jackie L. "Mum finds it interesting when I bring home school work, especially homework, a lot - she checks my books regularly and she finds it interesting because she's never had it herself since she left (school) early."

Murphy "Oh, my parents encourage me to do well in all my subjects."

John "My parents don't want me to take science."

Lei "My parents said to me it (science) might come in handy later on in life - if I was to be married, or something like that - if I was to work on cars, or something."

The expressed constructs in these comments were probably reflections of the economic times in that schooling was seen by students and parents alike to be primarily concerned with vocational preparation. Therefore, the prevalence of the parent-associated constructs was to be expected. The emergence of the sex differences in the nature of these preferred discriminatory constructs could provide a partial explanation of the reasons for the under-representation of girls in science but the origins of these sex differences have yet to be discussed. The influence of the parents' own outlook on schooling in general, and on science in particular, is considered following the analyses of the parental interviews presented in Section 5.3.

5.1.3 Principal component analyses

Table 5.3 provides a descriptive analysis of the first three components derived from the final grids of each student. In most instances, the categorisations were those identified with each student during the interviews with the kitset model, but where difficulties were experienced (particularly when attempts were made to 'label' the <u>third</u> components) the investigator subsequently provided a category which <u>seemed to him</u> to best represent the dispersion of elements and constructs along the component in question. In all such cases, the categorisation was discussed with the student concerned. However, the real possibility still existed that in order to satisfy the investigator, compliancy occurred.

<u>Table 5.3</u>: Categorisation of the first three components derived from the final grids distinguished by sex.

Component Category*	BOYS (N=10) Component 1st	2nd	3rd	Total	GIRLS (N=15) Component 1st	2nd	3rd	Total
Value	5	1		6	6	5	4	15
Affective	4	3	2	9	8		2	10
Difficulty		4	2	6	1	6	2	9
Social			2	2		2	2	4
Gender			2	2		2	4	6
Career	1	2		3				0
Idiosyncratic			2	2			1	1
TOTALS	10	10	10	30	15	15	15	45

* Notes: 1) The criteria for these categories are given below
2) In 10 cases the third components accounted for less than 10% of the total variance
3) In each case where more that one grid was developed the nature of the components did not vary (only the percentage of the total variance accounted for by components varied).

The categories were determined as follows:

(i) <u>Value</u>: everyday relevancy (as opposed to relevance for a career) as evidenced by such constructs as 'useful/ useless'; 'important/unimportant'.

(ii) Affective: feeling responses as evidence by such constructs as 'I like/dislike'; 'I find enjoyable/I find boring'.

(iii) Difficulty: as evidenced by such constructs as 'I find hard/I find easy'.

(iv) Social: dimensions influenced by social elements (such as family, friends, teachers) and evidenced by constructs as 'I discuss/I do not discuss with my friends'.

(v) Career: dimensions influenced by vocational considerations (often particular elements such as 'Technical Institute' contributed to the orientation of this component) and evidenced by such constructs as 'Is/is not necessary for a job'.

(vi) Gender: as evidenced by the dispersion of social elements (people) and such constructs as'Is a girl's thing/is a boy's thing'.

(vii) Idiosyncratic: such components not able to be categorised above, such as Russell's third component which included a 'temporal' dimension as evidenced by the construct 'Requires little time/requires a lot of time' and the dispersion around this third component of such elements as 'studying maths'; 'studying English' (requires little time) and 'Working in a hospital' (requires a lot of time).

Whilst these data reveal considerable similarity in the nature of the personal construct systems of girls and boys (in that all but one of the categories occurred in both the girls' and the boys' groups) several distinctive differences were apparent (refer Table 5.3).

For example, all the girls (100%) in this sample of students had a 'value' component as one of the first three component in their personal construct systems, as opposed to 60% of the boys. This is in contrast with the observation that all but one boy (90%) used 'affective' components, whereas 66.6% of the girls did.

The use of the 'value' dimension was expressed in such comments as:

Jackie L. "If I was to become a scientist and a physician, then the sciences would become important - but they are important in my world if I'm taking them for School C ... but they're not important in my world if I'm not taking them ... well science is part of our School C anyway, and biology, so they are quite important to me if I'm going to pass School C, but if I thought I wasn't going to pass School C, well then I probably wouldn't worry about them."

Jackie B. "I don't think science is particularly important."

Sandra "Science is not really that important, it's just that I like doing the experiments."

An interesting similarity between Jocelyn and Andrew occurred in regard to the 'value' each put on doing science experiments in school:

I	"Could we do science in schools without having to do science experiments?
Jocelyn	Probably, but you wouldn't learn it as much and as well.
I	So you see that science experiments facilitate learning?
Jocelyn	Yeah."

Andrew felt that with

"... too many experiments you wouldn't be doing any work. You'd be experimenting. You don't learn too much."

These two students, in some respects, appeared to be atypical of their respective genders in that Andrew was not particularly keen on science, whereas Jocelyn did enjoy it. Andrew expressed the opinion that he <u>would</u> continue with a study of it because it would help him get a job - Jocelyn's reasons for continuing with science was simply:

Jocelyn "Cos I enjoy the subject and I can generally do it alright".

Three boys (30%) used 'career' components but not one girl. It was possible that the career dimension was a more specific dimension, and was often subsumed by that of 'value'. That is, although the boys were more likely than the girls to make an explicit vocational association with particular elements, the girls use of 'value' terms could have implied that they also did respond to the vocational aspects of the elements but in a more general, holistic way. An analysis of the girls' grids in which career constructs were used showed them to correlate highly with other constructs and thereby be subsumed under other component categories. For example, Amanda's construct 'Necessary/unnecessary for a job' correlated with constructs 'things that are/are not important' (r = 0.8); 'Things we do/do not talk about at home' (r = 0.8); and 'Things I think I am/am not good at' (r = 0.7). Boys' use of the career constructs tended to be more specific, less influenced by other constructs, and thus, were revealed as primary contributors to particular components. The construct analysis within the previous sub-section noted that boys tended to use the career constructs to discriminate between the elements to a greater extent than did the girls. These findings may suggest the boys had given more thought to their career plans and thus, had more highly differentiated career constructs than had the girls.

For example, Robert, who had expressed a keen desire to go into farming when he left school, was asked in an early interview, "Why do you think science is taught in schools?" He replied:

Robert "Oh it helps when you go for a job in later life. It'll probably help me - it's got quite a lot in farming (sic) - it helps farmers a lot ... I think farming deals with science - different pastures and stuff like that, and rainfall measurements and stuff like that."

He gave a similar response, when asked about the positioning of the elements 'Working as a farmer', and 'Working in a scientific job' and the constructs "Things that are/are not helpful in my life"; "Things I feel I do/do not need to know much about", during the kitset model interview (see Appendix 5.1 for the graphical representations of Robert's construct system):

I "You see farming as being a scientific job?
Robert Yeah, I think so.
I In what respects?
Robert Um - take soil samples, that sort of thing - measuring and that sort of thing."

The data in Table 5.3 suggest that the girls were more likely than the boys to use 'gender' as an important dimension in their personal construct systems. For example, Jackie L's second component (which accounted for 17% of the total variance in her grid) was influenced by the construct 'Things I think are for females/Things I think are for males', and the elements 'Working as a secretary'; 'Working as a nurse'; 'Studying chemistry'; 'Studying physics' - the latter two being perceived as distinctly 'masculine'. She explained during the kitset model interview:

Jackie "Yeah, well if you added it up, sort of thing, a lot of males come in physics and science. You do get the lady scientist and lady physician, and stuff like that, but I looked at them from the other point of view in the people that I know who are scientists and they're mostly men.

I Hmmm, it's interesting that you've got the navy down towards this side also, the male side.

Jackie Yeah.

I Also, your maths is slightly down this way and economic studies - they're all slightly towards the males' end.

Jackie Well, if you look at the navy, all the people on the boats are men because they haven't got women passed yet, but quite a few women are on the shore as drivers, doing communication, and something like that.

I And you've certainly got (element) D, which is the opposite to that, which is 'Working as a secretary' - you see that very much as being non-male, so that will be a female thing. 'Being a nurse' is over that side also, and so is working in a factory.

Jackie Yeah, well you see, 'Working in a factory' - take Huttons, for example, Mum has got a big department in the small goods and nearly all women work in there."

Thus, Jackie's response to 'her' set of elements was determined, in part, by her perceptions of how they were associated with males or females. Her previous experience ('prior knowledge'), based on personal experience and her mother's employment, had apparently provided her with a personally useful discriminatory component which was applied in the current context of the repertory grid development. It is suggested that there is no reason to doubt that such a component is also likely to occur <u>whenever</u> such elements were being considered (e.g. when decisions concerning future school subjects were being made). Jackie's preference for such a discriminating component was not unique.

5.1.4 Possible sex differences

The analyses in the preceding sub-sections suggest that, in general terms, there were <u>qualitative differences</u> between the personal construct systems used by the boys and those used by the girls in this student sample. That is, although the <u>nature</u> of the elements used, and the intensity with which they were responded to, were comparable between both student groups, the students' use of different preferred constructs resulted in a consequential emergence of different preferred principal components. Essentially, the boys preferred to respond to the elements with perceptual 'goggles' (Bannister and Fransella, 1971) determined by 'affective' and 'career' considerations, whilst the girls tended to respond to the elements in terms of 'value' and 'gender' considerations.

The nett effect appeared to be that many students were thus predisposed to accept the customary sex-role stereotypes. As will be shown later, these stereotypes were commonly held by their parents, and were possibly reinforced by the media and the school (through peer pressure and a lack of alternative role models). The students themselves were asked to suggest reasons why they thought girls didn't continue with science; the following illustrations reveal something of this stereotyping.

(a) Peer-based perceptions:

Leanne "Usually males like science better as girls get older they're not really interested in (science) so much ... they'd rather find out about cooking."

Amanda "Boys read lots of science comics ... girls like reading love stories ... the more real-life sort of thing." (emphasis added)

(b) Media-based perceptions:

Sharon "Being a vet is more for boys ... I've never seen a movie with a nurse in it as a vet, they've always been the helper - you never seen men as helpers, you know, to help put the dog to sleep or whatever - it's always the ladies that have to do that part, and you don't see many lady vets around - I haven't."

Janis "You don't really see many female scientists, not usually hear about them, they're not famous, or anything."

Sean "Physics is mainly for boys cos I've never seen a woman mechanic before and that sort of thing."

Robert "I just think girls are not as interested in science as men, boys, are cos they don't really need it as much as men do ... because men have got to use it later."

(c) Parent-based perceptions:

Amanda "I suppose (my parents) like us doing science and all that, but they don't really encourage us ... They don't know a lot about science."

Leanne "I don't think Mum was all that interested in science."

Sharon "My parents don't even ask about how you do in science ... they nag at me for maths - Mum does, anyway, and about typing, Dad does because that's mainly to get jobs with."

(d) School-based perceptions:

Sandra "In our science classroom the boys go up to the teacher most of the time to ask him a certain problem, or something, the girls hardly do."

Janis "I've been talked out of science - 'Chemistry's hard, physics is hard too' (Interviewer - Who talked you out of science?'). Oh, lots of people - oh, some boys - I know one fella who said to me, "Oh, if you get over 63% in maths, then take physics ... if you're good at maths then you're good at physics.""

Aroha "Girls don't want to take physics cos it's more for boys and, if they took it, they would probably be the only girl in the class, or from other friends they're told that it's hard so they don't bother taking it."

The suggestion has been made elsewhere (Kelly, 1981a) that sex-role stereotyping predisposes boys to think about the future in terms of gaining a career, whereas it predisposes girls to think about the future in terms of achieving adulthood (perhaps the earlier physical maturation of the girls tends to direct their attention, encouraged by the popular media, towards 'growing up' sooner than it does for boys?).

The repertory grid analyses, augmented with the interview data, in revealing that the students' personal construct systems do differ qualitatively somewhat between the sexes and that, consequently, their outlooks on science do also differ, raise the question concerning the possible origins of these different construct systems. It was felt that the origins of many of the students' constructs lay within the family context and that, if any alteration of existing construct systems was to be suggested, aspects of the development of such construct systems would need to be explored. The implication here is that, if parental constructs were influential in determining the nature of the constructs used by their children, and these constructs developed particular outlooks on science (such that science is primarily for boys), an educational programme designed to affect outlooks on science might well need to consider how to prevent 'restrictive' outlooks on science becoming established in the first place. Section 5.3 presents insights gained from the parental interviews with this implication in mind.

5.2 Repertory Grid analyses of Polynesian and Non-Polynesian students' outlooks on science.

This section parallels Section 5.1 above so, in order to avoid repetition, less expository detail accompanies the data presented in each sub-section.

5.2.1 Element analyses

Table 5.4 gives a breakdown, according to ethnicity, of all the elements provided by the sample students in their final grids.

Table 5.4: Categorisation of all elements taken from the final grid of each student distinguished by ethnicity.

Categories	Non-Polynesian (N=10) No. of elements	Non-Polynesian (N=10) % of total elements	Polynesian (N=15) No. of elements	Polynesian (N=15) % of total elements
School associated elements:				
(a) science related	37	22	55	23
(b) non-science related	48	29	92	39
Recreational elements:				
(a) science related	1	1	3	1
(b) non-science related	31	19	44	19
Possible career linked elements:				
(a) science related	19	11	13	6
(b) non-science related	31	19	28	12
TOTALS	167	101	235	100
		rounding error included		

Whilst the nature of the elements, in general, is similar, several differences between the two student groups can be identified:

(a) The Non-Polynesian students offered slightly more science related elements (34% of all their elements) than did the Polynesian students (30%).

(b) The Non-Polynesian students offered a considerably greater proportion of career-linked elements (both science-related and non-science-related) (30%) than did the Polynesian students (17%).

A Chi-square test analysis was worked (see Appendix 5.2) in order to explore a possible statistically significant difference between the two student groups. The determined Chi-square value (10.2; 3df) indicated a significance level of $p<0.02$; that is, a statistically significant difference between the two student groups was observed. Note: As, once again, expected frequencies of less than 5 (Popham, 1967) were anticipated in the 'recreational element' cells, a contingency table using only 'school-associated' and the 'career-linked' elements was analysed.

Polynesian students used more non-science related school associated elements than the Non-Polynesian students, but used fewer possible career linked elements (other element categories were approximately equally subscribed to by both student groups). This may reflect a greater emphasis by the Non-Polynesian students on their future career considerations. If this is so, their outlooks on science may also be influenced by such career considerations. Such was noted in Section 5.1 where boys' outlooks on science appeared to be so influenced.

As in Section 5.1, a t-test analysis was made to explore possible overall ethnic differences in terms of the perceived saliency of the science related elements (Appendix 5.4 gives the calculations).

The calculated t value of 1.30 indicated no statistical ethnic difference had been demonstrated between the composite saliency scores. That is, both groups of students responded to the science related elements in their grids with similar 'intensities' (but, as discussed in Section 5.1, although the distances these elements lie from the origin of the students' construct systems may be similar, these scores do not consider the nature of the reference 'axes' nor the direction from the origin the elements lie).

5.2.2 Construct analyses

Table 5.5 provides a breakdown of the three constructs found to discriminate most between the elements of each final grid completed by each student (see Section 5.1.2 for a discussion on the rationale for this analysis).

Table 5.5: Categorisation of the three most discriminating constructs taken from the final grid of each student, grouped according to ethnicity.

Construct categories	Non-Polynesian (N=10) No. of constructs	Non-Polynesian (N=10) % of total	Polynesian (N=15) No. of constructs	Polynesian (N=15) % of total
Career considerations	2	6	5	10
Affective associations	10	32	12	24
Social status - parents	7	23	14	28
- peers	1	3	1	2
Perceived difficulty	6	19	12	24
Personal relevancy (other than career)	4	13	5	10
Miscellaneous	1	3	1	2
TOTAL	31*	99 (rounding error included)	50*	100

*These totals include tied rankings which occurred when different constructs shared the same proportion of the total variance.

The significant observation to be made about this table is the similarity between the two student groups in terms of the constructs used to discriminate most between the elements in the individual repertory grids. The most prevalent constructs were those of an 'affective' and of a 'social' kind, followed by those which related to 'perceived difficulty'.

That is, even though the combined sets of elements used by the two student groups were statistically dissimilar (Section 5.2.1), both student groups preferred to use similar constructs to discriminate between their elements in their respective sets. It would appear from these data, and those presented in Table 5.2, that these students differed more between the sexes in their preferred use of discriminatory constructs than between ethnic groups.

The very real possibility existed that the combination of the various Pacific Island and Maori students (Cook Islanders, Samoan, Tongan, and Maori) into the single 'Polynesian' sample was inappropriate as 'real' differences in the use of discriminating constructs may have been obscured. This possibility is taken up following the presentation of the data on principal component analyses in the next sub-section.

5.2.3 Principal component analyses.

Table 5.6 provides a descriptive analysis of the first three principal components derived from the final grid of each student.

From these data several general observations are offered:

(a) The most prevalent component derived from <u>both</u> groups were able to be categorised as 'value', 'affective', and 'difficulty' components,

(b) the Polynesian students' grids provided a greater proportion of 'value' and 'affective' components than the Non-Polynesian students, and conversely,

(c) the Non-Polynesian students grids provided a greater proportion of components in the 'difficulty', 'social', 'career', and 'gender' categories than the Polynesian students,

(d) All the 'idiosyncratic' components (each one occurred as third components) were derived from the Polynesian students' grids.

Table 5.6: Categorisation of the first three components derived from the final grids distinguished by ethnicity.

Component category*	Non-Polynesian (N=10) Component 1st	2nd	3rd	Total	Polynesian (N=15) Component 1st	2nd	3rd	Total
Value	4	2	1	7	7	4	3	14
Affective	5	1	1	7	7	2	3	12
Difficulty		5	2	7	1	5	2	8
Social			3	3		2	1	3
Gender		1	3	4		1	3	4
Social	1	1		2		1		1
Idiosyncratic							3	3
TOTALS	10	10	10	30	15	15	15	45

* Note: The criteria for these categories are those given in Section 5.1.3

Examination of these coarse data suggest the similarities between the two student groups' component categories are greater than their differences (and if the components within the 'idiosyncratic' category were assimilated into the other five categories, apparent group differences would be further reduced). Therefore, it would appear that the perceptions (and the 'anticipations') of both student groups are mediated by similar personal construct systems.

The possible inappropriateness of the attempt to effect a nomothetic analysis by creating a single 'Polynesian' group (noted above) is recognised, yet, when an analysis of the nature of the individual personal construct systems is made and the directions the science-related elements lie from the origin and referenced with respect to the principal components (refer again to Figure 1 Appendix 5.1), differences between the two 'groups' do emerge.

Of the fifteen students within the 'Polynesian' group, only two girls, Ruth and Aroha, could be considered to express positive outlooks on science. Aroha's outlook, extensively described earlier (Section 4.2) placed considerable emphasis on her vocational plans in which physics and chemistry were perceived as 'important' and this outlook would undoubtedly result in her continuing with her science studies. Ruth, similarly perceived science to be 'important' because:

> "experiments and the work - mostly I like doing the experiments ... (and) because science is to do with animals in to do with animals in some ways and I like animals. (Working with chemicals is important) so if you're out in the forest, or something, and people put out poisons, you'd understand about it and know what you're getting into."

This last statement referred to a TV commercial warning viewers of the dangers of cyanide opposum bait laid in bush. However, when her future study plans were examined, Ruth stated she did not expect to continue with a study of science because she considered it to be a 'Pakeha thing', and not many Polynesian students studied it because:

Ruth "Europeans kind of brought it in and they teach the Polynesian children and that - it all started off from the Europeans ... Polynesians just put themselves down and think they're not as good, and don't try hard enough ... They probably look at the European kids and see that they're more intelligent and yet they don't know that they might be better."

This expression of a perceived lack of ability, or low academic self-esteem, occurred several times with Polynesian students:

Susan "I wouldn't do science cos I'm too dumb!"

Angela "(Maoris don't study science) probably because Maoris think they're too dumb, or something. I think, you know, Pakehas would be more good at science than them and, you know, it's just no use trying to get there."

Aroha "(Maoris turn away from science) because it's the whole English system - they're not really used to it because they haven't been sort of in it. You know, it's not really part of their background - I don't want to say that Maoris are dumb because a lot of them aren't - but they reckon that science is one of the harder subjects. I don't really know why they turn away from it, maybe it's because their parents don't know that it would be a good subject, so they don't get their kids to take it. The kids don't know any better anyway - the parents don't know any better through no fault of their own. Well, I'm glad that my father's a teacher because it's through his teaching that he's been able to guide me in my things."

This acknowledgement of the influence of others (particularly parents') on their beliefs was noted with many Polynesian students. In two cases (Jackie B. and Susan) the importance of others was such that it determined the nature of the second principal component (see Appendix 5.1).

The following extract from an interview with Susan (a F1 Maori student) reveals the domestic context in which her outlook on school (and science) was established and shows the low academic esteem often encountered with the Polynesian students - in this case, Susan's parents themselves were held in academic low esteem:

I	"Do your parents help you with your science at home?
Susan	Nope.
I	Do they help you with any of your school work?
Susan	Nope.
I	Have you ever asked them?
Susan	Nope.
I	Do you think they would be able to help you if you asked them?
Susan	Nope.
I	Why not?
Susan	Cos they're dumb.
I	Are they really? Why do you say that?
Susan	Cos my father left school when he was in standard four.
I	I see, and what about Mum? Can she help you?
Susan	No, cos she goes to work.
I	Do you think if she had time she could help you?
Susan	No, she won't help me.
I	Why not?
Susan	Cos she's got too much work."

It was apparent that Susan received no encouragement from home (this was corroborated by Susan's school headmaster) and as very little science was taught in her classroom, the application of one of her most discriminating constructs "What does/does not interest Mum" virtually ensured she would develop a negative outlook on science long before she was exposed to any significant science experiences.

Another example of the influence of others on the development of a student's outlook on science is that of Sandra, a F3 Maori girl. Although having been positively disposed towards her intermediate school level science, she became ambivalent towards it during the first term at secondary school. She was an academically able student but she felt typing, cooking, and Maori were the most relevant, important, and the most interesting school subjects. These were the subjects most often discussed at home with her parents and were encouraged by her friends. She was unable to identify with most of her teachers on a personal level; the two exceptions being her Maori and 'tutor' teacher (a woodwork teacher). These latter teachers, she felt, were 'important', 'patient', 'interesting', 'helpful', and were people who 'do listen to me'. Sandra perceived that these teachers, her parents, and her friends, would not especially encourage her to concentrate on her science as it appeared to have little relevancy for her future needs - particularly those of a vocational and socio-cultural kind. Note: These 'social' insights into Sandra's personal construct system were drawn from an analysis of a repertory grid which used people in her life as elements - see Appendix 5.1 (Figure 20).

The Pacific Island students, within the Polynesian sample, appeared to be particularly influenced by their parents' beliefs and desires. For example, Murphy (a F4 student), the only boy in his family (he had one older and three younger sisters), expressed a strong determination to be able to contribute to his parents' wellbeing:

Murphy "Especially my Mum.
I Is that so? Why do you say that?
Murphy Oh, because when I need something Mum alway seems to get it for me and she always backs me up in things I do. And if I go for an exam she encourages me more than Dad does, in a way."

It was important to Murphy that his parents thought highly of him; he explained one reason for studying science was:

Murphy "Say you were on holiday, or something, and you're going on a walk and you pick up a few rocks, and that, and you say you've studied them at school, you can think proud of yourself when your parents ask, 'What kind of rocks are these?'"

Whilst the majority of the Polynesian students who passed comment regarding their parents' knowledge of science, did not demean their parents, they did feel their parents had little need to know much science and that their parents did not consider the study of science to be as important as the study of English and mathematics. One example is Wayne:

I "Your parents don't encourage you to take an interest in science?
Wayne Oh, Mum doesn't know anything about science, and all that.
I What about Dad? Does he know anything about science?
Wayne No.
I Do your parents encourage you to take an interest in any school work at all?
Wayne Yeah, in maths."

This perceived apparent 'non-necessary' response to science, and indeed to most school subjects (other than mathematics and English) by many Polynesian students, coupled with a sense of disenchantment (as reflected in lowered academic self-esteem) with the school system, may explain the low incidence of the 'career' component in their personal construct systems. This interpretation is consistent with the observations of Bray (1970; 1971a; 1971b) and Havighurst (1973) regarding Maori-European differences in future time perspective. Career considerations require long-term planning and such planning would require the existence of the appropriate career constructs. These construct systems, were not manifested as principal components in their analysed repertory grids. Perhaps this was because of their obscuration by the preferred 'value' and 'affective' components?

5.2.4 Possible ethnic differences

The parallel of sex-role stereotyping would be 'ethnic-role' stereotyping. Much within the analyses in the preceding sub-sections could be used to substantiate the position that ethnic-role stereotyping <u>was</u> perceived by the Polynesian students to exist and that, while few students (such as Aroha and Angela) were able to articulate its presence, its presence was pervasive. Several points may be suggested to support this assertion:

(a) Many Polynesians (particularly the Maori students) did not have high academic esteem and so tended to reject much of the school's curricula for not offering sufficient of personal value to them. Therefore, Science, in being perceived by them as an example of an academic subject of low <u>social</u> relevancy, was so 'rejected'.

(b) School was perceived primarily as preparation for work where, for many Polynesian students, <u>social</u> affiliations were held to be of high priority. Consequently, the limited stereotype the majority of students held of a 'scientist' (that of a white-coated, Caucasian male, working in apparent isolation from other people) precluded close identification with such a vocational role.

(c) Following from the preceding point, because many Polynesian students perceived science not to be particularly concerned with people (but with formulae, abstract principles, and 'things'), it was perceived as being 'unimportant'.

(d) Several students (including non-Polynesians) had expressed difficulty with understanding scientific vocabulary. Many of the Polynesian students (particularly the first and second generation Pacific Islanders) had impoverished English speaking language backgrounds (many Pacific Island parents preferred to speak their mother tongue at home) and their problem of understanding the language of science was thereby greater than their non-Polynesian peers.

A consideration of these points, together with the observation that the preceding analyses suggest only minimal qualitative ethnic differences exist between the personal construct systems of Polynesian and non-Polynesian students (compared with the sex differences), raises the possibility that the under-representation of Polynesians in science needs to be sought in terms of particular socio-cultural factors - some of which have been alluded to here.

The discussion on the material arising from the parental interviews enables some of these factors to be explored from another perspective. In this regard, Aroha's comments provide a suitable link from this, to the next, section:

Aroha "I think why a lot of Maori kids, a lot of my friends, turn away from the school is because their parents - the way they've been brought up - not just Maori kids either, non Maori as well ... and the attitudes they form. Some parents think that school is a waste of time, it's not worth doing your homework and they don't encourage their kids to do their homework and try to work as hard as they can. Some parents don't know any better, some of them didn't even go to school for very long ... If parents could be made to realise that schooling is important, even though it's European ... if they could see learning things at school isn't going to necessarily ruin the culture because there's a lot of things here at school that we can learn and then bring back to our culture and help the rest of the people out."

5.3 The parent interviews

> "To the extent that one person employs a construction of experience which is similar to that employed by another his (sic) processes are psychologically similar to those of the other person."
> (Kelly, 1955).

Whilst it was not possible to develop repertory grids with the students' parents, and thereby empirically to reveal similar 'constructions of experience', it was anticipated that the interview data would be such that parent-child congruency in verbal expression of particular beliefs and opinions would serve as indicators of possible similar construct systems. The parent interviews were unstructured and, as such, identical questions were not asked of each parent, although the same general ones were covered. A few typical responses to these general areas are given here.

5.3.1 The issues discussed

(a) The function of the school.

The parents' perceptions of the role of the school in society were explored early in the interview as part of the getting-to-know-you phase, as it was felt an immediate focusing of attention on 'science' could deny the opportunity to elicit the parents' less tangible overall orientation to school in general.

Virtually every response reflected the belief that the school's prime function is to prepare children for the workforce.

"To prepare the kids for when they are ready to go out and get a job." (Sean's mother)

"To make them get their education - to get into a good job later on." (Andrew's father)

(b) Important school subjects.

In following this general area, parents were usually asked which particular school subjects did they consider to be the most important. Again, the responses were unanimous: English and maths.

"Well, I've always thought English and maths were the two most important (subjects)." (Russell's father)

"If you don't understand English and all that, if you're out to get a job, you won't get anywhere ... (and maths is important because) I suppose you're going to come up against figures, and all that." (Ruth's mother)

(c) What is science?.

Parents were asked to define or to explain what is involved in science. Very few parents had a clear understanding of what science is.

"I think science makes you think. I don't know a lot about science, but what I hear you know, and all these atoms and Christ knows!" (Amanda E's mother)

"I don't know much about science, nothing at all as far as science is concerned. ... You see, at the time when I was going to school, there was no such thing as science in that time ... When I came to New Zealand, that's the first time I hear about science, you know." (John's father)

(d) How necessary is a knowledge of science in the everyday world?.

In following up the parents' explanations of science, the perceived relevancy of a personal knowledge of science was explored with them.

(Interviewer - "Why teach science?")

"Gosh! Well we're surrounded with - gosh, it's everywhere around us, isn't it? We have living things all around us - we need to be aware of what's going on around us. Surely we take an interest in why things happen, how do they happen, why is this different to something else? Why is this bigger, larger, thinner, heavier?" (Aroha's father)

However, this was an isolated response. More typical were:-

"I suppose I'm sort of fairly biased about it (science). I don't care about it, to be perfectly honest. I don't, cos I was hopeless at it and therefore I don't expect - you know - if my kids do well at it then I'm pleased because I'm pleased at anything they do well, but if they're hopeless at it I can understand because I was hopeless at it." (Sharon's mother)

"I just see it as an academic subject and if you've mastered your English and your maths ... it just makes you look into life maybe differently or something. That's how I feel about science." (Amanda E's mother)

The next quotation illustrates the reliance parents have on their children's own attitudes and beliefs about science as a school subject; even though, as will be shown later, children are influenced by their parents' beliefs and wishes, the parents are, in turn, influenced by their children's outlooks on science.

Father We really haven't got a terribly good idea on what - you know - what it (science) really covers.

I So when you're in a situation like this, where do you get your advice from? There is the possibility of your son taking science, are you influenced by his comments, and so on?

Father Oh yes. Yes, very much so. (Leanne's father)

(e) <u>Who studies science?</u>

Another aspect of the parents' beliefs was related to their perception of the kind of people who would want to study science beyond school and, by implication, whether their children would be seen as showing similar characteristics. The following excerpt from a transcription typifies the common parental response:-

I What sort of people become scientists?
Father I think possibly, the brighter ones, you know ...
Mother You said 'scientists' - you know - I sort of think of professors or something like that ...
I So you see science as being a fairly academic, or a fairly abstract, sort of subject?
Mother Yeah.
Father Hmmm (affirmative).
Mother Yes, somebody - the real, the bright - the brighter ones. I couldn't really see Leanne in that category, could you?
Father Not at this stage.
Mother No. To me, she's just an average student. I couldn't really see her going into depth into science, or anthing like that. (Leanne's parents)

Another parent expressed it:

"I've always thought of brainy people, you know, done science!" (Amanda E's father)

(f) Sex differences and science?

Although sexual equality is an expressed desire in much of society, many mothers gave the impression that they would wish to retain their traditional sex-role stereotyping in which preparation for a long-term career was more appropriate for boys.

"You know, you can't lump the boys and girls together. It doesn't matter what you say, you just cannot lump them together! You know, they're meant to be different otherwise there wouldn't be boys and girls! I don't believe in this total equality, I'm afraid, perhaps I'm old fashion, but I believe we were meant to be different and that's that!" (Sean's mother)

This sentiment was repeated in several guises, with many mothers claiming to be very contented with their domesticated (unliberated?) role:

"I'm liberated in my home and that's all that matters, and that's what I tell everybody." (Mihi's mother)

"I've been brought up in a time when a woman's place was in the home and that was that ... I'm the sort of person that still believes that the man of the house is the breadwinner, even though I go out to work." (Lynda's mother)

Perhaps not surprising, many parents interviewed expressed outlooks on science which reflected one set of expectations for their son(s) and another set for their daughter(s). For example, the often quoted example of girls being encouraged to become nurses while their brothers are encouraged to become doctors was encountered (c.f. Macoby and Jacklin, 1974:364):

"There's a lot of girls who'll go into nursing and science is certainly going to be one of those subjects they have to learn. I think boys if they - they may not know in the third form that they want to be a doctor but as they get on, they might decide that and that'll help them." (Andrew's mother)

The belief that fundamental (biological?) sex differences were influential in determining subject choice occurred regularly (some examples of this belief may be observed in several of the illustrations above). An example is given by Lynda's mother:

"Perhaps my idea on it (why girls turn away from science) would be that because science is different and because it's deeper. I think it tends to be something that males delve into more - they're more interested in it - science never really interested me."

A very similar viewpoint was expressed by Jocelyn's father, an owner of an electronics business:

"I actually employ a girl working in electronics although there's no technical knowledge required and I have found some of the girls very, very good. Mainly because they'll do what they're asked to do and, having done what they've been asked to do, they don't want to carry on and go further with it. They'll then go and do something else they're asked to do, whereas, a young man will usually want to delve into it and carry it on further until the point where he's up to his neck in trouble, you see, and that's what I can't afford to happen. Boys also want a long-term job, perhaps something like an apprenticeship, or something of that nature, and they want to go on and get a qualification, whereas the girls are quite happy just to ... just to do it and not want to know why a certain thing is or why it has happened, or what that is. If I just say, "Take that piece out of there and put that one in", they're quite happy to do it and they don't ask anymore questions."

Andrew's mother expressed concern that one of her daughters _had_ intelligence:

"Our eldest daughter used to drive the teachers crazy. She's a real brain-box. Well, I kept saying, "You should've been a boy" ... It would've been better, yes, I think it would, if had she been a boy - I think it - well, a _man_ usually grows up and _he_ marries and _he_ has a family - _he's_ got to be the breadwinner." (emphasis added)

However, the domestic 'sentiment' expressed here was more commonly found in Polynesian families where traditional sex roles are often very strongly held. For example:

Father	As far as I can see, why the girls turn away from studying science, it's not very important for girls, particularly, because sometimes they go by themselves and they can't leave them with science for a living - then they get married - then they finish with it - with the study. But the man - got the big family, or whatever, has still studying and living in the - I think that's what it is ... the science is too far - study, study. Not like English and arithmetic - for the science you have to study for the facts too much. For what effect?
I	So you see that the males, perhaps, have got a longer term career?
Father	Yeah, yeah.
I	And that's where science fits in - whereas with girls, their future is what?
Father	Very short. When they marry, then they finish. (Lei's father)

Murphy's father expressed a similar belief:

"The boys do all the work, you know what I mean. If a girl gets married, she's stuck as a house-keeper, or something like that - have a family and that's it. But the boy - he's got to have a good education because he earns the money for the family, you see."

(g) Ethnic differences and science?

When interviewing Polynesian parents attempts were made to elicit explanations as to why relatively fewer Polynesian than European students studied the sciences. Often the responses reflected a simple lack of knowledge as to what was involved in science:

"For myself, my parents never gave science a thought and probably, because their interests weren't there, that's probably why I never took an interest." (Maurice's mother)

"I know on (sic) science - I think, for the Pacific Islanders - maybe because there's no interest in the parents, perhaps this one has gone through the children as well, because there's no backing for them as far as science is concerned." (John's father)

Lei's eighteen year-old brother, in helping his parents respond to the interviewer's questions, suggested that the influence of the home was considerable:

"In so much at home they're (the Polynesian children) brought up to use their hands and not their mind. And the science - it's very hard not to use your mind - if they can go into woodwork where they can enjoy it because it's easy and they can use their hands - all the kids are good with their hands - so if they're good with their hands why should they waste time in science? It's their point of view."

The Pacific Island parents placed considerable emphasis on the importance of education for their children. In many cases, the quest for education, better than they themselves experienced in the Islands, was an important factor in deciding to come to New Zealand. Considerable encouragement for their children to succeed educationally was evident in all the families interviewed, but it was often misguided and very little meaningful advice was able to be given to their children on how to study, or where, or from whom (other than the teacher) assistance could be sought.

"Even though we don't understand the way of the education system here - very much we don't understand much - but we have a fair idea what's the students' needs - so got that - their needs - we brought books and all those things - even we got the set of Encyclopaedia Brittanicas for them when they were in the third form - they use it but not to the extent we hoped for. We tried to encourage them to study because we know that the basic of good education is study - we tried to encourage them but they still want their time - their free time." (John's father)

Aroha's father offered the suggestion that the Maori way of thinking and feeling is inherently different to that of Europeans and that it was incumbent upon teachers to be aware of these differences and be prepared to accommodate them:

"I think it's more a relationship between the teacher and the child - if a teacher can relate and understand the Maori background, in the way they think and the way they feel, then they teach them through the medium of science, I think they'll be able to get through a lot more Maori students. In my experience, I think I feared European teachers ... (at) the college that I went to, they were all Pakeha teachers and I feared them quite a bit because of their differences - the differences of their knowledge of their subject, obviously, and what I knew myself, which was very, very little, and I was frightened to ask questions." (sic) (Aroha's father)

John's father (a Cook Islander) made a similar observation of one of his sons:

"My son, James, he lose interest when he was in the form four - he doesn't ask the teachers, you know - he doesn't understand how things are at school - cos he's a bit shy - a lot of Islanders are shy ... I know Islanders sometime give up easily and it could be one of the problems."

Some of the differences in thinking and feeling could be linked with language difficulties. These were expressed by several students as well as several parents; for example:

"One reason for failure, as far as the Pacific Islanders are concerned - well they've got a different language and for parents to help their children, it's very hard, as far as English is concerned. So they depend very much upon the children themselves to help themself at school." (John's father)

That is, John's father felt unable to offer his children as much support as he would wish and therefore he placed considerable 'faith' with the school and with his own children. His predicament did not appear to be atypical.

5.3.2 Parents' outlooks on science - generalisations

While each family situation was unique, sufficient commonality between the families emerged from the collective consideration of the interviews to enable a generalised parental outlook on science to be offered.

Science was seen by the parents as an intellectual, esoteric, difficult discipline with little everyday application and of limited vocational value (other than that of being a pre-requisite subject specified for particular careers, such as architecture and medicine). Science had greater appeal for boys because boys probably had a greater innate science ability than girls and science required a long-term commitment to its study. Therefore, boys would be less likely to be dissuaded from studying science as they were expected to be prepared to spend considerably more time developing their careers than were girls.

The nett effect of such a restricted parental outlook on science on their children (girls and boys) is probably indeterminable but it is suggested that, particularly where only the home provided (either explicitly or implicitly) the children with information about science of an immediate and of a personally relevant nature, the effect could be considerable.

The case of Leanne (Section 4.1) illustrates this suggestion well. Her parents had had very limited exposure to school science and knew little about it:

"My concept of science at school was where we had two periods a week and that was in the laboratory and that was it. You know - I sort of - I work in an office so, you know, I suppose I don't really know what field science covers really." (Leanne's mother)

"I always thought as science is, you know, to do with plants, animals, anything - you know - that way. Laboratory doing - oh, science at school, sort of dissecting frogs ... I'm not fully aware of what, you know, how big a field science covers now. I don't know about science." (Leanne's father)

Leanne had expressed the beliefs that science would be of little value to her and that it was something of interest to boys rather than girls. Her parents expressed similar beliefs:

"I was never very interested in science and mixing up things and that." (Leanne's mother)

"(Science is of some value) especially for a boy, I think ... you think of, you know, science is more - you think of as a boy being more involved than a girl." (Leanne's father - see Section 4.1.3 for a fuller transcript)

Leanne's school-science experiences did little or nothing to challenge her familial-developed outlook on science (ibid). Therefore, the maintenance of her initial outlook on science (an outlook based on very limited factual knowledge and reinforced by role stereotyping in the home, school, media, and an outlook very possibly shared with many of her peers), appeared likely. Such an outlook on science could be anticipated to result in Leanne deciding not to continue very far with a study of science.

The reason for interviewing the parents was to seek evidence of possible indicators of construct system components common to parents and their children. The data suggest the evidence _is_ available - the students interviewed in this study, more often than not 'echoed' their parents' beliefs. That is, the students were very aware of how their parents' perceived the school system in general, and science in particular, and the students often used constructs in their own personal construct system which took these perceptions into account (e.g. 'Is encouraged/is not encouraged by my parents').

However, it is not possible to state the students always accepted their parents' perceptions as being appropriate for themselves. A measure of their parents' influence is found within the TRA analyses presented later.

For example, Jocelyn, as a F4 student, was able to articulate clearly her responses to her parents' perspectives:

I	"Does your mother offer a kind of model to you to follow? I mean, her particular values, and so on? Would you be happy following those, to any extent?
Jocelyn	Yeah, most of her ideas, and the way she thinks, and that, I agree with. But - I sort of - she doesn't have much of a mind for horses and that. She'd rather stay inside, but I'd rather go outside, and that - so we're different in that respect. You know, she could probably do an office job but I'd go up the wall if I tried doing that - I'd go batty!
I	And what about Dad? Does he influence you at all with his particular values? ...
Jocelyn	Not really ... but Dad and I do get along, I suppose, a bit better than Mum and I do ... (Dad's) more willing for me to try new ideas and try new things out. You know, Mum is more protective and that. She doesn't want me to do anything she thinks might be dangerous or anything like that."

Thus, Jocelyn appeared to reject her mother's 'models', although it was very likely she was considerably influenced by those of her father.

Jocelyn's father's encouragement for her 'to try new ideas' was identifiable in many of the constructs she used in her repertory grid; the most discriminating were: 'Things that do/do not challenge me'; 'I am/am not good at'; 'Things that are practical/theoretical'. Whilst her father claimed not to influence her interests, he affirmed he actively encouraged her with them:

Father "I've got no desire to try and push her into any of my own fields ... I'd never try to push her in that direction at all. If she wants to go that way, okay, that's fine - if she doesn't want to - there's no pressure that she has to - just because she's a girl doesn't make any difference. If they (the children) have interests, okay, that's fine - if they haven't got interests, you try and find out what their interests are and go with them - show an interest in what they're doing instead of them showing an interest in what we're doing."

It became apparent from the interviews with Jocelyn that she shared many of his interests, such as those in amateur radio and photography (she was experienced in developing and printing her own photos). Therefore, it was not surprising to find Jocelyn with a positive outlook on science - science was perceived as 'important now'; 'enjoyable'; 'something we talk about at home'; 'practical'; 'I know a lot about'; 'encouraged by my parents'; 'interesting'; 'useful when I leave school'; and something 'I am good at'.

An interesting similarity may be noted between Jocelyn's and Aroha's (Section 4.2.4) outlooks on science; in both cases, the girls' fathers were actively involved in their daughter's concerns and were able to provide role models of individuals actively involved with recognisable aspects of science. In Aroha's situation her father's friends provided the role models; in Jocelyn's situation, her own father provided an appropriate model. The importance of specific role models, or mentors (usually male), has been noted by others (Jackson, 1979; Kelly, 1981b).

The school experiences of Aroha and Jocelyn were markedly different. While both attended co-educational schools, Aroha attended a small country school where science was not particularly well developed and her own science teacher, a male beginning teacher, experienced many classroom control and organisational difficulties. Aroha received very little (if any) support from the school for her endeavours in science - her support was to be found almost entirely from her family. Jocelyn attended a large city school and had an enthusiastic, experienced, competent woman science teacher who encouraged all her students (girls and boys) to become actively involved in science. It might be conjectured that Jocelyn's positive outlook on science was initiated at home and that it was nurtured and extended at school. It might also be suggested that had Jocelyn not received encouragement from her parents, her positive outlook on science may still have developed as a result of her current school experiences. However, since a student's school experiences are so variable from year to year (or even from term to term!) in being dependent upon particular classes, a particular science scheme of work, and, most important, on particular teachers, the consistency over time of the home influence (whether positive, neutral, or negative) is more likely to be the more significant factor in determining a student's outlook on science. That is, the parents' own outlooks on science <u>were</u> communicated to their children, either explicitly (as appeared to be the case with Aroha, Jocelyn, Peter, Robert, and Leanne, for example) or implicitly (e.g. Mihi, Wayne, Susan, Maurice, John), and the influence of these outlooks <u>was</u> discernible in those of their children.

5.4 An over-view of chapter five.

5.4.1 Comments on the Repertory Grid technique

This technique is more a method than a test (Fransella & Bannister, 1977) and, as such, provided the stimulus material for most of the qualitative data generated with the students. The anticipation of possible problems (see Appendix 3.2), and the use of the construct and element cards with the wooden rating rule, Section 3.3.2) resulted in no difficulties being experienced in the formation of the raw grids. The use of the kitset model to display the element and construct loadings on the first three components extracted by the INGRID analysis provided the opportunity for further exploration of the students' personal construct systems.

The possibility exists that some compliant students may not have mentioned any anomalies they perceived in the model but it is felt that the investigator's invitation for them to criticise the model was heeded by most students. Many students did identify elements which had 'moved' in the intervening period of time (2-3 weeks, in some cases) between the formation of the raw grid and the discussion with the kitset model. Invariably, it was found these students had either gained further experience with the elements in question or had reflected on them. e.g. Andrew's element 'studying chemistry' moved from being a salient element, negatively perceived ('unliked' and 'unimportant'), to being somewhat less clearly identified (see Appendix 3.1) because:

"Now we're into chemistry, I'm beginning to like it more."

These 'movements' provided additional information on the stability/lability of particular elements where several comparable grids were developed with the same student. However, in most cases where additional grids were developed a variety of different elements and constructs were added/deleted making direct inter-grid comparisons inappropriate. For example, contrast Sandra's grids: one grid used 'activity' elements, such as 'studying science', whilst the second grid used 'people' elements (see Appendix 5.1).

The time period between the formation of the raw grid and its subsequent analysis and interpretation with the kitset model did give rise to the difficulty in requiring students to recall why they had made particular responses. It would have been preferable to have had an INGRID analysis available for student comment immediately on completion of each grid. Such a procedure would have enabled more comprehensive grids (possibly with higher order constructs) to have been developed.

A pilot study attempt using a TRS-80 microprocessor and the only computer programme then available - an interactive repertory grid programme (PETRA - Shaw, 1980a) - was not successful. The response requirements of this particular programme restricted direct communication between the interviewer and the students as the student became 'locked' into the programme itself.

For a subsequent study, it is suggested INGRID be adapted to run on a portable microprocessor and printer. A raw grid could be developed as above and, as each element is rated on each construct by the student, the corresponding entry could be made by the interviewer into the microprocessor. On completion, the INGRID analysis would be immediately available and the kitset model constructed as described. Note: Two dimensional plots of any two principal components are possible direct from a computer but, when investigated it was found students have difficulty in interpreting them - a three dimensional representation was much more readily conceptualised by all students.

5.4.2 Concluding comments

The qualitative analyses discussed in this chapter have suggested that outlooks on science differ distinctly between the sexes, and only slightly between the two ethnic groups identified here.

The explication of boys' personal construct systems revealed their outlooks on science to be more mediated by career considerations and to be based on a wider variety of informal, out-of-school science experiences, than girls'. These informal science experiences were often actively encouraged in boys by the boys' parents, yet were not so encouraged in girls by girls' parents.

The 'conservatism' of the parents interviewed was apparent (Section 5.3) and it may be suggested that this factor was very strong in many homes. Parents perceived science to have a masculine image and to be, therefore, associated only with traditionally male-orientated vocations. The stereotypical personality traits for scientists stress high academic ability, personal detachment, total commitment, high analytic and rational behaviour, traits which are antithetical to the ideal of femininity, were often expressed by parents and their children.

As schooling was perceived by parents and their children primarily as vocational preparation, school science tended to be evaluated accordingly. This evaluation was expressed explicitly by boys in terms of careers, but girls tended to respond in more general, affective ways. That is, boys were able to cite specific applications of science, with confidence. For example, Sean (F2) explained that a knowledge of science was necessary for a mechanic:

Sean "'Cos of the motor and everything - the way that they move - where the petrol goes - how the petrol gets to the motor - and all this sort of thing. So yes, science would apply very much, actually. Cos physics comes under science."

Girls were not so confident in giving explicit vocational applications. For example, Lynda explained she would not want to get a job which involved science because:

Lynda "I'd be scared of doing something that would affect a lot of things ... but I suppose I will need to know some science if it's hairdressing I want to do ... all the solutions and stuff, you'd need to learn about those." (emphasis added).

The importance of the home environment in affecting students' outlooks on science is perhaps not always appreciated by teachers, but was clearly expressed recently by Barbara Hodgson, deputy editor of Physics Education, when considering the relative contributions of school and home on her own decision to study science:

> "I faced a choice (at school) between physics and history but I recall being advised that there were better employment prospects for physicists than for historians. But the most important factor in my case I am sure was my home environment. The fact that I wanted to study science, far from being thought unusual or unsuitable (for a girl), was actively encouraged."
>
> (Hodgson, 1979:270. Emphasis added)

In considering ethnic differences, comment was made on the possible inadequacy of simply combining the Maori and Pacific Island students into the one 'Polynesian' group, but, even so, these students tended not to appear so vocationally orientated, and they tended to use a greater proportion of value and affective responses, than their non-Polynesian counterparts. However, these differences between the two groups were slight, and led to the suggestion that, as their personal construct systems were not too dissimilar, explanations for the under-representation of Polynesian students in science might need to be sought in terms of particular socio-cultural factors, such as the status of schooling in their value system. The nature of cultural value systems was not explored in any depth in the particular study but one aspect of one such system may be found in the following statement, expressed by a Pacific Island parent, and it illustrates the caution that must be exercised when such an omnibus term as 'Polynesian' is used:

"We come from the islands - from Samoa, you know - I want to explain to you about - our problems is that it is hard to explain in English because, you see, we come from there and when we came here, there was not opportunities to get a good education - in the island before we came over here, we are in the bottom level of education ... and what we trying to do, we're trying to put my family at school, you know - we've come to get a good education - it's good for them. Because them's (the children) are very lucky because they have a good opportunity here for education, you see, not like us - for us, from now on it's too late ... I try to see that the kids get to study, do the homework, and see that they go to school everyday - to see if they want to go anywhere else to see - the parents from school - we go to see the teachers or the headmaster, in any way like that ... I believe to see education is very important - for myself and for the kids and their future, because I know where I am, I wished to get a good education but - that's what I aim to try and see my kids - if my kids have got any brains, and working hard to earn School C and go to university to study ... Yeah, that's the way we try and see our children, because we know that education is important in the life and for earning the money, and things like that." (sic) (John's father)

Therefore, the claim that Polynesian students had low academic esteem must be carefully qualified: the qualitative evidence discussed in this chapter (corroborative quantitative evidence is provided in the next chapter) suggests that many more <u>Maori</u> students than non-Polynesian and Pacific Island students had low academic esteem which was reflected in 'poorer' outlooks (that is, outlooks with more negative components) on school in general, as well as on science.

The Pacific Island students, while having more positive outlooks on school than Maori students, did not necessarily express positive outlooks on science. The non-realisation of vocational applications of science, the lack of role models, and the existence of stereotypic perceptions of the nature of science and of its practitioners were possible determining factors in such outlooks. The expressed language difficulties, more obvious in the students' parents rather than in themselves, would not necessarily have been specific to science, although many students (Polynesian and non-Polynesian) did comment on difficulties they experienced with 'big words' found in science. However, this study did not explore this as a distinct contributor to the Pacific Island students' outlooks on science.

No 'definitive' statement of the outcomes of the qualitative analyses are provided here as the object of this (and the previous) chapter was to provide a 'flavour' of the qualitative insights gained using the individual interview format and the repertory grid technique. These insights are illuminated from a quantitative perspective in the next chapter, and observations on the usefulness, or otherwise, of these approaches are made in a later chapter.

CHAPTER SIX - QUANTITATIVE INSIGHTS INTO STUDENTS' OUTLOOKS ON SCIENCE

This chapter presents the findings from the quantitative analyses conducted to provide an alternative, but complementary, perspective to that discussed in the previous two chapters. The chapter is divided into three sections:

Section 6.1 contains the general findings from the initial class surveys followed by examinations of the two experimental hypotheses proposed (Section 3.3.1).

Section 6.2 contains the findings from the TRA analyses.

Section 6.3 provides an overview of the quantitative insights gained into the students' outlooks on science and critically examines the instruments used in this phase of the research.

6.1 The class survey results.

6.1.1 The general results. Table 6.1 gives the mean scores and the standard deviations for each measure used in the initial class surveys.

The TOSCA data are similar to those reported by Reid et al (1980) who found a range of mean scores from 27.27 (s.d.= 11.61) to 38.62 (s.d. = 13.22) on the Intermediate B form (for combined male and female students across the ages of 11 to 14 years inclusive) and a range of mean scores from 31.27 (s.d. = 12.68) to 34.69 (s.d. = 12.88) on the Secondary B form (for combined male and female students at the ages of 13 and 14 years). Thus, it would appear that the students sampled in this study may be considered to be 'scholastically' comparable to a representative sample of the New Zealand student population.

The IAR data are also similar to those found in the literature. Crandall et al (1965) report mean scores of between 24.19 (s.d. = 3.83) and 25.90 (4.33) for students of both sexes between grades 5 and 10 on the total IAR scale; between 12.42 (2.53) and

Table 6.1: Descriptive statistics from the initial survey group measures with all students treated as a single group.

Measure	N	Mean Score	s.d.
TOSCA	557	30.18	13.15
Total IAR	543	24.84	3.90
+IAR	543	12.84	3.26
-IAR	543	12.00	2.50
Categ.CS	542	9.30	4.09
Descr.CS	542	8.46	3.98
Relat.CS	542	7.01	4.67
Hidden Fig.	550	7.37	4.76
Sc. Quest.	549	-1.75	16.95

13.21 (2.41) on the +IAR subscale; and between 11.75 (2.69) and 12.68 (2.68) on the IAR subscale. Since each of the 34 items presents an internal and an external alternative, chance distribution would result in mean total IAR scores of 17 and mean +IAR and -IAR subscores of 8.5 each. Unless there is a test artifact operating (or perhaps a tendency of students to give the 'expected' responses), the high mean scores would suggest a reasonably high overall belief in personal responsibility for intellectual-academic success. However, the relatively small amount of variance about the mean suggests many items do not discriminate between different students who give internal responses.

The distribution of responses on the Cognitive Style Test differed somewhat from that found by Harker (1976) who found, with students aged 9 years, the relational responses most prevalent (mean = 11.94), categorical next (mean = 7.66), and the descriptive responses least prevalent (mean = 5.36). Archer (1970) found, with his sample of 11-12 year old students, the same overall ordering of preferred response modes: viz, relational (mean = 10.0), categorical (mean = 7.76), descriptive (mean = 6.06). However, in both of these studies the marked sex differences were masked by these overall data.

The Hidden Figures Test was found to be difficult for many students, particularly those in F1 and F2. Ekstrom et al (1976) referred to only one study which used comparable aged students (although these were male only) and reported a mean of 9.2 and a standard deviation of 4.5. No other meaningful comparisons were found.

The Science Questionnaire results were similar to those found during the final trial. Whilst the total possible range was ±60, the manifested range was ±46, and the experimental sample's heterogeneity was greater than that of the trial sample (according to the standard deviations - 17 versus 14).

Table 6.2 gives the intercorrelations between all the measures used in the survey.

Several features may be noted:

(a) All but the 'Descriptive' subscale of the Conceptual Style Test, correlate significantly ($p < 0.001$) with the TOSCA. This feature suggests the existence of possible common factors between these measures (an <u>ex post facto</u> principal components analysis of these data is discussed later

<u>Table 6.2</u>: The Pearson product-moment zero-order correlations between all measures used in the initial class surveys, with the data from all students combined.

		2	3	4	5	6	7	8	9
1	TOSCA	.21**	.19**	.16**	.22**	.10	-0.23**	.41**	.54**
2	Total IAR		.80**	.84**	0.0	0.0	.01	.06	.04
3	+IAR			.34**	-0.02	0.0	.02	.05	.05
4	-IAR				.02	-0.01	0.0	.05	.01
5	Categ. CS					-0.29**	-0.58**	.14*	.22**
6	Descr. CS						-0.57**	.10	.07
7	Relat. CS							-0.18**	-0.22**
8	Hidden Fig.								.38**
9	Sc. Quest.								

N = 499-542 * = $p < 0.01$ ** = $p < 0.001$

<u>Notes</u>: 1. Separate Pearson product-moment correlation tables for each sex, and each ethnic group, are given in Appendix 6.1
2. Refer to the addendum for comments on a possible age-related factor.

in this chapter). Of particular note is the moderate correlation ($r = 0.54$) between the TOSCA and the Science Questionnaire. Thus, although the science measure used in this study was designed and presented so as to allow students with lesser scholastic ability to respond confidently to it, evidently there was still a considerable commonality between it and the TOSCA. It was quite likely that the Science Questionnaire, although designed as a 'science' measure, also measured aspects of 'scholastic ability' (and vice versa!).

(b) The correlation of 0.38 ($p < 0.001$) between the measure of field independence and the science measure may have been influenced by the way in which the science measure was presented to the students.

The administration procedure of the Science Questionnaire used strong visual stimuli (OHP illustrations and practical demonstrations) and, as the Hidden Figures Test is a measure of 'flexibility of closure' ("The ability to hold a given visual percept or configuration in mind so as to disembed it from other well defined perceptual material" - Ekstrom et al, 1976:19) and loads onto a 'spatial orientation' factor (ibid), it is possible that similar <u>per</u>ceptual skills may be necessary to score well on both measures rather than simply similar <u>con</u>ceptual abilities.

Many school science activities require reasonably well developed visual spatial skills (particularly where experimental work is involved) with the ability to discriminate between figure and ground relationships. Field dependent individuals could be considered disadvantaged in a discipline which requires such skills. In a study of 64 eminent scientists, Roe (1951) found all subjects tended strongly to depend upon visual imagery in their thinking. Martin (1969) observed mathematics and science teachers to be more successful on the spatial reasoning scale of a 'Differential Aptitude Test' than those in the humanities or social sciences. Piburn (1980), in a study of New Zealand sixth form students, found spatial reasoning to be a correlate of science achievement (as measured by the School Certificate science exam) and of proportional reasoning. He makes the link between spatial ability and science achievement by claiming:

> "...proportional reasoning seems to be heavily spatial in its cognitive requirements. Since most experienced teachers know that ability in proportionality is essential to success in science, they may wish to emphasize its spatial qualities in their teaching."
>
> (Piburn, 1980:447)

(c) Archer (1970) suggested a preference to use a categorical response style reflects a preference to use higher order constructs which may allow for greater cognitive economy and efficiency. This significant correlation ($r = 0.22$; $p < 0.001$) between the Science Questionnaire and the categorical response style would thus support the suggestion (Section 3.1 and 3.3.1) that the nature of science (and that of the Science Questionnaire) is such that individuals who are able to exhibit a preference for using higher order constructs have less difficulty in responding to questions about scientific phenomena than those who prefer to use lower order constructs.

If Kogan's (1971) assumption that the 'relational' style involves a passive response to presented stimuli, the significant negative correlation ($r = -0.22$; $p < 0.001$) between the relational style and the Science Questionnaire would appear to support a suggestion that a high score on the Science Questionnaire requires an active response to presented stimuli. However, as the 'descriptive' style is supposed to represent an active response to presented stimuli (Kogan 1971), the non-significant correlation between it and the Science

Questionnaire in this study undermines this suggestion. Consequently, the interpretation of these results remain equivocal - the validity of aspects of the Conceptual Style Test is questioned later.

(d) The correlations between the Hidden Figures Test and the subscales of the Conceptual Style Test are of interest. Some researchers (e.g. Nelson and Chavis 1977) prefer to label students who score high on the Hidden Figures Test 'analytic', whilst those who are unable to score high on it 'global' or 'non-analytic'. The two sub-classes of responses within the 'descriptive' category, the 'descriptive-analytic' and the 'descriptive-global' (Archer 1970), were not identified in this study and the possible 'washout' effect of combining these may have masked any possible individual correlations with the field independence measure (and any other measure used in this study, other than those within the same test). The significant correlation ($r = 0.14$; $p < 0.01$) between the 'categorical' subscale and the Hidden Figures Test could suggest the categorical response style, not only is an active mode and one in which higher order constructs are preferred (see above) but, is possibly more analytic and, thereby, more effective in a science context. However, Wachtel's (1968) distinction that a high field independent score may reflect an analytic capacity whereas the production of analytic groupings, on such as Kagan's test, may reflect a stylistic preference, is acknowledged.

The general findings were conveniently summarized in the form of a regression equation in which the relationships between the various measures (the independent variables) used in the initial survey were particularised and thus allowed for a prediction of an individual student's likely score on the science measure (the dependent variable).

Table 6.3 gives the results of a step-wise multiple regression analysis, using the 'Statistical Package for Social Sciences', Nie et al (1975), as after the fourth step (so as to include only those independent variables with statistically significant F ratios - $p<0.01$).

Table 6.3: Summary of the variables included in the equation derived by the step-wise multiple regression analysis on data obtained by the measures used in the initial class surveys, with the Science Questionnaire as the dependent variable.

Variables entered on step number 4:

Variable	B	Beta	Standard error of B	F
TOSCA	0.58	0.45	0.05	116.4*
Hidden Fig.	0.65	0.19	0.14	21.2*
-IAR	-0.65	-0.10	0.26	6.3*
Categ. CS	0.32	0.08	0.17	3.9*
(constant)	-19.72			
			DF 4,454	*$p<0.01$

Regression Equation:

$$Y' = -19.72 + 0.58\,\text{TOSCA} + 0.65\,\text{Hid. Fig.} - 0.65\,\text{-IAR} + 0.32\,\text{Cat. CS}$$

R = 0.58
S.E.M. = 13.63

The TOSCA measure emerged as the most important independent variable, followed by the field independence measure. The inclusion of this second variable provides support for the suggestion that as science requires an analytic approach to information the field independence-field dependent dimension is associated with the degree to which individuals can function analytically (Witkin, et al 1977).

The inclusion of the -IAR subscore measure in the equation is interesting in that the negative weighting implies that a student who accepts responsibility for his/her academic failures is more likely to score lower on the science measure than the student who does not perceive responsibility for such failures. An explanation might be that the student who scores high on the -IAR subscore is one who is overly concerned with his/her failures and that this concern is counter-productive to achievement (as measured by the Science Questionnaire). Perhaps anxiety occurs as a consequence of this perceived personal responsibility and it is this anxiety which interferes with the expression of that ability being tapped by the science measure?

The inclusion of the categorical conceptual style adds little to the overall predictive utility of the equation (refer to the low associated Beta value) but its presence does suggest some support for the idea (above) that it does reflect an 'analytic' conceptual mode.

6.1.2 Hypothesis 1

Hypothesis 1 postulated that no sex differences will be found on the:

(a) Science measure
(b) Test of Scholastic Ability
(c) Hidden Figures Test
(d) Conceptual Style Test, and
(e) Test of Intellectual Achievement Responsibility

Table 6.4: Responses on the measures used in the initial surveys, by sex (two tailed criterion).

Measure	Male N	Male Mean	Male s.d.	Female N	Female Mean	Female s.d.	t-test
Sci. Quest.	264	2.99	17.61	283	-6.18	15.10	6.55**
Hidden Fig.	265	8.07	5.11	281	6.73	4.33	3.31**
Descr. CS	256	8.63	4.08	284	8.31	3.90	0.92
Categ. CS	256	9.28	4.07	284	9.30	4.09	-0.04
Relat. CS	256	6.87	4.67	284	7.15	4.68	-0.70
Total IAR	257	24.84	3.83	284	24.86	3.97	-0.07
+IAR	257	12.88	2.27	284	12.80	2.26	0.41
-IAR	257	11.95	2.41	284	12.06	2.58	-0.48
TOSCA	262	31.84	13.81	294	28.76	12.34	2.76*

* $p < 0.01$ ** $p < 0.001$ (Pooled variance estimate used)

Table 6.4 reveals statistically significant sex differences were found on three of the measures:

(i) The data show the girls did not score as well as the boys on the Science Questionnaire and this result may suggest a possible link to the different outlooks on science found between the sexes. That is, those students who tended to have non-science views (represented by negative scores on the Science Questionnaire) would possibly also express a poorer outlook on science. However, if a causal relationship is suspected, the direction of the relationship is open for conjecture - that is, does a poorer outlook on science produce non-science views, or does the preference to hold non-science views result in poorer outlooks on science?

An item analysis of the Science Questionnaire according to sex (see Appendix 6.2) revealed statistically significant differences on all but 6 out of the 16 items. Yet, of the five practical items involved, only one of them was shown to produce a statistically significant sex difference. This could suggest that those items which did not require other than experiences directly provided in the testing situation, were handled equally well by both girls and boys. All other item responses may have been mediated by prior experiences, and, with their sex role socialisation patterns (see Section 2.2.3), the boys would have been advantaged.

(ii) The previously discussed (Section 6.1.1) correlation between the Hidden Figures Test and the science measure, and the strong sex difference ($t = 3.31$, $p < 0.001$) on the Hidden Figures Test, suggests the existence of a possible intervening variable in the form of a particular ability, apparently more likely to be possessed by males which enables males to be advantaged over females when responding to questions of a scientific kind. This is not a novel suggestion (see Maccoby & Jacklin, 1974:105) but one supported by this study.

(iii) The statistically significant sex difference found on the TOSCA was surprising in that this contradicts the findings by Reid et al (1980) who found, in developing this test, significant sex differences which favoured the girls. The inter-correlations between TOSCA and virtually all the measures (Table 6.2) invited the consideration of an analysis of covariance to explore the extent of the contribution the TOSCA measure to the variance. An analysis of covariance and a multiple classification analysis (Nie, et al, 1975) is shown on Table 6.5.

Table 6.5: An analysis of covariance and multiple classification analysis showing the effects of sex on the Science Questionnaire when the influence of TOSCA has been controlled.

(a) Analysis of covariance:

Source of Variation	Sum of Squares	DF	Mean Square	F
Covariate - TOSCA	4279	1	42792	220**
Main effects - Sex	675	1	6757	35**
Explained	4954	2	24774	127**
Residual	99148	510	194	
Total		512	290	

** = $p < 0.001$

(b) Multiple classification Analysis:
Science Questionnaire Grand mean = -1.77

Sex	N	Unadjusted deviation	Eta	Deviation for TOSCA	adjusted	Beta
Male	243	4.97		3.85		
Female	270	-4.47		-3.47		
			0.28			0.21

Multiple R squared = 0.333
Multiple R = 0.577

From the analysis of covariance (a) in this table, it can be seen that both Sex and TOSCA are statistically significant ($p < 0.001$) variables in the Science Questionnaire scores, and the multiple classification analysis (b) gives the degree of influence in terms of the 'adjustments' needed to the Science Questionnaire grand mean to accommodate the individual effects of these variables. That is, to arrive at the Science Questionnaire means, without considering the effects of TOSCA, for boys, 4.97 would need to be added to the grand mean of -1.77; whilst for girls, 4.47 would need to be subtracted from this grand mean. However, when the effects of TOSCA are considered, the adjustments are reduced to +3.85 for boys, and

-3.47 for girls. This effect of TOSCA is also reflected in the change in the regression coefficients before (Eta) and after (Beta) controlling for TOSCA (i.e. from 0.28 to 0.21). That a third of the total variation in the Science Questionnaire scores may be accounted for by the contributions of the variables of Sex and TOSCA is observed by noting the value of the square of the multiple correlation coefficient (R squared = 0.333).

Within the context of this investigation, the essential point to be noted is that, even when allowance is made for possible scholastic differences between the sexes, statistically significant sex differences in responses to a science measure are readily demonstrated.

6.1.3 Hypothesis 2 examined

Hypothesis 2 postulated that no ethnic differences will be found on the

(a) Science measure
(b) Test of Scholastic Ability
(c) Hidden Figures Test
(d) Conceptual Style Test, and
(e) Test of Intellectual Achievement Responsibility.

The data depicted in Table 6.6 reveal the greatest ethnic differences to occur between the European and Maori student samples, and that the Pacific Island means tended to be intermediate to those of the other groups.

The ethnic differences on the TOSCA, together with the previously noted correlation between TOSCA and the Science Questionnaire scores, would suggest that the Maori and Pacific Island students

Table 6.6 : Responses on the measures used in the initial surveys by ethnic groups (two tailed criterion)

	European			Maori				Pacific Island				
Measure	N	Mean	s.d.	N	Mean	s.d.	t(E/M)	N	Mean	s.d.	t(M/PI)	t(E/PI)
Sc. Quest.	357	1.79	17.11	152	-9.88	14.07	7.4**	26	-4.62	10.98	-1.8	1.9
Hid Fig.	355	7.79	5.09	146	6.36	3.67	3.1*	30	7.20	4.98	-1.1	0.6
Des-CS	355	8.62	3.91	142	7.81	4.03	2.1	29	9.38	4.25	-1.9	-1.0
Cat-CS	355	9.58	4.05	142	8.49	4.11	2.7*	29	9.76	4.16	-1.5	-0.2
Rel-CS	355	6.62	4.34	142	8.28	5.27	-3.6**	29	5.48	4.02	2.7*	1.4
Tot. IAR	354	25.15	3.84	144	24.10	4.08	2.7*	29	24.97	3.20	-1.1	1.4
+ IAR	354	13.04	2.27	144	12.36	2.34	3.0*	29	12.86	1.68	-1.1	0.4
- IAR	354	12.11	2.41	144	11.74	2.71	1.5	29	12.10	2.18	-0.7	0.0
TOSCA	363	34.07	12.08	149	21.47	10.91	11.0**	29	23.79	10.53	-1.1	4.8**

* $p < 0.01$
** $p < 0.001$ (pooled estimate used)

Note: An analysis of variance, together with the Scheffe procedures, was used to corroborate these t-test significance levels - see Appendix 6.3 for details.

were disadvantaged in science because of their more restricted 'scholastic' capabilities. That is, the scholastic bias within the Science Questionnaire itself influenced the resultant ethnic ranking of the mean scores.

The data on the measure of conceptual style warrant comment: no statistically significant ethnic differences were apparent on the descriptive mode; European students scored statistically significantly more categorical responses than did Maori students, and statistically significant ethnic differences occurred with the use of the relational mode with the Pacific Island students giving fewer relational responses than did the European students. Therefore, in view of the correlation noted between the Science Questionnaire scores and the categorical response style, these results would suggest the categorical response mode to provide some indication of 'scientists' science' thinking.

Also, these results provide support for Harker's (1976) suggestion that stylistic preferences may vary across cultural boundaries. It is not possible to say whether the actual ability to form different conceptual categories per se varies across cultural boundaries, but the possibility that the Maori students within this study had difficulty with science because of their penchant for using relational, rather than categorical, response modes does exist. The European/Pacific Island similarities in the use of the various conceptual response modes suggests a greater commonality of conceptual styles (and construct systems) than hitherto suspected.

The European/Maori differences on the Hidden Figures Test contradicts Chapman's (1973) finding of no difference, but, as Chapman's study was with only male adolescents, further research would be necessary before an unequivocal interpretation of the educational implications of these findings is offered.

With respect to the IAR scores, the only statistically significant ethnic differences were those which occurred between the European and the Maori students on the total, and the positive IAR scores. That is, the European students were more likely than Maori students to perceive themselves as being responsible for their overall academic outcomes. All three student groups (European, Maori, and Pacific Island) were equally likely to perceive (or not to perceive) themselves as being personally responsible for their academic failures.

It is not possible to state whether these student samples differed from the population of school pupils in general because no normative data are available, but, as the mean scores for all groups were well above chance level, it would appear that all these students tended to have relatively high internal loci of control. Also, because of the lack of correlation between the Science Questionnaire scores and those of the IAR, it is not possible to suggest how the locus of control concept can be usefully applied in a direct way to answer the research question. It had been anticipated that the study of science might be perceived by the students as being somewhat academic and that, as evidence has been cited which linked locus of control with general academic achievement (Chance 1965), empirical support for a possible causal link between scientific thinking and locus of control would have been found.

6.2 The TRA analyses.

This section provides the data from the final questionnaire given to the F4 students only (brief analyses of the F5 responses are found in Appendix 6.4). The results of the preliminary open-ended questionnaire which provided the material for the final 'closed' questionnaire are provided in Appendix 6.5.

In order to highight possible sex and/or ethnic differences between the student groups, data pertinent to each component of the TRA are considered separately, before the complete models are presented and discussed.

The small numbers of Pacific Island students in this particular student sample have been combined with the Maori student figures to give the single 'Polynesian' group.

6.2.1 Prediction of science intention

The first item of the questionnaire (see Appendix 3.19) asked the students to indicate, on a five point scale, the 'strength' of their intentions to be successful in science in F5.

The data presented in Table 6.7 show the strength of the boys' intentions to their anticipated F5 science studies to be statistically significantly greater ($p < 0.05$) than the girls', and no statistically significant differences between the strength of intentions for the two ethnic groups. However, the direction of the difference in the means between the ethnic groups concord with the evidence (see pps 1-2 of this thesis) that more European students than Polynesian students (and more boys than girls) manifest such intentions by studying science at the F5 level. Had the item required the students to simply express their intention to study, or not to study, science in F5, statistically significant differences between both pairs of groups might have been found, but such an item would have rendered the rest of the questionnaire inappropriate for those students who indicated they did not intend to study science in the next year. As written, the item did allow for relevant responses to the remaining items from all students to be made.

Table 6.7: t-test analyses of the sex and ethnic differences between F4 students in their responses with respect to the strengths of their intentions to be successful in science in F5 (two tailed criterion).

Group	N	Mean	t-value	probability
Boys	71	3.82	2.40	0.02
Girls	81	3.27		
European	115	3.57	1.35	0.18
Polynesian	26	3.15		

6.2.2 Attitudes and social standards with respect to studying science.

The TRA model allows for a comparison to be made between the contribution made by the students' attitudes to studying science, and that made by their social standard (the students' beliefs that most people, important to them, think the students should, or should not, study science in F5).

The students' 'attitudes' (as operationally determined for the purposes of this analysis) were determined by calculating a value (see Appendix 3.19) derived from a summation of the students' responses on a five-point scale to eight bi-polar constructs. For example:

For me, studying science next year in the fifth form will be

interesting	________	_____	_______	_____	________	boring
	extremely	quite	neither	quite	extremely	

The simple linear transformation of the values assigned to each response category produced an attitude range from -10 to +10 (with negative, neutral, and positive attitudes being identified with the appropriate sign of the resultant scores).

The data displayed in Table 6.8 show all the mean values to be positive but with discernible intergroup differences between the mean attitude values; the boys' attitudes were shown to be considerably more positive than that of the girls, and Europeans' to be slightly more positive than that of the Polynesians'. These data also concord with the qualitative evidence presented in the previous chapter concerning the outlooks on science expressed by these student groups. The correlation coefficients between these measures of attitudes and of intentions were all statistically significant ($p < 0.001$). Namely, $r = 0.78$ (boys); 0.91 (girls); 0.83 (Europeans); and 0.85 (Polynesians). Thus, attitudes would appear to covary strongly with intention. That is, students who expressed positive attitudes towards science also tended to express an intention to study science in F5 and those students with negative attitudes towards science were less likely to intend studying it in F5.

Table 6.8: t-test analyses of the sex and ethnic differences between the F4 student groups with respect to their attitudes towards studying science in F5 (two tailed criterion).

Group	N	Mean	t value	Probability
Boys	71	4.99	3.21	0.002
Girls	81	2.46		
European	115	4.03	1.98	0.049
Polynesian	26	1.89		

The social standards were determined by the responses given to the item:

Most people who are important to me think I should study science next year in the fifth form

agree ______ ______ ______ ______ ______ disagree
strongly quite neither quite strongly

This was scored on a five point scale (-2 for 'strongly disagree' to +2 for 'strongly agree').

Table 6.9: t-test analyses of the sex and ethnic differences between the F4 student groups with respect to their social standards for studying science in F5 (two tailed criterion).

Group	N	Mean	t value	Probability
Boys	71	0.70	2.97	0.004
Girls	81	0.12		
European	115	0.51	2.06	0.041
Polynesian	26	-0.04		

The data in Table 6.9 show very similar patterns to that in the previous table. Boys, and European students, perceive 'significant others' in their lives to think they (the boys and the European students) should study science to a greater extent, than do girls and Polynesian students. This evidence provides an empirical measure of the extent that other people's beliefs and opinions are perceived by the students themselves. The degree to which the social standards covary with intention is reflected in the correlation coefficients associated with these measures. Namely, $r = 0.50$ (boys); 0.80 (girls); 0.77 (Europeans); and 0.61 (Polynesians). All are statistically significant ($p < 0.001$).

Within the TRA model, the attitudes and social standards are the immediate determinants of intention. Therefore, a multiple correlation coefficient between intention (the dependent variable) and students' attitude and social standard would be predicted to be high. This was shown to be so: $R = 0.81$ (boys); 0.94 (girls); 0.91 (Europeans); and 0.94 (Polynesians). Thus, students who had positive attitudes towards studying science in F5 and who believed others thought they should study science, intended to be successful in their next year's science studies. The converse also would apply.

Although the analyses, to this point, show that both attitudes and social standards contribute significantly to the students' intentions to be successful in science in F5, it is interesting to note several differences in the <u>relative</u> contributions to intention made by these determinants between the different student groups. Estimates of relative importance may be obtained by considering the regression coefficients (beta weights) associated with each component and the dependent variable.

For boys, these values were 0.78 and 0.27 for the attitudinal and social components, respectively; for girls, they were 0.65 and 0.45; for Europeans, 0.62 and 0.42; and for Polynesians, 0.86 and 0.52. Therefore, within each student group, the attitude component was considered the more important determinant of intention than was the social standard. The finding that the contribution of the girls' social standard to intention was of greater relative importance than that of the boys' supported the observation that during interviews it was more often the girls, rather than the boys, who mentioned the influence of others on their thinking:

"Nana believes I could do without science as she thinks it's not important - I'd be better doing something like Home Economics, clothing, etc." (F4 girl).

"Friends would think you were crazy (if you took science) because it's so hard!" (F4 girl).

6.2.3 Determinants of attitudes and social standards

According to the TRA model the determinants of attitudes and social standards towards studying science are the salient objective and social beliefs within the conceptual system held by the students. These were explored by the open-ended questionnaire with the questions:

> "What are the advantages, for you personally, in studying science in the fifth form?"

> "What are the disadvantages, for you, in studying science, in the fifth form?"

Responses to these questions enabled eight specific salient objective beliefs to be identified (e.g. 'I believe that obtaining scientific knowledge is worthwhile') to which students, answering the final questionnaire, expressed the extent of their agreement or disagreement on a five point Likert scale. Also, in order to arrive at a measure of the student's evaluation of these objective beliefs (as distinct from mere agreement/disagreement), another response item in the questionnaire required them to respond to these same objective beliefs within the context of F5 science. Thus, a typical objective belief evaluation statement, to which the students responded, was:

> "I believe that by studying science next year in the fifth form I will be able to find a job when I leave school."

Strength of agreement/disagreement was again indicated on a five point scale.

The responses to both components of these objective beliefs were scored, combined, and linearly transformed (Appendix 3.19) to provide a range of values from -80 to +80 (negative values corresponded with unfavourable beliefs and/or low evaluations of them; positive values corresponded with favourable beliefs and/or high evaluations of them).

Table 6.10 provides the t-test analyses of the resultant data.

Statistically significant inter-group differences occurred only between the sexes, with the boys tending to agree with the set of objective beliefs more, and/or associating them closer with F5 science, than the girls. The boys' greater informal, out-of-school experience with scientific phenomena may be implicated in this analysis. The non-significant ethnic difference suggests the European and Polynesian students, as distinct groups, responded similarly to the objective belief items.

Table 6.10: t-test analyses of the sex and ethnic differences between the F4 student groups with respect to their objective beliefs and outcome evaluations of these beliefs (two tailed criterion).

Group	N	Mean	t value	Probability
Boys	71	4.11	2.67	0.008
Girls	81	3.45		
Europeans	115	3.87	1.24	0.217
Polynesians	26	3.46		

Just as the attitudes within the TRA model are determined by the set of objective beliefs and their evaluations held by the students, the social standards are determined by the set of social beliefs, or beliefs about specific people, and the extent of the students' motivation to comply with these people. These people were identified within the preliminary open-ended survey by the question:

> "Think hard about the people, or groups of people, who are most important to you in your life (perhaps relations, friends, teachers, possible employers, etc).

- List those who you believe would think science is an important subject for you to study. Indicate who they are after their name.

- List those who you believe would think science is not an important subject for you to study. Indicate who they are beside their name."

In a fashion comparable to that used in determining the measure of the students' objective beliefs, two items referring to specific people, or groups of people, were developed for the final questionnaire. For example, the students were instructed to indicate the strength of their agreement or disagreement (on a five point scale) that 'My father thinks I should study science next year in the fifth form.' The motivation to comply component of the social belief was determined by the students' responses to the statement, 'I usually do what my father wants me to do' (again scored on a five point scale with respect to agreement/disagreement).

The two social belief components were combined (Appendix 3.19) to produce scores with a possible range of value from -80 to +80 (negative values correspond with student perceptions that the people identified did not want them to study science in F5 and/or expressions of non-compliance with those people who would want them to continue with a study of science, and/or compliance with those people who would not want them to continue with a study of science; and vice versa).

Table 6.11 provides the t-test analyses of the resultant data.

From this table it can be seen that no marked inter-group differences were apparent, although the differences noted indicate that the boys, and European students, did perceive specific people to encourage them to study science in F5, and/or tended to comply with these people, more than did the girls and the Polynesian students. The influence of sex role stereotyping and the image of science as being a masculine pursuit could be suspected to be a factor in forming such perceptions.

Table 6.11: t-test analyses of the sex and ethnic differences between the F4 student groups with respect to their social beliefs and motivations to comply with the referents identified in these beliefs (two tailed criterion).

Group	N	Mean	t value	Probability
Boys	71	3.02	2.32	0.022
Girls	81	2.69		
Europeans	115	2.93	2.55	0.012
Polynesian	26	2.48		

Within the TRA model the predictive utility of ascertaining the students' objective and social beliefs is assessed by noting the extent of the correlation between the objective beliefs and the attitude components, and that between the social beliefs and the social standard components.

For boys, the correlation between the objective beliefs and the attitude component was high ($r = 0.71$), while for the girls it was still positive but relatively considerably lower ($r = 0.36$). This would suggest that the determinants of attitude differ between the sexes. That is, girls' attitudes are determined by factors other than just their objective beliefs about science, whereas boys' attitudes are considerably determined by their objective beliefs. One explanation for this could be that as boys generally have a wider range of out-of-school science experiences than do girls and so, have formulated a greater range of objective beliefs about science and, in evaluating them, are more likely to express positive attitudes.

A similar pattern of intergroup differences occurred when the ethnic groups are compared. The correlation coefficient between objective beliefs and attitudes for Europeans was r = 0.53, and r = 0.34 for the Polynesian students. Perhaps a similar explanation to that offered above to account for the sex differences is also tenable here?

The resultant correlations between the social beliefs and social standards did not show such marked intergroup differences: r = 0.62 (boys); 0.51 (girls); 0.50 (Europeans); and 0.71 (Polynesians). Thus, overall, the responses to the set of social beliefs appear quite strongly predictive of social standard responses (particularly for Polynesian students).

6.2.4 Cognitive foundations of intentions to study science in F4

This subsection provides a more detailed analysis of the cognitive foundations on which the various components of the TRA model rest. Figure 6.1 shows the relationships between the components of the TRA model as discussed above. These relationships give a measure of support to the assumptions which lie behind the TRA model.

Figure 6.1: TRA models illustrating the relationships between F4 students' objective beliefs, attitudes, social beliefs, social standards, and their intentions to study science in F5.

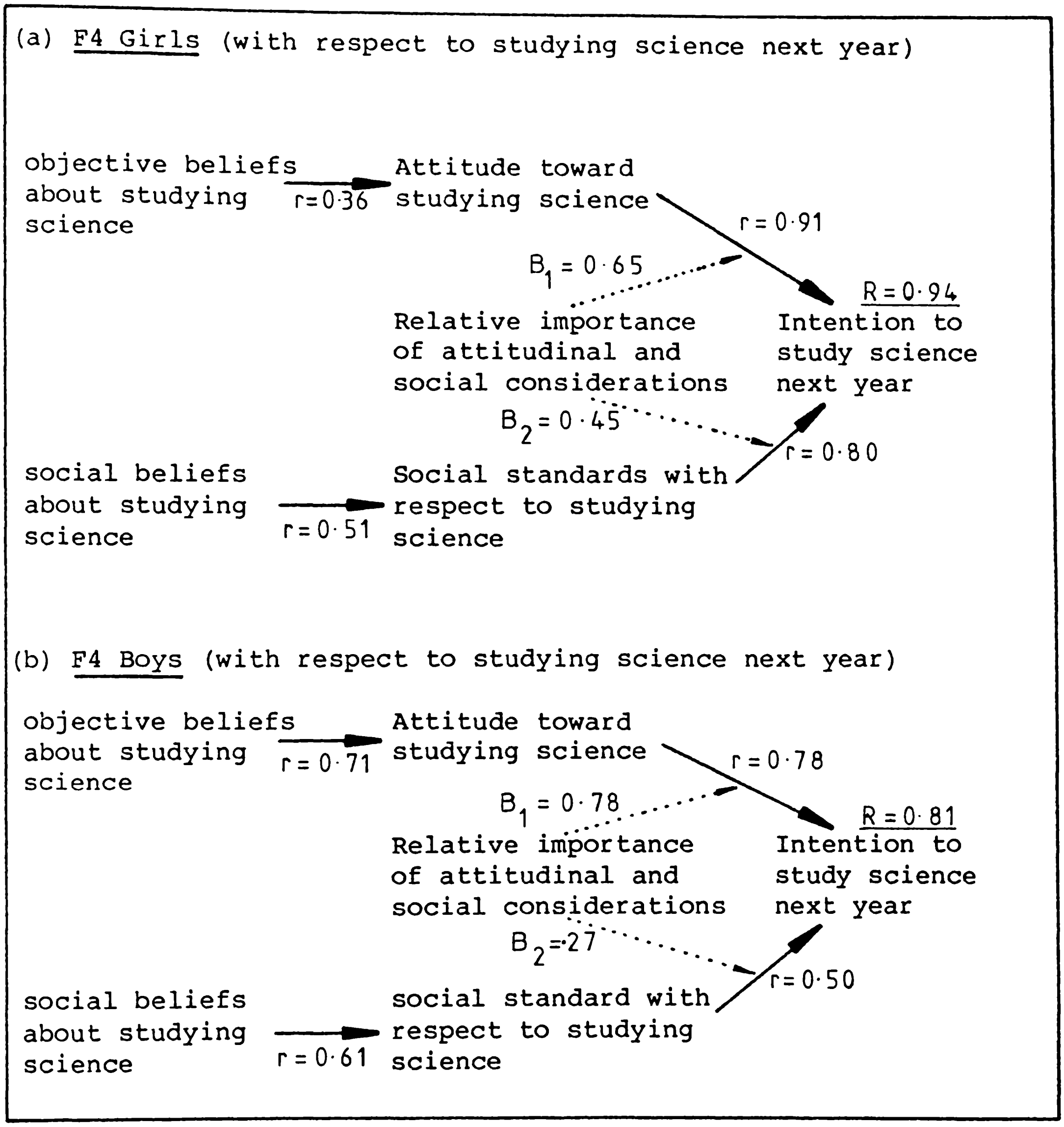


Figure 6.1 (Continued)

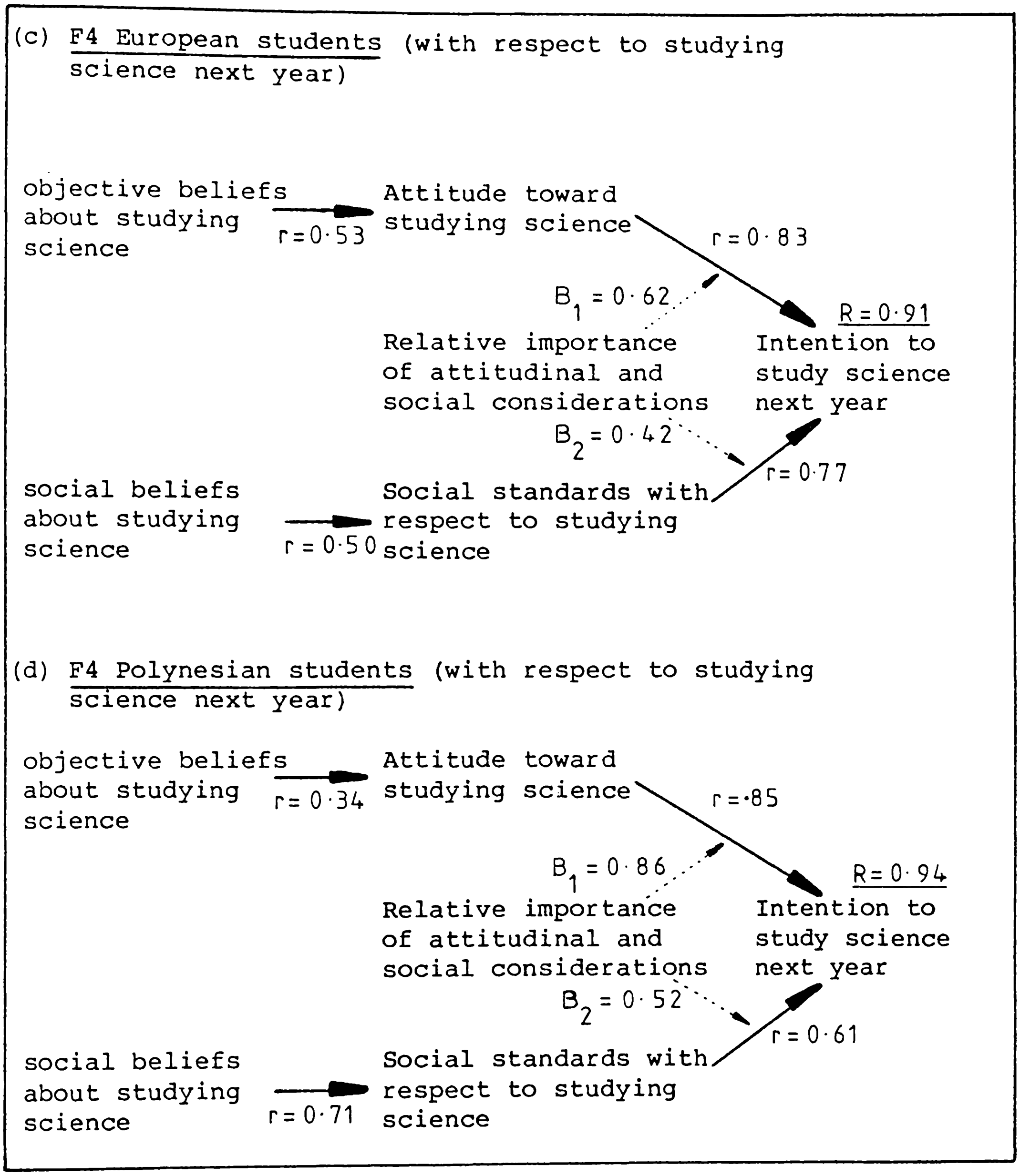


Table 6.12: t-test analyses of the sex and ethnic differences between the F4 student groups on the attitude measure used in the final TRA questionnaire (two tailed criterion).

Items	Mean Scores Boys (N=71)	Mean Scores Girls (N=81)	t value	Mean Scores Europ. (N=115)	Mean Scores Poly. (N=26)	t value
a) interesting/ boring	2.2	2.7	-2.65**	2.4	3.0	-2.67**
b) worthless/ worthwhile	4.1	3.5	3.24***	3.9	3.4	1.86
c) wise/ foolish	2.0	2.4	-2.32*	2.1	2.5	-2.09*
d) necessary/ unnecessary	2.1	2.7	-3.18**	2.3	2.5	-0.82
e) difficult/ easy	2.8	2.3	3.34***	2.6	2.1	2.46*
f) lot of work/ little work	2.1	1.9	1.74	2.0	2.0	0.45
g) useful/ useless	1.9	2.4	-2.75**	2.0	2.4	-1.56
h) feminine/ masculine	3.0	3.0	1.93	3.0	3.0	1.15

1. The left hand pole of the item pairs was scored 1, the right hand pole 5, with intermediate response categories scored appropriately Therefore, interpretation of these scores requires attention to be given to the orientation of each item adjective pair.
2. These items were preceded with the statement, "For me, studying science next year in the fifth form will be ..."

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

The attitude scores were derived from the students' responses to the eight item (Likert) bipolar adjectives. An item analysis of the groups' responses is given in Table 6.12.

The data in Table 6.12 reveal the considerable sex differences in attitude to be due to the boys anticipating their F5 science studies to be more interesting, worthwhile, necessary, easy, and useful ($p < 0.01$) than the girls. The slightly more positive attitudes of the European students seem to be particularly influenced by the first item; European students anticipated F5 science to be more interesting than did the Polynesian students ($p < 0.01$). The only other statistically significant ($p < 0.05$) ethnic difference which occurred indicated the Polynesian students perceived science to be more 'difficult' and more 'foolish' than did the European students. However, the directions of the differences of all other items were such that discernible, and possibly important, differences between the student group's outlooks on science would be anticipated.

The set of objective beliefs, identified by the preliminary survey, the student groups' mean responses to them, and their mean evaluations of them, are shown in Table 6.13. Four statistically significant intergroup mean differences emerged from this item analysis, but, once again, consistent differences emerged in the general direction of boys and European students expressing the more positive outlooks on the anticipated F5 science studies. The first item, "I believe that obtaining scientific knowledge is worthwhile" produced a significant sex difference ($p < 0.01$). However, the students' interpretations of the term 'worthwhile' was not investigated. The qualitative research, previously discussed, would suggest boys to use the term as in 'worthwhile for a career', whilst the girls may have interpreted as 'worthwhile in an everyday sense'. An 'affective' dimension could also be involved as is evident from the significant ($p < 0.01$) sex difference on the mean evaluation scores on the final item, "I believe that by studying science next year in the fifth form I will find my school work enjoyable"; boys evaluated this item far higher than did the girls. That is, while both sexes agreed school work should be enjoyable (mean concordance values for both sexes was 1.4, that is, between 'strongly' and 'quite' agree), the girls tended to disagree that the study of F5 science would contribute to their finding school work enjoyable (the boys were 'neutral' in their evaluation of this item).

Table 6.13: t-test item analyses of the sex and ethnic differences between the F4 student groups on their objective beliefs and outcome evaluations with respect to studying science in F4 (two tailed criterion)

(i) Groupings by sex:	mean concordance		#	mean evaluation		#
beliefs	boys	girls	t value	boys	girls	t value
a) obtaining scientific knowledge is worthwhile	1.8	2.1	-2.61**	1.8	2.1	-1.97*
b) we need to know about our world	1.6	1.8	-1.70	2.0	2.2	-1.65
c) we need to learn about ourselves	1.6	1.6	-0.22	2.3	2.3	0.56
d) we need to improve the world	1.7	1.8	-0.58	3.1	3.2	-0.42
e) I need to find a job when I leave school	1.3	1.2	0.44	2.4	2.7	-1.57
f) I need to understand school subjects better	1.9	2.0	0.74	2.8	3.2	-2.44*
g) practical work is important	1.7	1.9	-2.17*	2.2	2.6	-2.47*
h) school work should be enjoyable	1.4	1.4	0.38	2.7	3.2	-2.74**

(Continued on next page)

Table 6.13 (Continued).

(ii) Groupings by ethnicity:

beliefs	mean concordance # Eur.	Poly.	t value	mean evaluation # Eur.	Poly.	t value
a) obtaining scientific knowledge is worthwhile	1.9	2.2	-2.19*	1.9	2.2	-1.48
b) we need to know about our world	1.7	1.7	-0.29	2.1	2.2	-0.93
c) we need to learn about ourselves	1.6	1.8	-1.85	2.2	2.4	-0.75
d) we need to improve the world	1.7	1.9	-1.11	3.2	2.9	1.44
e) I need to find a job when I leave school	1.2	1.3	-0.32	2.4	2.7	-1.16
f) I need to understand school subjects better	1.9	1.9	-0.18	3.0	3.1	-0.23
g) practical work is important	1.8	1.7	0.49	2.5	2.2	1.45
h) school work should be enjoyable	1.3	1.6	-2.12*	3.0	3.2	-0.76

= Low scores indicate strong concordance, and high evaluation

* $p < 0.05$ **$p < 0.01$

The student groups' responses to the specific social beliefs underlying the social standards and their mean motivation to comply values, are displayed in Table 6.14.

Several intergroup differences are apparent. As well as themselves, the boys believed that their parents, friends, teachers, and possible employers, would think the boys should study science in F5. The girls did not perceive these people to think the same about themselves (the girls) and F5 science. Very marked sex differences are noted for the students' mothers, teachers, and possible employers; the latter probably reflects the boys' perceived career application of science. No significant sex differences occurred on the mean compliance scores (the range from 1.6 for the boys' 'myself', to the girls' 4.0 for 'sister', is noted with interest!).

Table 6.14: t-test analyses of the sex and ethnic differences between the F4 student groups on their social beliefs and motivation to comply with the referents so identified (two tailed criterion).

(i) Grouping by sex:

referents	mean concordance # boys	girls	t value	mean compliance # boys	girls	t value
a) Myself	2.0	2.5	-1.88	1.6	1.8	-1.25
b) My father	2.2	2.6	-2.28*	2.2	2.3	-0.52
c) My mother	2.0	2.5	-2.89**	2.1	2.1	-0.18
d) My brother	2.7	2.8	-0.80	3.7	3.7	0.16
e) My sister	2.7	2.8	-0.64	3.7	4.0	-1.18
f) My relations	2.8	2.9	-0.69	3.2	3.1	0.41
g) My friends	2.5	2.9	-2.35*	2.9	3.0	-0.46
h) My teachers	2.1	2.5	-2.97**	2.4	2.4	0.30
i) My possible employers	2.1	2.7	-3.52***	2.6	3.0	-1.38

(ii) Groupings by ethnicity:

referents	mean concordance # Euro.	Poly.	t value	mean compliance # Euro.	Poly.	t value
a) Myself	2.2	2.9	-2.21*	1.7	1.9	-1.29
b) My father	2.3	2.7	-1.66	2.1	3.0	-3.74***
c) My mother	2.2	2.5	-1.45	1.9	2.9	-4.55***
d) My brother	2.8	2.7	0.71	3.8	3.2	1.76
e) My sister	2.8	2.7	0.10	4.0	3.3	2.13*
f) My relations	2.9	3.1	-2.55**	3.1	3.3	0.65
g) My friends	2.6	3.1	-2.12	2.9	3.3	-1.57
h) My teachers	2.3	2.4	-0.34	2.3	3.0	-2.56**
i) My possible employers	2.4	2.7	-1.73	2.5	3.3	-2.02*

= Low scores indicate strong concordance, and high compliance.

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

The only statistically significant ($p < 0.05$) ethnic differences on the mean concordance values were those for 'myself' and 'relations' where, in both cases, the European students' responses were the more positive. An examination of the mean values indicated that the Polynesian students felt they themselves, and their relations, believed they should not study science next year.

Several statistically significant ($p < 0.05$) intergroup ethnic differences occurred between the mean compliance values. European students were less likely than Polynesian students to perceive themselves as complying with their sisters. The reasons for such perceptions, unfortunately, were not investigated, but the possibility exists that culturally different child rearing practices may be a factor. Polynesian children tend to be brought up in larger families more by older siblings (Ritchie & Ritchie, 1978; 1979; Smith, 1982) whereas European children tend to be brought up in smaller families in which contact with adults is more apparent. Such practices may influence subsequent impressions of compliance to others, particularly to adults and siblings.

6.2.5 Summary of the TRA analyses

The Theory of Reasoned Action is premised by the assumption that a person's intention (for example, to study, or not to study, science in F5) is a function of two basic determinants, one personal in nature, and the other reflecting social influence.

The analyses provided in this section have indicated that, for boys, the personal determinants, that is, their attitudes towards studying science, in the fifth form and their objective beliefs about studying science are considerably more important in determining their intention towards continuing with a study of science, than are their social determinants. For girls, whilst the personal determinants are also important, so too are the social determinants. Significant sex differences were identified between the students' perceptions of what particular people, important to them, thought about them studying science in F5. These people were parents, friends, teachers, and possible employers.

Boys' attitudes towards studying science were seen to be largely determined by their objective beliefs about science, whereas girls' attitudes were determined by factors other than just these beliefs (these other factors lay outside the domain of the TRA model and are discussed in the next chapter of this thesis). The suggestion was made that the boys' objective belief systems, regarding science, would be more extensive than the girls' and so offered them stronger bases from which to evaluate possible outcomes of studying science.

The ethnic differences were of a similar kind to the sex differences. Polynesian students' objective determinants towards studying science were stronger than their social determinants, but their attitudes were not wholly determined by the set of objective beliefs about science (this paralleled the girls' pattern above), whereas the European students tended to be more so (obviously, the contribution of the European boys' association between objective beliefs and attitudes would account for much of this correlation). However, the Polynesian students' social standards were determined by their underlying social beliefs to a larger extent than was the case with the European students. An item analysis of the students' responses to the social beliefs, and motivation to comply with specific referents items, revealed interesting ethnic differences - Polynesian students were less likely than European students to perceive themselves, and their relations, as believing science to be an important subject for study in F5, and the Polynesian students indicated they were less likely to comply with adults than were the European students. The suggestion was made that different child rearing patterns may be a factor in determining these findings.

6.3 The results from Section B of the Science Attitude Questionnaire

Section B of the Science Attitude Questionnaire allowed for the collection of supplementary quantitative data and, although they are not part of the TRA analyses, for convenience, a brief summary of the findings are provided in this section. Full tabular results are to be found in Appendix 6.6.

The first two questions asked the students (a) how likely was it that they would study each of the three science options (Biology, Chemistry, Physics) in the future, and (b) to indicate reasons for their responses. See Table 6.15.

As was expected, girls were more likely than boys to study biology, but less likely to study chemistry and physics. No significant ethnic differences occurred within the responses to biology, but the European students were more likely than the Polynesian students to study chemistry and physics.

Table 6.15: t-test analyses of the sex and ethnic differences between the F4 student groups on their likelihood of studying each science option beyond F4 or F5 (two tailed criterion).

Group	N	Biology Mean	Biology t value	Chemistry Mean	Chemistry t value	Physics Mean	Physics t value
Boys	71	2.9	2.57**	2.9	-2.06*	2.4	-6.07***
Girls	81	2.4		3.3		3.7	
European	115	2.6	-0.43	2.7	-2.08*	2.2	-3.93***
Polynesian	26	2.7		3.3		3.3	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

An analysis of the most prevalent reasons given for these responses showed that 27% of the boys 'didn't like' biology (versus 15% of the girls), whereas 30% of the girls believed it to be 'interesting' (compared with 21% of the boys). Although significant ethnic differences on the intentions to study biology further were not found, different reasons were offered; for example, European students suggested possible career applications more often than the Polynesian students. In fact, the suggestion of a career application was a common theme behind all the remaining intergroup differences. That is, boys and European students, offered a career dimension for studying chemistry and/or physics in one of the first three most 'popular' categories of response, whereas girls, and Polynesian students, preferred to offer 'affective' responses (e.g. 'I don't like physics') or 'objective belief' statements (e.g. 'I don't need to know anything about physics'). For example, 38% of the boys indicated physics would be necessary for a career, but only 6% of the girls offered a similar reason.

Table 6.16 gives the data on the three most common response categories given by each student group to the questions:

(a) "What job, or career, do you hope to have when you leave school?"

(b) "What job, or career, do you think you will have when you leave school?"

Table 6.16: The three most common response categories given by each F4 student to the question, "What job, or career, do you hope to have when you leave school?"

Boys (N=69)	Girls (N=81)	Europeans (N=114)	Polynesians (N=25)
Semiprofessional (25%)	Don't know (25%)	Semiprofessional (25%)	Don't know (28%)
Apprenticeship (22%)	Semiprofessional (22%)	Don't know (18%)	Apprenticeship (20%)
Professional (19%)	Shop Assistant (21%)	Professional (17%)	Semiprofession (16%)

(b) "What job, or career, do you think you will have when you leave school?"

Boys (N=70)	Girls (N=79)	Europeans (N=112)	Polynesians (N=26)
Don't know (43%)	Don't know (57%)	Don't know (34%)	Don't know (69%)
Semiprofessional (21%)	Shop Assistant (17%)	Semiprofessional (19%)	Semiprofess. (12%)
Apprenticeship (13%)	Semiprofessional (15%)	Professional (13%)	Apprenticeship (8%)

These data reveal important sex and ethnic differences in vocational aspirations and expectations. The intergroup differences in the 'status' of vocational aspiration is particularly noticeable; the boys and European student groups expressed 'higher' status aspirations than did the girls and Polynesians.

25% of the girls stated they did not know what job they hoped for when they left school (as opposed to 16% of the boys); and 28% of the Polynesian students did not know (25% of the Europeans). This 9% sex difference and 3% ethnic difference in the 'don't know' category jumps to a 14% sex difference and 35% (!) ethnic differences in the students' response to the second part of the question. That is, girls and Polynesians have a lower expectancy of obtaining the type of job or career they desire than do boys and European students.

Several suggestions to explain the findings that 69% of the Polynesian students 'didn't know' what job they thought they would have on leaving school may be offered:

(a) The phenomenon of shorter future-time perspective, suggested by Bray (1970; 1971a; 1971b) may operate such that the F4 Polynesian students perceive their future vocations not to be discernible and therefore, do not 'know' what they will be doing; whereas the European students, having been well encultured into thinking about the future, are less likely than the Polynesian students to feel they 'don't know' what their vocational future may hold for them.

(b) The attribution of personal control may differ between the ethnic groups in that the European students, being part of the majority ethnic group in New Zealand society, may feel they are able to 'control' their lives, and so anticipate their futures, to an extent not possible to members of a minority ethnic group.

(c) The students' responses (both European and Polynesian) may simply be reflecting the current employment 'reality' - Polynesian people are disproportionately represented in the ranks of the unemployed (e.g. 7% of Maori and 4.3% of European people were estimated to be unemployed in February, 1980; Tauroa, 1982).

(d) The greater contact with adults, experienced by children growing up in a European family (Ritchie & Ritchie, 1978) may result in their possessing wider perceptions of possible vocational ideas and beliefs, than have the Polynesian students, such that the European students are better able to perceive themselves as being in some future employment. The Polynesian students, with these more restrictive perceptions of possible vocational possibilities (and with fewer vocational role models) may not feel so confident in expressing a belief regarding the nature of their future employment. This suggestion is supported by the responses to the question, "Who, or what, helped you to decide what courses you should take?". 63% of the European students stated their parents; this contrasts with the 32% of the Polynesian students who gave the same response. The most common response given by the Polynesian students was that of 'themselves' (44%), only 7% of the European students claimed this (see Appendix 6.6).

One outcome of any of these suggestions could be reflected in a disinclination for Polynesian students to give much consideration for planning future courses of study at school. Table 6.17 provides the percentages of each student group's responses to the question, "How much thought have you given to your future courses at school?".

Table 6.17: F4 sex and ethnic group percentage responses in each response category available to the question, "How much thought have you given to your future courses at school?"

Group	a very considerable amount	quite a lot	very little	none
Boys (N=71)	31.0	59.1	9.9	0.0
Girls (N=81)	38.3	45.7	14.8	1.2
European (N=115)	36.5	53.9	9.6	0.0
Polynesian (N=26)	26.9	46.2	23.1	3.8

Note: A Chi square analysis on the raw frequency data (see Appendix 6.6) showed significant ethnic differences ($p < 0.02$). No significant sex differences were found.

These data show the Polynesian students' responses to be significantly different to those of the European students' ($x^2 = 7.9$; df = 2; $p < 0.002$), see Appendix 6.6). There were no significant differences between the sexes.

Therefore, it might appear that European students are more future orientated in their perceptions than the Polynesian students and, if the study of science is not seen by the Polynesian students to have immediate application, its relevancy for them is not perceived and so it is rejected. The European students, however, appear less likely to need to be satisfied with an immediate application of their studies and to be more accepting of their possible future usefulness.

The final question in Section B of the questionnaire asked the students to state the three most important subjects they would be studying in the next year and to give reasons for each. Very little intergroup difference occurred (see Appendix 6.6); English and mathematics were considered to be the two most important subjects, followed by science.

Career reasons were offered as the main reason for studying these subjects by 64% of the European students, and 46% of the Polynesian students.

Whilst no pronounced sex differences in the reasons offered for studying these subject occurred, more boys than girls consistently suggested career applications for <u>each</u> of the three subjects suggested, whereas a sizeable proportion of girls (e.g. 25% of their third subject choice) suggested reasons such as, "It helps you understand your world better". Thus, boys expressed a greater degree of conformity in their reasons for studying particular subjects, than did the girls. A similar phenomenon occurred between the ethnic groups with a larger proportion of Polynesian students suggesting reasons other than those associated with a career (e.g. "Cos it interests me").

6.4 An overview of the quantitative results.

This section reviews the contribution the quantitative perspective makes to an understanding of the students' outlooks on science by suggesting a 'conjectural scheme' to allow for a consideration of the various insights revealed by each instrument. It concludes by critically examining the instruments used to collect the data for this perspective.

6.4.1 A conjectural scheme

In this scheme a student's outlook on science is considered to involve two major interacting psychological components; namely, the cogitative (or intellectual), and the conative (that to do with intentions). These components may be further subdivided, and the possible relationships between these various components and their derivatives, are depicted in Figure 6.2.

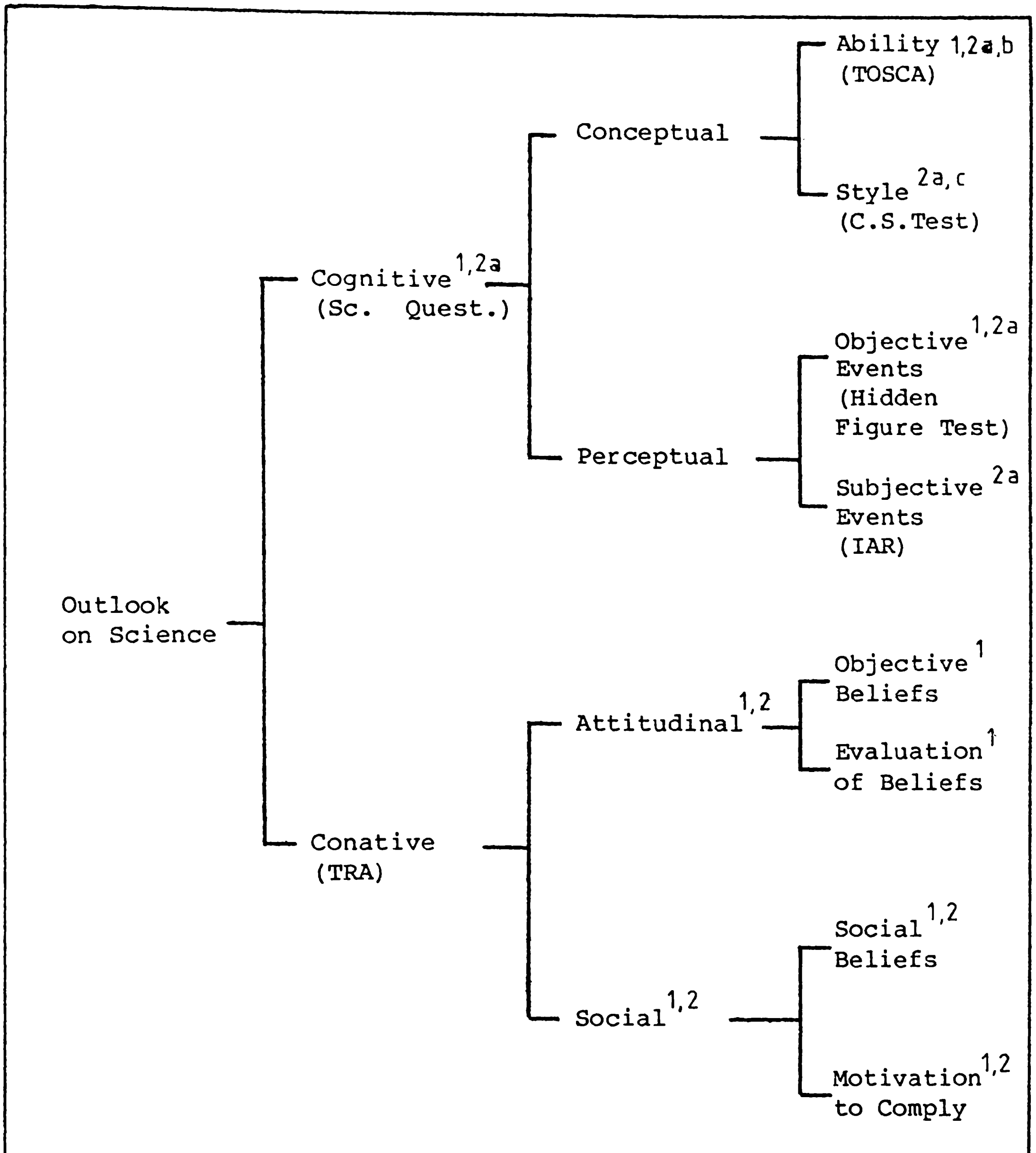
Within this scheme, an individual student's conceptual style (as measured by the Conceptual Style Test) and conceptual ability (as measured in part by TOSCA) may be considered to be part of the cogitative component of his/her outlook on science - the other part of the cogitative component is that found within the perceptual domain. The perceptual domain itself may be considered to consist of two dimensions - that to do with perceptions of objective events external to the individual (such as those provided by the Hidden Figures Test); and that to do with subjective events, which are part of the individual's personal internal world to do with his/her self perceptions (the IAR measures one aspect of this 'world'). The Science Questionnaire is thus, considered to reflect the contributions of these measures within the cogitative component of the individual's outlook on science. This interpretation is consistent with the regression equation previously derived and repeated here for convenience:

$$SQ' = -19.72 + \underset{(TOSCA)}{0.58} + \underset{(Hid.Fig)}{0.65} - \underset{(-IAR)}{0.65} + \underset{(Cat.\ CS)}{0.32}$$

The TRA analyses provide the contribution to the conative, or the intentional (and motivational), component of an individual's outlook on science. Some internal overlap between the various components is anticipated. For example, the TRA analysis of the girls' attitudes showed them to be only partially dependent upon their objective beliefs and evaluations of these beliefs (see Section 6.2.3) and that other 'factors' were suspected. Perceptual 'factors' could provide such other inputs into attitude formation (for girls).

The data produced by the Section B of the TRA questionnaire support several components of this conjectural scheme. For example, the students' responses to the question, "How likely is it that you will study Biology (Chemistry, & Physics)?" provided more data related to the students' <u>conative</u> component of their outlook on science; the reasons the students gave for their responses provided other corroboration of already known, or additional, <u>beliefs</u> (objective and social). Similarly, the questions on the students' <u>perceptions</u> of the kind of future job they hoped to have, and/or think they would have,

<u>Figure 6.2</u>: The conjectural scheme suggested to indicate possible links between the various findings obtained by each instrument used in the quantitative phase of the investigation.



<u>Note</u>: The instruments used in this study are indicated in the parentheses.

1 = Significant sex differences ($p < 0.05$)
2 = Significant European/'Polynesian' differences ($p < 0.05$)
Alphabetical subscripts refer to specific ethnic groups; viz:
a = European/Maori
b = European/Pacific Island
c = Maori/Pacific Island

and the question which asked about the amount of thought they had given to their future school courses, reflected aspects of their 'subjective perceptions'. The final question in this section asked about the three most important subjects the students would be studying in the next year (with stated reasons) and this provided additional beliefs. These beliefs were not necessarily restricted to the science options but they did provide a broader context in which their responses to the science options could be viewed.

Such a conjectural scheme provides for only a partial explanation of the different outlooks on science held by different groups of students. But, within it, an example of a student with a totally positive outlook on science would be one who is scholastically capable (with a high TOSCA score); prefers a categorical or descriptive style of conceptualising; is able to isolate stimuli from a more complex field in which the stimuli may be embedded (as shown by a high field independence score); does not consider him/herself to be particularly responsible for his/her academic failure (shown by a low -IAR score, although this is an equivocal postulate - see Section 6.1.1); believes studying science is worthwhile (has positive attitudes towards studying science); and believes significant others in his/her life think he/she should study science (and tends to comply with these people).

A more complete explanation of the different outlooks on science held by different groups of students requires the simultaneous consideration of the qualitative insights and these quantitative insights. This is taken up in the next chapter.

6.4.2 Comments on the instruments used.

(a) The Science Questionnaire. This instrument adequately met the five criteria (Section 3.3.1) laid down at the inception of the quantitative phase of the study but, it was noted (Section 6.1.1) that the high correlation between it and TOSCA (r = 0.54) suggests it might be measuring more of a 'scholastic' trait than was originally intended. However, an alternative interpretation would be that the study of science *is* a scholastic endeavour and a valid measure of 'scientists' science' would need to show a high correlation with a measure such as TOSCA, which purports primarily to be a measure of scholastic endeavour. Therefore, it is accepted that the Science Questionnaire provided data appropriate for the purposes of this study and that it provided a convenient reference scale with which to determine an individual student's, or a group of students', tendency to respond scientifically to questions of a scientific nature. Item analyses, according to sex and ethnicity, are provided in Appendices 6.2 and 6.7.

(b) The Test of Scholastic Ability (TOSCA). This instrument revealed sex differences in the direction opposite to that found by the test developers (Reid et al; 1980). This finding would indicate that the students investigated in this study may have been an atypical sample of the New Zealand student population. Therefore, as the possibility existed that the TOSCA scores could have influenced the 'apparent' correlations found between all but one measure (the Descriptive conceptual style - refer Table 6.4) another correlation table was drawn up in which the TOSCA scores were partialled out. See Table 6.18.

Table 6.18: First order correlations between all the measures used in the initial class surveys, with the TOSCA scores partialled out, on the data from all students combined.

	2	3	4	5	6	7	8
1. Total IAR	.79**	.84**	-0.05	-0.03	.06	-0.03	-0.10
2. + IAR		.32**	-0.06	-0.02	.07	-0.04	-0.07
3. - IAR			-0.02	-0.03	.04	-0.02	-0.09
4. Cat-CS				-0.32**	-0.56**	.06	.13*
5. Des-CS					-0.57**	.07	.02
6. Rel-CS						-0.09	-0.11*
7. Hidden Figures							.21**
8. Science Questionnaire							

* = $p < 0.01$ ** = $p < 0.001$

Three distinct clusters of significant correlations remain: first, the inter-correlations within the three IAR subscales; second, the inter-correlations within the conceptual style subscales; and third, those between the Science Questionnaire and two of the preceding conceptual style modes, and between the Science Questionnaire and the Hidden Figures Test. The first two clusters of correlations were to be expected, given that the measures were to be reasonably 'internally reliable'. The presence of the remaining cluster suggests, although TOSCA was responsible for some of the correlation obtained between the Science Questionnaire and the Hidden Figures Test, and between the Science Questionnaire and the Cat-CS and Rel-CS scores, other factors are also implicated.

(c) The Hidden Figures Test. This measure, in strongly discriminating between the sexes, and in correlating with the Science Questionnaire, appears to provide some evidence for the existence of a specific ability (or specific abilities) more likely to be expressed by males, rather than by females. This possibility does not answer the research questions, but it does raise others, such as, 'If a specific ability _is_ involved, what is the nature of it (is it analytic)?' 'Why is it possessed by males and not females?' 'Is this ability innate or is it learned?' 'In what way does the possession of this ability assist in the expression of an ability in science?'.

Such questions lie beyond the context of this study but, in being thrown up by this measure, they do indicate one direction subsequent research may be profitably extended.

(d) _The Conceptual Style Test_. This measure was selected because of the possibility that a student's conceptual style may be influenced by the particular micro-culture in which he/she lived, and that the nature of this style may have a bearing on his/her outlook on science. The implication is that, as conceptual styles may differ in the degree of activity or passivity involved, and that if an ability in science requires an active response mode, the student from a micro-culture in which a passive response mode is the norm would be disadvantaged in science.

It is pertinent to consider here the relationships found between the three response modes, based on the total student group responses, and compare and contrast them with those found by Gray and Knief (1975) and with those found by Harker (1976) (Archer, 1970, did not given these intra-test correlations). Gray and Knief (1975) found no correlation between the categorical and relational modes, but did find significant correlations between the categorical and descriptive modes, and between the descriptive and relational modes. See Figure 6.3. They suggested that:

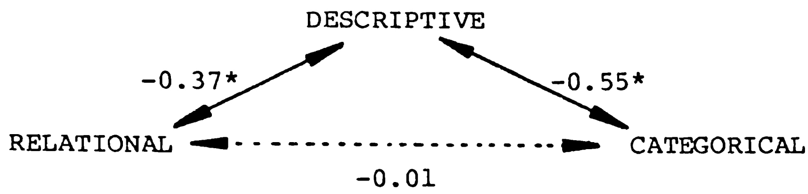
> "Correlations among the cognitive style (sic) indicate that descriptive style was a bi-polar factor with respect to both categorical and relational style, while categorical and relational styles were independent of each other."
> (Gray & Knief, 1975:68)

Harker (1976; n.d.) found a much reduced correlation between categorical and descriptive styles for New Zealand students and strong correlations between relational and categorical, and between relational and descriptive. These findings lead him to conclude:

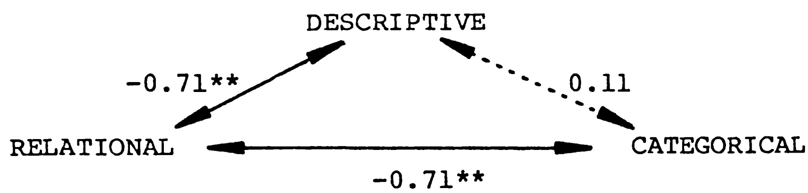
> "... relational style was bi-polar with respect to both categorical and analytic (read 'descriptive') styles, while categorical and analytic styles were independent of each other."
> (Harker, n.d:38)

He suggested that the different 'cognitive environments' between the two school samples (one from the American south-west and the other from New Zealand) could explain these differences.

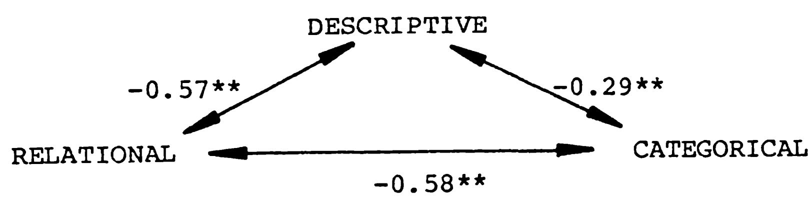
Figure 6.3: A comparison of the correlation coefficients between the conceptual styles obtained by Gray & Knief (1975), Harker (n.d.; 1976), and those in the present study.



(a) Gray and Knief (1975), Table 2, p. 69



(b) Harker (n.d.), Figure 1, p. 37



(c) The total sample used in this study.

*$p < 0.05$ **$p < 0.01$

The current study found correlations between all three cognitive style responses. The correlations between the relational and the descriptive modes, and between the relational and the categorical, were comparable to those of the previous studies, but the correlation between the descriptive and categorical modes, whilst being comparable to Gray and Knief's study, differed markedly from that of Harker's. This leads one to speculate that as each cognitive style appears bi-polar with respect to the other cognitive styles, and, ipso facto, none is independent of any other, that a test artifact may be operating.

For example, the scoring system is such that as the sum of all response styles is equivalent to the total number of triads, a high score on any one response style must depress the score on the other styles. Therefore, by chance alone, the expected response frequency on the 25 triads would be 8.33 for each of the three cognitive modes. In this study, Table 6.1 shows the three means to be clustered around this value (i.e. categorical mean = 9.3; descriptive = 8.46; relational = 7.01).* Consequently, some caution may need to be exercised when interpreting the data generated by the Conceptual Style Test.

(e) The Test of Intellectual Achievement Responsibility. This measure provided results of limited value for revealing insights into outlooks on science. The -IAR subscale appeared in the regression equation derived for predicting the Science Questionnaire scores and the suggestion was made

* Footnote: Whilst these effects on the means need not effect the correlations, they do suggest the respondents may have been responding to the test in a somewhat random fashion.

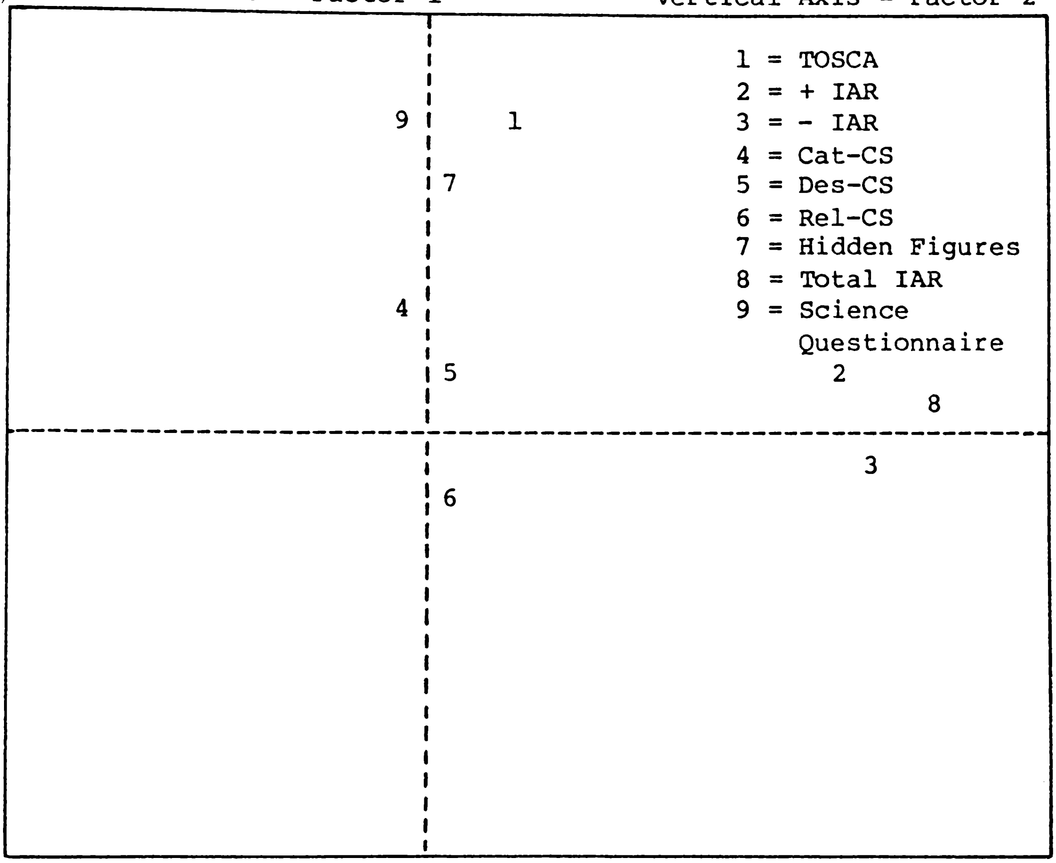
that perhaps too great a concern for one's failures (as indicated by high -IAR score) is counterproductive and would tend to decrease one's score on the Science Questionnaire. It is of interest to note that it was the -IAR subscale score which correlated significantly with TOSCA for the girls, but not for the boys. The +IAR subscale did not correlate significantly with TOSCA for the girls, whereas it did for the boys. Thus, in terms of general attitudes to academic success and failure, significant sex differences were revealed by this instrument, but any applicability specific to science was not apparent. The ethnic differences noted were also of limited value.

An ex post facto Principal Components Analysis (Nie, et al, 1975) of the data presented by these instruments revealed four factors could be identified to account for all the variance recorded (see Table 6.19). Factor one (with 40.1% of the total variance) was determined essentially by the contributions of the IAR measures (Note: Part of this variance may be assumed to have been determined by the inclusion of both part and whole IAR scores in the analysis)*; factor two (with 30.6% of the variance) was determined by TOSCA, the Hidden Figures Test, and the Science Questionnaire; and factors three and four (together totalling 29.3% of the variance) were derived from the Conceptual Style Test.

* Footnote: Spurious weightings on factor one would have resulted from the inclusion of both part and whole IAR scores in the analysis.

Figure 6.4: Graphical representation of the factor loadings depicted in Table 8.2 on (a) Factors 1 and 2, and (b) Factors 3 and 4.

(a) Horizontal Axis = Factor 1 Vertical Axis = Factor 2



(b) Horizontal Axis = Factor 3 Vertical Axis = Factor 4

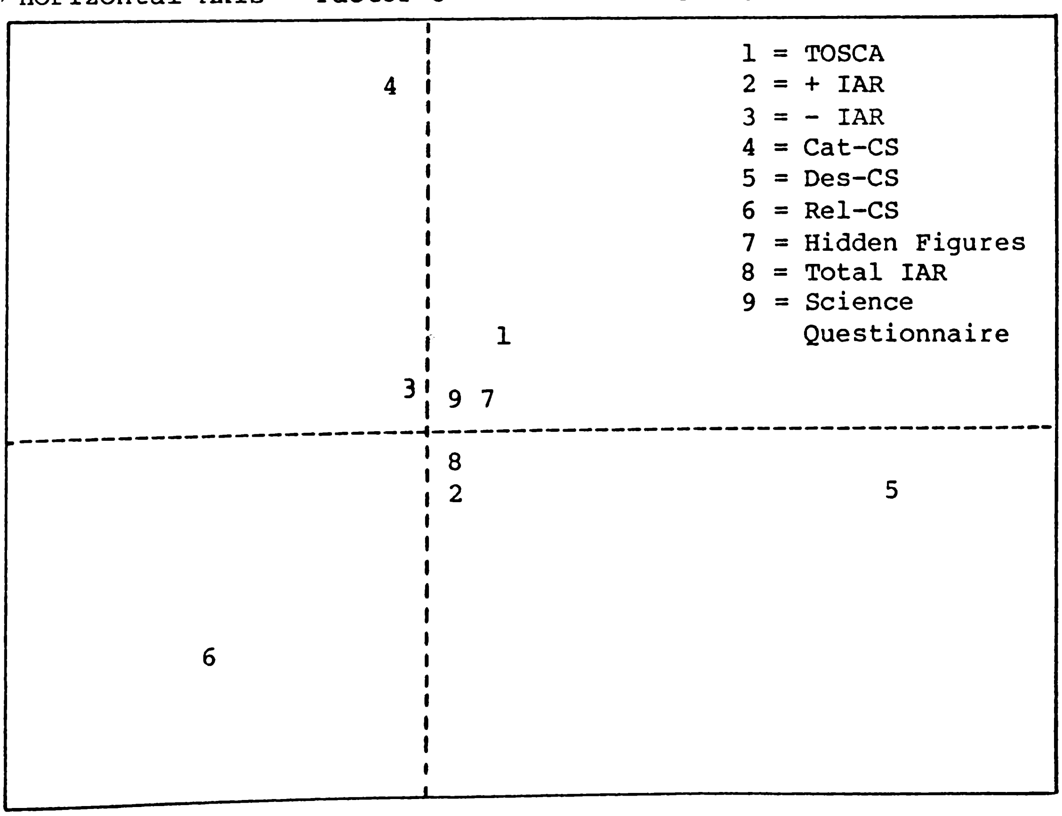


Table 6.19: Loadings of the measures on the four factors identified (and varimax rotated) with a Principal Components Analysis, together with the factor-associated eigenvalues.

Measure	Factor 1	2	3	4
TOSCA	0.17	0.70	0.05	0.12
Total IAR	0.97	0.06	0.00	0.00
+IAR	0.76	0.13	0.03	-0.09
-IAR	0.82	-0.02	-0.03	0.07
Categorical Concept. Style	-0.02	0.17	-0.07	0.18
Descriptive Concept. Style	0.01	0.09	0.83	-0.11
Relational Concept. Style	0.00	-0.18	-0.63	-0.58
Hidden Figures Test	0.02	0.55	0.08	0.05
Science Questionnaire	-0.02	0.72	0.04	0.10
Eigenvalue	2.31	1.77	0.92	0.76
% of total variance	40.1	30.6	16.0	13.3

Figure 6.4 shows the graphical dispersion of these measures in component (factor) space: (a) factors one and two, and (b) factors three and four. This latter dispersion provides additional support for the analysis of the 'Conceptual Styles' discussed previously (c.f. Figure 6.3).

(f) The TRA Questionnaire. This one measure provided all the input into the 'conative' component of the model proposed in Section 6.4.1 and its theoretical rationale, based on socio-attitudinal factors, provided data pertinent to the research questions. The most significant of this input appears to be that to do with the role of specific objective and social beliefs held by the students with respect to their perceptions regarding personal outcomes associated with the study of science.

Thus, given the assumption that students study science because they _intended_ to study science, the TRA analyses of particular groups of students' attitudes towards studying science, and their social standards (the immediate determinants of intention) allowed for preliminary explanations of the sex and ethnic imbalance in proportions of students studying science to be offered.

The qualitative phase of this study provided insights into particular _individual_ personal construct systems (with their concomitant beliefs) and the TRA analyses were able to complement these by providing insights into _groups_ of students' responses to particular sets of beliefs.

(g) _The instruments - summary_. This examination of each instrument has identified several with specific weaknesses. Obviously, a repeat of this study would avoid these. The requirement of identifying a group of students, large enough to be representative of ethnicity, sex, age level, and school type (Appendix 3.7) and yet small enough to be adequately investigated by a single researcher, necessitated the use of such instruments. A more comprehensive analysis of possible instruments, prior to the selection of the student sample, although time consuming, may have resulted in more precise descriptions of some of the variables involved in the under-representation of girls and Polynesians in the sciences. In particular, the possible significance of the field independence/field dependence dimension, as suggested by its association with TOSCA and the Science

Questionnaire (refer Figure 6.4, and the accompanying discussion), requires much further investigation.

> "Scientific activity, particularly in the physical sciences, is helped by a field independent cognitive style. Such a style develops when parents raise their children to be independent, nonconforming, explorative, and willing to try new things."
> (Triandis, 1980:176)

Triandis' assertion suggests further investigation may need to look at child-rearing practices and explore the extent to which the well-documented differences between how parents respond to different sex children (refer Section 2.2.3), and how the differences between ethnic groups (refer Section 2.3) do affect field independency. A complementary investigation could explore the degree to which schools can develop field independence in students who lack the ability.

CHAPTER SEVEN
THE RESEARCH OUTCOMES

This study was introduced with the research question, 'Why are New Zealand girls and women, and New Zealand Maori and Pacific Island students so under-represented in the sciences?' and the answer to it was sought within that domain subsumed under the term 'students' outlooks on science'. The previous chapter suggested a scheme in which the students' outlooks on science could be considered to originate from two major components (the cogitative and the conative). This chapter takes this scheme and, with the material from the qualitative chapter (Chapter 5), endeavours to provide a more complete understanding of why there is the under-representation of these groups of people in the sciences.

This investigation had originally anticipated that, although the research question referred to <u>two</u> discernable student groups, <u>one</u> answer might be found to accommodate both. Therefore, no attempt had been made, in the presentation of the research data in the preceding chapters, to postulate possible alternative answers to the research question; those specific to sex differences, and those specific to ethnic differences. However, with the advantage now of hindsight, a single inclusive answer, capable of providing an explanation for the under-representation of <u>both</u> females and Polynesians, is found to be untenable. That is, one response to the research question is required to account for the sex differences, and another, which highlights other mechanisms, is required to account for the ethnic differences.

Also, it can now be seen that throughout all phases of the study, the investigator's tendency to seek a common explanation created difficulties which would have been avoided had either only one student group's under-representation in the sciences been investigated or had each group been examined entirely separately. Each alternative would have resulted in a more detailed exposition of the issues than has been possible.

Section 7.1 and Section 7.2 present separate syntheses of the qualitative and the quantitative perspectives according to sex and ethnicity respectively. Section 7.3 provides a series of possible educational consequences of the study, before concluding with brief comments on the methodology and the theoretical perspectives adopted within it.

7.1 Sex differences in students' outlook on science.

It is in this section that one part of the 'thesis' proper (the "theme to be discussed and defended") is proposed. This is that the under-representation of New Zealand girls and women in the sciences is an outcome of a socially transmitted, consistent, gender-related inequality in the way the processes, many products, and (particularly) the agencies of science are represented to them. That is, the 'image' of the individuals associated with science (the 'scientists'), the work they do, and many of the outcomes of their work, in being instrumental in creating particular outlooks on science, is such that boys and men are more readily able to 'identify' with science than are girls and women.

This is not to suggest that this inequality is deliberate or conscious in the minds of the 'social transmitters' but merely that its effects are considerable and that these effects are able to be altered. It is further suggested that educational practitioners, as one group of social transmitters, in becoming aware of this inequality, would then be in a position to attempt to influence other groups to work with them to reduce it.

7.1.1 The suggestion of gender-related inequality.

The regression equation developed in the previous chapter indicated a degree of association between the measures of science (Science Questionnaire), scholastic ability (TOSCA), field independence (Hidden Figures Test), the preference to use a 'categorical' conceptual style (Conceptual Style Test) and, the extent to which a person expresses personal responsibility for his/her academic failures (-IAR subscale). The 'cogitative' component of the conjectural scheme suggested in Figure 6.2 attempted to represent this association.

The cogitative component was considered to be made up of a 'conceptual' and a 'perceptual' subcomponent and statistically significant sex differences were found in <u>both</u> subcomponents. With respect to the former subcomponent, the girls in this sample scored statistically <u>lower</u> that the boys on the measure of conceptual 'ability' (TOSCA). Consequently, it might be suggested that as school science <u>is</u> a scholastic endeavour and as the girls within this sample were shown by TOSCA to be scholastically less able than the boys, these girls' responses to the Science Questionnaire, ipso facto, would be 'inferior' to those of the boys. However, the analysis of covariance (Table 6.5), in which the influence of the sex differences in the TOSCA scores was controlled, revealed the presence of yet other sex differences in the Science Questionnaire scores. Also, as the conceptual style subcomponent of the conjectural scheme did not discriminate between the sexes, it is in the 'perceptual' component of the conjectural scheme that these 'other' sex differences are now examined.

The two 'perceptual' determinants of the cogitative component, the measure of 'objective' (Hidden Figures Test) and the 'subjective' (IAR) events, both showed variations between the sexes.

The discussion accompanying the presentation of the quantitative results derived from the Hidden Figures Test provided support for the literature-suggested possibility of a sex-linked mechanism of a 'spatial' type (see Section 6.1.1). If Piburn's (1980) comments are tenable, that aspects of school science may be being presented to students (and/or the students are being evaluated) in a way which advantages those students with such a spatial ability, the sex differences found in the field independency scores in this current study would indicate it is the boys, rather than the girls, who would be so advantaged.

This possibility has been raised by Harding (1979). She has analysed British O-level science examination performance data and, in observing the sex differences in the candidiates' responses between the multiple-choice and essay-type questions, asks, inter alia,

> "Are spatial factors involved, when much information is presented diagramatically? Do multiple-choice items penalise the candidate who is more aware of possible contextual dependence of the data presented?"
>
> (Harding, 1979:284)

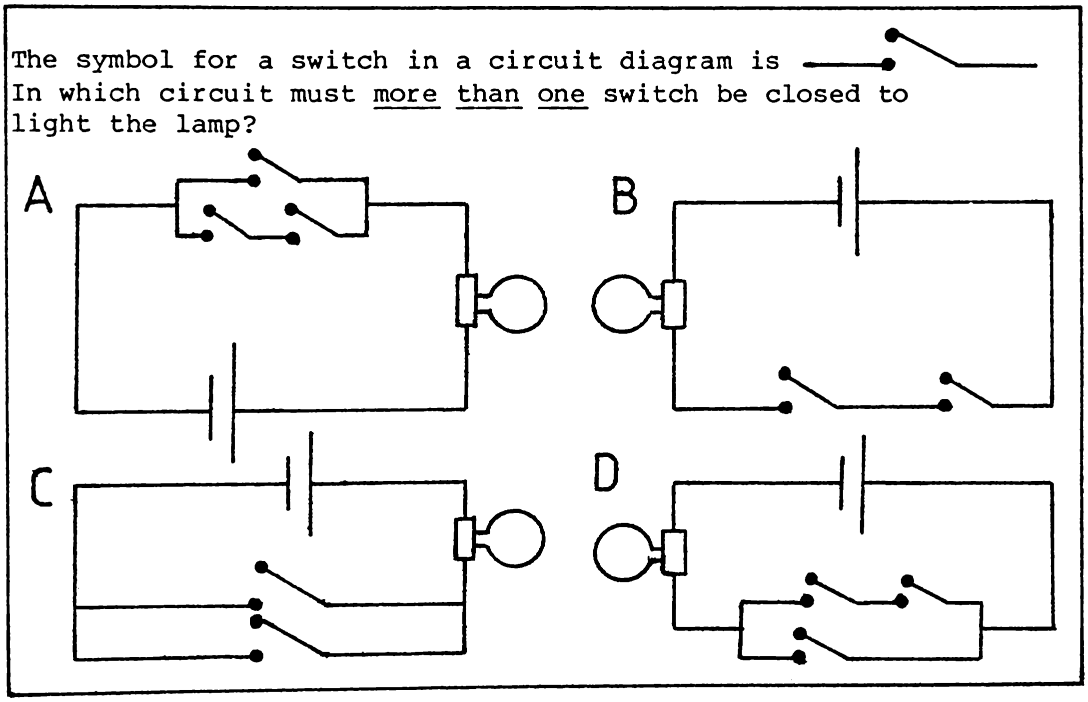
Independent support (of local significance) for the suggested existence of such gender-related inequality may be found in several items of a New Zealand F5 Modular Science Reference Test (Perris, 1981). One item in particular, reproduced in Figure 7.1, is suggested here to require a similar perceptual ability (for objective events) as that required for Hidden Figures Test. That is, an ability 'to focus on a single component in a complex field without being distracted' (see Section 3.3.1). To the field dependent student, the discreteness of the four circuits, A, B, C and D, in Figure 7.1, may not be recognised and perceptual miscueing occur. It is perhaps no surprise to find the girls did significantly more poorly than the boys on this particular item.

However, as no research appears to have been conducted which has systematically sought evidence that

(a) school science is presented in such a way that students with particular spatial (and/or field independent) abilities <u>are</u> advantaged, and as

(b) the qualitative perspective adopted within this study was not directed towards perceptual characteristics of the students, no definitive conclusions regarding the extent, or possible origins, of the suggested gender-related inequality may be made here.

<u>Figure 7.1</u>: An illustration of a sex-biased test item used in a F5 Science Reference Test (after Perris, 1981).



The suggestion (Section 3.3.1) that field independent people may prefer to use fewer personal constructs and to be more likely to use superordinate personal constructs, than might field dependent people, was not specifically examined. However, the observations that there were sex differences in the <u>nature</u> of the personal constructs used (Table 5.2), and that there were sex differences in the Hidden Figures Test data, would indicate that the suggestion could be worthy of further investigation. Consequently, it is hoped that further work will be done in this sparsely researched area and that educators be mindful of the possible difficulties some of their students may experience where 'figure and ground' distinctions are not made explicit.

The second 'perceptual' determinant of the cognitive component was that to do with the perceptions of subjective events, and whilst no statistically significant sex differences were found in the students' responses on the IAR measure, interesting sex differences in the correlations between the IAR subscales and TOSCA were noted (Appendix 6.1). Although the correlations between scholastic ability and the overall perceptions of responsibility for academic outcomes were similar in both sexes, it was the girls' perceptions of their academic failures, and the boys' perceptions of their academic successes, which were significantly different.

This phenomenon was reflected in Section B of the TRA Questionnaire responses where the boys' expectancies of obtaining particular jobs were found to be higher than those of the girls' (Blackstone & Weinreich-Haste, 1980, report similar findings), and it has been noted in other disciplines.

For example, Nichols (1979) found it in reading, even in cases where the girls' attainment was rated significantly higher than boys' by both the girls themselves and their teachers. Badger (1981), in his review of the literature on sex differences in mathematics, commented that:

> "Girls show a persistent tendency to underestimate their performance, while boys tend to overestimate theirs ... Girls' tendency to attribute failure to poor ability appears to be a general phenomenon."
> (Badger, 1981)

Rosenfield & Stephan (1978) have explained this phenomenon in terms of 'egotistical' attributions, in which males make more internal attributions for success and more external attributions for failure than do females. However, these researchers found, in a task stated by the experimenter to be a 'masculine' task, the males made more egotistical attributions than the females, but females made more egotistical attributes than the males when the task was described as being 'feminine'. They further found in this particular study that 'ego-involvement' (i.e. a motivational factor) was a more important determinant of egotistical attributions than was expectancy.

Zuckerman (1979) suggests the tendency to accept responsibility for success and failure is related to personality and situational factors. He also considers a motivational factor to be involved with this relationship and that females show less self-serving (i.e. egotistical attributions) because they may be less involved with masculine tasks and thus be less concerned with the achievement of success and the avoidance of failure. The prevalence of the masculine image of science held by the students and parents noted within this current study allows for a ready endorsement of these suggestions.

Raviv, Bar-Tal, Raviv & Levit (1983) have extended the attributional model suggested by Weiner, Frieze, Kukla, Reid, Rest & Rosenbaum (1971); Weiner (1974); to distinguish between students' affective responses (such as feelings of pride or shame) and their evaluative responses (such as 'good', 'poor'). They suggest individuals may highly evaluate a person with low competence who tries hard, but feel high satisfaction while succeeding without trying, because such success, particularly on a difficult task, indicates high ability. Their reasoning has implications for this study - they suggest:

> "Students desire to be perceived as having high ability. Society appreciates hardworking people, but at the same time it glorifies the talented and brilliant individuals. High ability is often the criterion for job finding, promotion, or recommendation. Ability is the stable characteristic with a predictive power of future achievements. Exertion of effort depends on volition, and can be taught or motivated ... Students do whatever they can in order to maintain a self-concept of high ability. This attempt affects their behaviour in the classroom. They avoid situations which could imply having low ability. Therefore, they feel especially satisfied when they fail without exerting effort. At least, such failure can be attributed to low effort, but not to low ability."
>
> (Raviv et al; 1983. Emphasis added)

While Raviv et al do not differentiate between the sexes, sex differences found in the current study can be explained by their position - the first emphasised passage (above) could have saliency particularly for girls in science, and the second emphasised passage could explain the boys' findings.

This interpretation finds support in the application of the concept of 'learned helplessness' (Dweck & Bush, 1976; Dweck et al, 1978).

> "Learned helplessness exists when failure is perceived as insurmountable. This perception is associated with attribution of failure to stable, uncontrollable factors, like a lack of ability, and is accompanied by deterioration in performance following failure."
>
> (Dweck et al, 1978).

These researchers cite studies that have shown, that as boys tend to misbehave more than girls in the classroom and are thus more likely to receive negative evaluations, boys tend not to relate such negative feedback to their scholastic capability; whereas for girls, negative feedback cannot be explained in terms of general behaviour, as their general behaviour is more often compliant with the teachers' requests, and so the criticism is thus perceived in terms of scholastic failure. That is, scholastic failure will more often be attributed to lack of ability rather than to lack of effort on the part of the girls.

Support for such perceptions is found in the qualitative phase of this study where the sex role stereotyping was seen to be a pervasive influence in the everyday experiences of the students - parents, peers, media and the school, were all implicated. The prevalence of the value of gender constructs in the girls' personal construct subsystems could be an indication of one outcome of such sex role experiences and explain something of the nature and origins of the perceptual 'goggles' worn by the girls. Also Callaghan and Manstead (1983), in explaining the attributions about the outcomes to public examinations made by F6 students, found the girls ascribed greater causality than did the boys to the factors of help from the teachers and help from home.

It may also be suggested that the anxiety felt by the girls in science lessons would be perceived by them as indicators of lack of personal ability (rather than lack of effort), and a perceived lack of ability would not be conducive to a continuation of study in science.

The degree to which the school experiences could be altered to effect a change in such perceptions is an important issue. Dweck (1975), in an experimental setting, was able to show how a group of children (aged between 8 and 13 years) identified as being 'helpless' were trained to attribute failure to lack of effort rather than solely to lack of ability. This change in attribution then enabled strategies for dealing with failure to be taught.

The implication for science educators is that at least one part of the complex of variables which contributes to the girls' outlooks on science appears susceptible to change and that a continuance of current practices reinforces the perceptions of science the girls bring with them into the science lesson.

Another part of this 'complex of variables' is shown in the conjectural scheme as the <u>conative</u> component. This term, conative, is used to refer to the <u>intentions</u> of students predicated by their sets of attitudinal and social beliefs about studying science. Some overlap with the previously discussed cogitative component is anticipated, particularly in regard to perceptions about subjective events and the subjective beliefs which underlie the social conations associated with studying science. However, such an overlap provides a convenient lead into the discussion of further evidence of gender-related inequality in science.

Several of the girls' repertory grids, shown in Figure 5.1, had first and second components based on gender or people (none of the boys' was). This suggests that social factors <u>are</u> important in the way girls perceive events and, if these influences do not provide a 'balanced' set of experiences and beliefs to the students (girls and boys) from which their personal construct system may evolve, consequential idiosyncratic perceptual impoverishment is inevitable (such as results in 'poorer' outlooks on science).

The qualitative evidence of sex role stereotyping, and the students' responses to the TRA questionnaire, indicate that this <u>is</u> so. Whilst the boys were not necessarily actively encouraged by peers, the media, or parents to continue with a study of science (for example, parents often did not realise themselves how or where science could be applied in a prospective career), they were not discouraged either. Whereas, the girls were covertly (e.g. by the lack of appropriate sex role models, or by tacitly adopting their mother's beliefs about science) or overtly (e.g. "Nana thinks I could do without science ...") discouraged from continuing with a study of science.

Within these stereotypes appropriate sex role behaviour was defined such that science, in being linked with career constructs, had greater relevancy for boys than for girls and, perhaps more important, was the observation that girls did not value science as highly as boys. The suggestion was made that as boys had a wider informal 'scientific' knowledge base than girls they were better able to identify positively with science, whereas girls, in having a more restrictive perspective on science, felt less confident with it, and so tended to express negative values towards it. The nett outcome was to reject science as not being of personal value to them.

Abigail (1983), after examining the various influences which affect school students'vocational choices, claims that schools, in reflecting society's attitudes, are directly responsible for such outcomes. As her analysis is consonant with much of the feelings expressed by the students, parents and teachers during the informal, often 'off-tape' conversations with the investigator, a long passage, taken from a teachers' professional journal, is given here. Abigail expresses much which was not able to be recorded by the quantitative perspective adopted in the current research, but that which was 'in the air' but not always made explicit during the qualitative phase.

> "I have found many factors which are working against equal opportunity for girls. These included overt and covert discrimination against girls in particular subject areas, antagonism towards girls by male staff, invisibility of women in language and pictorial matter, lack of understanding by staff of how socialisation processes constrain girls, ignorance of the social component of sex differences, discouraging messages to girls from counselling staff and careers speakers, lack of role models and models of alternative life-styles, bias in school textbooks, bias in careers materials, lack of interest in informing parents of the limitations of the traditional patterns for girls, resistance by staff

> to concentrating attention on girls, ignorance by staff of the structure of the workforce and its implications for girls' education, trivialisation or hostility towards the issue of sexual equality, and lack of interest in taking any concrete action to raise girls' confidence in their abilities."
>
> (Abigail, 1983:11-12)

7.1.2 Sex differences in outlooks on science summarised.

The literature survey on sex differences in science presented at the beginning of this study was guided by three propositions which are used again here to summarise the evidence yielded by this current research.

(i) Girls and boys have different attitudes towards science.

The repertory grid analyses and individual interviews revealed qualitative sex differences in the affective constructs which form the basis for 'attitudes' and, although the TRA analyses have shown the attitudinal component of intentionality to be very important for both sexes, the determinants of girls' attitudes were not wholly the same as the boys'. The implication raised was that girls' attitudes may be influenced by a variety of factors, other than just those subsumed under 'objective' beliefs, such as those of social origin.

(ii) Girls and boys bring to the study of science different cognitive abilities.

Different cognitive abilities were noted between the sexes on the measures of scholastic ability and field independency (but not on the measure of cognitive style). The positive correlation between the Science Questionnaire and these particular measures indicated them to be possible contributors to the resultant lower scores of the girls in the sample.

(iii) Sex differences in science are influenced by identifiable social factors (both from within and from outside the school).

These findings suggest that the lower achievement of girls in science is one expression of the socialised sex role adopted by girls. That is, girls are not expected to do well in, or to continue with, the study of science and gender-related inequality is communicated to them from a variety of sources, the most significant of which appears to be those of home and school.

7.2 Ethnic differences in students' outlook on science.

The research question makes the implicit assumption that the under-representation of Maori and Pacific Island students in the sciences is of concern, and that the answers to the supplementary question, 'Why study science anyway?' (see p2) are deemed valid by these students and their kinspeople.

In the ethnically pluralistic New Zealand society these assumptions derive from a particular complex of cultural values (determined, in the main, by the dominant European cultural values) which may, or may not, be justifiable to minority groups. The research reported here has endeavoured to understand the outlooks on science held by different students in their own terms so as to increase the possibility that, when comparing behavioural patterns which on the surface seem quite similar, quite different underlying meanings are recognised. Such a position is particularly important in cross-cultural research.

It is in this section that the second part of the 'thesis' proper is proposed. This is that cultural inequality is to be found within the New Zealand educational system which finds expression in the manner in which 'success' and 'failure' are defined in ways commensurate with European achievement criteria. Whilst such criteria appear to be accepted by those Pacific Island people who esteem New Zealand educational qualifications (Ioane, 1981), many indigenous Maori people appear to prefer other criteria commensurate with alternative cultural values. Ramsay (1982) has expressed the 'dilemma' clearly:

> "What is often the most valued knowledge of minority groups is sometimes not valued at all by majority groups. Somehow we must move towards resolving this dilemma which is of course a community problem as well as a school problem."
> (Ramsay, 1982:15)

7.2.1 The suggestion of cultural inequality.

The test of Scholastic Ability (TOSCA) has been shown in this study (and others, e.g. Reid, 1981; Reid et al, 1983) to discriminate markedly between European, Maori and Pacific Island student groups and it has been shown to be a major contributor to the predicted Science Questionnaire scores. Comment has already been made that similar scholastic skills appear to be required for responding successfully to both the Science Questionnaire and TOSCA. It is worth noting that

TOSCA has been designed specifically as a measure of:

> "(A) comprehensive range of learned or developed abilities which involve the manipulation of the verbal and numerical symbols systems of our culture."
> (Reid, et al, 1980 - emphasis added)

Here lies the rub! The implied assumption is that 'our culture' is homogeneous with a set of values acknowledged and accepted by all constituents of contemporary New Zealand society. Such an assumption is clearly untenable yet it underlies the bases on which TOSCA is developed. Nash (1983) describes it as:

> "(A) test of the knowledge of particular facts about the world and of ways of solving particular problems - which have rather less to do with the world as most people know it - in a school-approved way. (On your own, under strict supervision, within an arbitrary time limit insufficient to complete the job, with no indication of the level of success achieved and so on.) This knowledge has been called cultural capital. You inherit it, and invest it, and barring ill-luck or a slump in the market it pays dividends. The cultural capital needed to do well on TOSCA is possessed almost exclusively by (British) New Zealanders, in just the same way that actual financial and real capital is possessed by the same people."
> (Nash, 1983)

The previously noted decline in the proportion of Maori students staying in school at each consecutive year of secondary schooling (Appendix 1.2), in part, could be a reflection of such cultural inequality. If Nash's critique is accepted, there exists the possibility that a similar, or identical, cultural inequality occurs in school science (and perhaps in all science) too - an inequality biased towards 'particular facts' and particular 'ways of solving particular problems'. The TOSCA/Science Questionnaire correlation (r = 0.54) underscores this possibility, as does the appearance of the conceptual style and field independence variables in the regression equation.

The existence of such 'knowledge codes' (Bernstein, 1977) has been suggested by Harker (1981):

> "... we know virtually nothing of the Maori knowledge code, nor what kind of knowledge Maoris regard as most worthwhile... A genuine multi-cultural education system would not only have various knowledge codes in operation and the different subjects that these imply, but there would be a variety of ways of transmitting these knowledge codes using culturally appropriate pedagogical methods."
>
> (Harker, 1981:31. Emphasis added)

Within the current study, several participants intimated they perceived a mismatch between what is publicly sanctioned as being of educational value and that which they personally perceived as being of educational value. For example:

> "Maoris tend to be talented in arts and music and things like that because of their traditions and their customs of the past ... I can still keep up with my Maori customs because I like to speak Maori fluently, that's why I take the Maori language, so that I could feel that I'm more a Maori and not just a Maori by birth, but a Maori in the way of speaking and the way that I think, and in being able to do the things that the old Maoris used to do, and preserve the culture and hand it down to my children so they have something to hold on to."
>
> (Aroha)

Aroha's expression, 'I can still keep up my Maori customs ...' may imply that her commitment to her Maori heritage is maintained separately to that required for her schooling. That is, what she deems to be of value, is not that 'officially' prescribed for her 'education'. Within this passage, Aroha has expressed not only the nature of the particular kind of knowledge 'code' she values, but she has discerned that alternative 'ways' of thinking are also to be valued. Her own father, in a later interview, drew attention to the differences in response styles between Europeans and Maoris. He suggested the teacher needed to 'relate to and understand the Maori background, in the way they think, and in the way they feel'.

Several Polynesian parents made similar references to this difference in thinking styles between European teachers and their Polynesian teachers (Section 5.3.1). Ioane (1979) expressed it this way:

> "Pacific Island children have a learning style which is characteristic of the oral tradition... I think, in general, it applies to the Maori child as well. They use the sense of sight much more acutely, in terms of learning, than the sense of hearing ... mainly because these are the basic tools of an oral tradition. This is much more so for Pacific Island children, especially the immigrant types where their demonstrators, or teachers, are always performing and the learners are silent. They watch, they listen - there's no little dialogue between the learner and the instructor - that's one of the characteristics of the oral tradition - the use of silent language. When I say, 'silent', I mean gestures, the eyes, the looks, even the expression on the teacher's face, communicate to the child."
>
> (Ioane, 1979. Pers.com)

The existence of different thinking styles was shown up in the quantitative phase of this study. The Maori students' mean scores on the measure of field independence and the categorical conceptual style were both significantly lower than the European students' mean scores and, by themselves, would indicate the Maori students could be predicted to be less successful than the European students on the Science Questionnaire. Possible reasons why field independence and a categorical conceptual style appear advantageous in science have been previously discussed (Chapter 6) and the issues raised in the discussion on the sex differences with respect to the field independence measure are equally applicable in the cross-cultural context also (for example, if aspects of school science are presented such that they advantage students readily able to discriminate between figure and ground events, it is suggested these students are more likely to be European rather than Maori).

The European/Maori differences, and the European/Pacific Island similarities, on the categorical conceptual style subscale have also been commented upon in the context of this subscale's positive correlation with the Science Questionnaire and with the measure of field independence. Therefore, its inclusion in the regression equation lends greater support to the suggestion that 'the Maori students within this study had difficulty with science because of their penchant for using relational rather than categorical response modes'.

It was also suggested that particular preferred styles of thinking may be a consequence of particular social experiences gained early in life.

Several writers (e.g. Ritchie & Ritchie, 1979; Smith, 1982) have commented upon the possible outcomes of the Polynesian custom of older siblings taking on the responsibilities of 'socializing' younger children. For example;

> "In Polynesian culture the peer group is tremendously important and a separate sphere from the adult world. Children have less contact with the adult world and are inclined to be less dependent than Pakeha children. From an early age they share responsibilities and problems with each other. A type of consensus leadership and solidarity develops in many peer groups. Children of all ages have contact with each other. The Western ideals of individual achievement and competition conflict with Polynesian ideas of working together with others and social interdependence. Peer status does not depend as much as it does among Pakeha children on personal achievement."
>
> (Smith, 1982;196-7)

There is much to suggest (see Harker, 1979) the New Zealand school system does little to encourage Polynesian cultural and educational values and Polynesian ways of thinking. It would appear that the schools' emphases on individual independence, a verbal/written mode of communication (with a particular form of spoken language), European achievement goals, and its apparent isolation from the day-to-day affairs of the community, serve to create a micro-environment in which many Polynesian students feel alienated with an attendant lowering of their academic self-esteem (Section 5.2.3). Science, in being perceived by most students as an academic discipline, and in not being 'seen' to be of particular relevancy in their parents' lives, and in not being actively supported by their parents and their own peers (unlike mathematics and English, <u>if</u> anything pertaining to school is to be supported), soon becomes perceived by many Polynesian students as being a non-essential school subject (the experience of Sandra illustrates this phenomenon well - see Section 5.2.3).

Another facet of the proposed cultural inequality may be seen in the correlations found between the locus of control measure (the Intellectual Achievement Responsibility scale) and TOSCA for it was in only the European students' groups that the statistically significant positive correlations occurred (see Appendix 6.1).

One interpretation for this finding is that European students approached the two measures in similar ways, whereas the Polynesian students did not. 'Success' and 'failure' events were made quite explicit in the IAR but not in TOSCA where no outcome for any response was specified - the assumption being that all students would value getting as many items correct as possible in the given time limit. It may be suggested that when criteria for success and failure are not explicit, by default, individuals use internalised, culturally determined personal criteria which may, or may not, correspond to those assumed by those setting the task in question. To the Polynesian student, the task involved in responding to TOSCA could have been yet another school activity and, as such, it was not associated with culturally determined personal values of importance, status, or relevance.

7.2.2 Ethnic differences in outlooks on science summarised.

The literature survey on ethnic differences in science presented at the beginning of this study was guided by two propositions which are used here to summarise the evidence yielded by this current study.

(i) European, Maori and Pacific Island students bring different cognitive abilities to the study of science. The empirical measures used in the quantitative phase of the study revealed some inter-ethnic group differences. Differences were found between the European and Maori groups on all cognitive measures (refer Figure 6.2) but differences between the European/ Pacific Island and Maori/Pacific Island groups were not so unequivocal. Therefore, whilst the TOSCA scores would imply the Polynesian students to be 'scholastically' different to the European students and would thereby be disadvantaged in school science, the other measures would support the proposition for only the Maori students.

(ii) Socio-attitudinal factors partially account for the under-representation of Maori and Pacific Island students in science. Differences between Maori and Pacific Island students were noted with respect to motivation - Pacific Island students tended to be strongly encouraged by their parents to accept European academic goals as criteria for success but often these students were not provided with the role models and explicit parental guidance necessary to reach these goals. This appeared to be particularly so in science where parental knowledge and experience with science was minimal and so resulted in Pacific Island students having reasonably positive attitudes towards school in general, but with indifferent, or negative, outlooks on science.

The repertory grid analyses and the individual interviews revealed qualitative ethnic differences - Polynesian students used more value and affective dimensions in their personal construct systems than did European students. It was suggested that the school system operates with particular emphases which tend to reject Polynesian value systems (i.e. particular Polynesian knowledge codes and ways of thinking) and, in so doing, undermines the Polynesian students' self-esteem in academic settings where 'success' is measured in terms antithetical to Polynesian criteria.

The disproportionate percentage of Maori school leavers at each form level (Appendix 1.2) suggests that many Maori students totally reject many school-associated values - their negative outlooks on science express but one aspect of this rejection. The research reported here indicates that positive outlooks on science could develop only when the context of school science (that is, the educational setting, its products, its processes, and its priorities) is able to accommodate Polynesian values. This suggests the under-representation of Polynesian students in the sciences to be a long-term phenomenon of the New Zealand educational scene.

7.3 Comments on possible educational consequences of the study and on the methodology used.

7.3.1 Suggestions for redressing the gender-related inequality in science.

The rationale developed in this study is that the under-representation of girls in the sciences is a consequence of the particular outlooks on science held by them and that the development of these outlooks on science are attributable to identifiable social factors in the girls' everyday experiences. In particular, in the absence of positive role models and limited access to appropriate knowledge about women in science has resulted in the uncritical acceptance of traditional and inadequate sex role stereotyping by both girls and boys, their parents, the media and the school. The outcome of such sex role stereotyping is identified in the limited knowledge, less developed skills, and the poorer attitudes girls bring to their school science. Therefore, any attempt to effect a change in the current situation will require attention to be directed at breaking down these currently held sex role stereotypes and challenging the commonly held views concerning the nature of science and its place in society.

The first of these is already undergoing change and, in many areas of public life, sexual inequalities have been legislated against, but the changes need to be maintained. It is important to recognise that changes in the roles available to girls and women will benefit not only them, but they will also benefit boys and men, for, not only will males in turn, be less confined to fairly rigid sex roles, but the <u>nature</u> of the resultant scientific pursuits would be expected to change for the better (Saraga & Griffiths, 1981). Science has been characterised as being 'cold', 'impersonal' and not too concerned with social issues (refer Section 2.2.3) - this image <u>is</u> changing and this change is necessary for, as Kelly (1981d) writes:

> "... the implications for society of anything as powerful as science being controlled by men with little or no interest in, or understanding of, social relations are frighting."
> (Kelly, 1981d:294)

The following list of suggestions is directed at the classroom teachers who are able to considerably influence the outlooks on science held by the pupils they teach.

(i) <u>Students beliefs about science need to be explored, challenged, modified and/or extended</u>. We, as teachers, should regularly set aside time to ask our pupils such questions as, "Why do you think <u>you</u> do (or do not) need to study science?" "Is science necessary (worthwhile, valuable, important, etc)?" "What is science?" "How does science differ from your other school subjects?" "Why do you think that is so?" "Who uses science, in their jobs, in their everyday life?' "Where would science not be appropriate?" "Why not?' "To what extent has science changed our world for better and for worse?"

Students do not have a clear idea of what science is, how relevant it is (both in an everyday sense and in a vocational sense) to them, how the disciplines within the general area of 'Science' (biology, chemistry, physics) differ, or even why they are being taught science at all.

"You do it because it's on the timetable" (F3 girl)

The ensuing discussion arising from such questions would expose the nature and extent of the pupil's sex role stereotypic beliefs and thus allow for women involved with science to be invited to speak about themselves and about their work, or for visits to places where women work in scientific and technological employment to be arranged.

(ii) Students' perceptions of other people's views need to be identified, explored, challenged and or extended. It is during the middle school years that students' self images come under considerable scrutiny and girls' peer groups are particularly important in determining behaviour deemed 'appropriate' (Meyenn, 1980). This study has shown students are influenced by their own perceptions of other people's views and even if these perceptions of other views are accurate, because these other views are likely to be limited (and often negative) and of the traditional stereotype, the students are likely to be misled by these views. Particularly, if their own independent set of behavioural beliefs about science is restricted. Therefore, teachers would need to ask such questions such as, "What do you believe your parents think about you studying science?" "What do most other people think about studying science?" "What do you believe I, as your teacher, think about you studying science?"

"Friends would think you were crazy (if you took science) because it's so hard!" (F4 girl)

(iii) Teachers' styles of teaching science need to be examined. Whilst this study did not explicitly examine the nature of different teaching styles *per se*, sufficient evidence emerged to suggest the teachers' role in presenting not only particular science content but in determining how the chosen content was presented to the class, and how the teachers related to their students, were of considerable importance.

"On some experiments the text book tells you to do one thing and the teacher tells you to do another and you get confused." (Sandra)

"The teacher's more interested in the boys and only they ask questions in class." (Angela)

"I mainly don't like science because of Mr P. our science teacher." (Leanne)

The sex differences on the field independency measure and the reported boys' superiority in spatial reasoning (Maccoby & Jacklin, 1974) raises the possibility that school science may tend to be presented, and assessed, in ways commensurate with masculine abilities rather than those commensurate with feminine abilities. The equally well documented superiority of girls' verbal reasoning (e.g. Ormerod et al, 1979) possibly is not utilised as well as it might in science classrooms. For example, Harding (1979) cites examples of examination results in which boys scored significantly higher than girls on multiple-choice papers, but in which girls were significantly more successful than boys on essay questions. She raised several pertinent questions:

> "Does the use of a multiple-choice paper ensure the testing of a wider grasp of a subject by eliminating choice? Is the confidence to make judgements an advantage? Is dependence on learned work a disadvantage? Does the style of learning encouraged during the study of a subject influence the ability to score well? Are spatial factors involved, when much information is presented diagrammaticially? Do multiple-choice items penalise the candidate who is more aware of possible contextual dependence of the data presented?"
>
> (Harding, 1979:284)

The answers to these questions are important, but the questions themselves draw attention to the kinds of assumptions teachers make about the similarities between girls and boys - in particular, the assumptions that girls and boys can (and should?) be treated identically and that, as a consequence, similar responses will be offered by either sex.

Boys bring with them into their science classes large reserves of incidental scientific knowledge and skills accumulated as a consequence of their particular socialisation experiences and expectancies (Section 2.2.3), whereas girls do not. Several girls in this study expressed uncertainty and anxiety with their science, particularly when doing experimental work, which was symptomatic of limited prior experiences with the apparatus and/or the ideas involved. Just as remedial courses in reading are available in many schools (and often subscribed to by more boys than girls), so too could 'remedial' courses in science be offered where the emphasis on 'tinkering' with apparatus (such as levers, pulleys, electrical circuitry, masses, chemicals). These courses would not necessarily solely be for girls but it is anticipated single sex sessions would be preferable so as to minimise the expression of conventional sex stereotype behaviour apparent in mixed sex situations.

During practicals within the regular laboratory periods, coeducational teachers sensitive to the 'male-doer' 'female-secretary' phenomenon may prefer to operate single-sex groups and insist on high levels of experimental participation and neat presentation of records from both sexes (the 'tidy' book criterion of 'appropriate' behaviour is not a feminine perogative - boys do respond to such a criterion in the 'masculine' field of Technical Drawing!). The girls' feelings of anxiety would need to be recognised and accepted, not as reasons for avoiding the practical work but, as support-seeking expressions of concern. Within a supportive, non-patronising, context, girls' self confidence would develop as familiarity with the material and concepts accrued.

Whilst the content of the science courses may well be gender-free, the examples and illustrations have traditionally been male biased:

"I don't think I would ever use science. I don't really want to know how far a projectile will land." (F4 girl)

Teachers need to be alert to such biases, particularly where they occur in texts, film and other media material. The girls' socialisation experiences are such which predispose them towards an interest in people and in life processes (HMI, 1980) so science courses need to contain material which emphasises the importance of science to society and explore what life was like without its benefits (Ormerod, et al, 1979).

(iv) Parents' own outlooks on science need to be developed. Parents have considerable influence in determining the initial beliefs and attitudes towards school in general and, consequently, towards science too. Their knowledge and experiences of science are often very limited and very much affected by their own school science experiences. When decisions concerning their children's future subject choices were to be made, their opinions (even though often tacit) were influential (see also Haertel, et al, 1981). Several parents interviewed in this study expressed concern about feeling very inadequate when attempting to give subject choice advice to their children and intimated they needed more support from teachers:

> "When it comes to deciding what subjects children are going to take, I feel there could be more scope for parents to go along (to the school) and learn more about the subjects ... To have, say, a teacher give a discussion on each subject ... to give you a bit of depth in what the subjects involved so you are able to help the family make the right decision, or at least understand what they're doing more ... The whole education scene has changed that much since we were going to school and we really don't understand half of what they do."
>
> (Sharon's father)

From such comments it can be seen that school science teachers, and their science departments, need to be involved with subject and career guidance. Perhaps a series of parent evenings needs to be organised (e.g. at least one per term) to provide parents with the knowledge on which effective decisions concerning their children's future courses can proceed. In this way aspects of the 'public' image of science and of scientists may be redressed:

"(The scientist) is a bald man with glasses wearing a white lab coat who doesn't take much notice of the outside world." (Sharon)

Parents are often employers in positions able to influence employment opportunities for girls but, in spite of legislation (such as the 'Human Rights Commission Act', 1977), may not have seriously considered hiring girls for scientific or technological positions. Several overseas projects, recently established specifically to research the issue of the under-representation of girls in the sciences, such as the 'Girls into Science and Technology' project in Manchester (Smith, Kelly and Whyte, 1980), and the 'Maths/Science Sex Desegregation' project in Novato, California (Skolnick, et al, 1982), have placed particular emphasis on liaisoning with prospective future employers and report a marked increase in the numbers of girls expressing interest in vocational science (Harding, 1982).

The suggestions given above have been couched in broad terms so as to provide a general overview of the major areas in need of attention - areas which can be effected by science teachers working, initially from schools, then into homes, to the media, and finally, into places of employment. Such a programme would systematically challenge the sex role stereotyping in today's society which is seen as being primarily responsible for the limited, and limiting, outlooks on science held by too many girls in New Zealand schools. Suggestions for teachers and parents, of a more detailed nature, may be found in Kelly (1981a); Fausto-Sterling (1981); and Skolnick, et al (1982).

7.3.2 Suggestions for redressing the cultural inequality in science.

> "The time for turning a blind eye to Maori underachievement in education is past - time is no longer on our side, and we must act urgently. New Zealand will not achieve social cohesion and enhanced mutual respect between the races until Maoris are represented in due proportions in all walks of life, taking their place in the prestige occupations... It is clear that if we are to meet the educational needs of Maoris our educational system requires improvement. The community and teachers alike need to examine closely our educational philosophy, and our

> classroom strategies, the organisation and climate of our schools and, where necessary, change them."
> (He Huarahi, 1980)

The complexity of this issue has already been alluded to (Section 7.2) and, when the tenets on which an entire educational system rests are queried, no simple 'solutions' can be anticipated. Harker (1979), after reviewing a wide range of studies which investigated Maori scholastic performance, concluded:

> "... the difference between the culture of the child's home and community, and the culture inherent in the curriculum organisation and teaching methods of the school is an independent causal factor in the lower achievement of Maori children in New Zealand schools."
> (Harker, 1979:9)

He labelled this 'factor' responsible for this difference 'ethnicity'. Essentially, he appears to be saying that New Zealand schools assess pupils according to criteria which are culture-dependent and, as that culture is European, ipso facto, members of non-European cultural groups will be disadvantaged. Tauroa (1982) uses the term 'ethnocentrism' in his report to the New Zealand government for the Human Rights Commission, and Waghorne (1982), in his report to the New Zealand University Students' Association, refers to the phenomenon as 'institutional racism' - all these terms are expressions of the cultural inequality found in this current study.

This cultural inequality in education was succinctly expressed by a Maori educator interviewed during this study:

> "Look at the question, education for what? What are you trying to educate us for? To be better road

> sweepers? To be better freezing workers? To be better miners? We don't need an education for that. If you are educating us to be better teachers, to be better accountants, to be better scientists, then what you really want us to do is become Pakehas, and we can't be Pakehas and stay ourselves in the community. But, that's where we find our greatest satisfaction and that is our means of success."
> (Mahuta, 1980)

The various reports which have examined the issue of Maori and Pacific Island under-achievement in New Zealand schools (e.g. 'He Huarahi - the Report of the National Advisory Committee on Maori Education, 1980; 'Te Tatai Hono - the Report and Recommendations on Maori Education, New Zealand Educational Institute, 1981; 'Race Against Time', Tauroa, 1982), and the observations made within this study, imply there is a tacit educational assumption operating in the New Zealand school system which, if stated, would read: 'The official curricula, the educational organisation, the teaching and learning styles, the assessment criteria, and the European-determined values, are valid for all New Zealand school pupils'.

If stated, such an assumption could be immediately challenged by all involved with, and affected by, education, but as it is not stated the cultural inequality is maintained. Whilst such a consideration of the fundamental assumptions upon which the New Zealand educational system rests lie outside the brief for this current study, it is important to acknowledge their presence and ultimate influence on what actually occurs within the classroom and laboratory. These fundamental assumptions, those tacit and those explicit, provide the broad backdrop against which the implications of specific outlooks on science can be highlighted.

One assumption, previously implicit, has been indicated by Osborne (n.d.). This is that school science should enable all pupils to become 'committed to the endeavours of science' (those pupils who do not become so committed are often judged to be 'unsuccessful' in science). Osborne suggests an alternative:

> "Scientists and young children are interested in finding out about things and about how and why things behave as they do.
>
> We want children
>
> 1. - to investigate things and explore ideas
>
> 2. - to seek and develop explanations that are sensible and useful to them
>
> also, if possible, we want children
>
> 3. - to appreciate the scientists' way of investigating
>
> 4. - to regard some scientific explanations as sensible and plausible,and as potentially useful to society
>
> also, we want some children
>
> 5. - to replace their own explanations with the explanations of science
>
> 6. - to become committed to the endeavours of science."
>
> (Osborne, n.d. emphasis added)

The under-representation of Maori and Pacific Island students in the sciences would indicate that very few of them have achieved Osborne's objectives #5 and #6. However, because of the kinds of outlooks on science they hold, as revealed in this study, it is also likely that few of them have reached even objectives #3 and #4 - the 'scientists' ways' and their 'scientific explanations' lack relevancy and applicability to many Maori and Pacific Island students - the image of science, its methods, and its practitioners lie outside the 'range of convenience of the constructs' (Kelly, 1955) available to them. Much needs to be done and much can be done, starting within schools and, by giving greater emphasis to Osborne's objectives #1 and #2, before attempting any of the subsequent ones. It is possible, that unless the school system accepts a pluralistic identity and provides alternative criteria for assessing 'success', other than solely academic achievement, Osborne's objectives #3 to #6 would be valid only for students who elect to subscribe to European-type values.

The suggestions for influencing students' outlooks on science with respect to accommodating sex differences offered in the previous subsection have substantial validity in the inter-cultural context also.

(i) Students' beliefs about science need to be explored, challenged, modified and/or extended. Maori and Pacific Island students have few ethnic role models available to them (either through direct acquaintance, or through the media - texts, T.V. & films), their parents themselves (particularly those of recent Pacific Island immigrants) have a restricted set of beliefs about science, and their exposure to 'scholastic' school science, provide them with a set of experiences in need of systematic examination and development. Even those students whose outlooks on science are positive and express a desire to continue with a study of it may hold very simplistic beliefs about science.

"I like science but I won't need chemistry because I don't want to become a chemist (i.e. a pharmacist)." (Janis)

Exposure to a wide range of first-hand experiences, such as visits to places where science and technology is applied and where a variety of different people are seen employed in science and heard talking about their work, would provide the student with an experiential base on which to develop a more comprehensive set of beliefs about science. Such a set of beliefs would allow for a better considered decision to be made regarding a continuation, or otherwise, of their study of science.

The following suggestion, made by a Maori educationalist, expresses the importance of embedding this set of beliefs in the context most significant to the Polynesian students - the social context of his/her own community:

> "The people must see what you are trying to get them to do. You've got to actually show them something. You can talk until the cows come home and they'll never learn anything until they can physically see it. If you're talking about science then show me what science can do for me as a people, as a community. Show me in a very practical way. Not in the classroom but here in my home community."
>
> (Mahuta, 1980)

The science teacher's recognition of the importance of Maori and Pacific Island students of the social context for their learning enables the teacher to readily explore his/her students' beliefs concerning their perceptions of other people's views about science. That is:

(ii) Students' perceptions of other people's views need to be identified, explored, challenged and/or extended. The Maori or Pacific Island students, in always being an integral part of a group of people, tend to share a 'communal' perception. For the school student, it is the peer group's perception which is most influential in determining the nature of the individual's outlook on science. The importance of the peer group, and its genesis, is clearly identified by Smith (1982):

> "In Polynesian culture the peer group is tremendously important and a separate sphere from the adult world. Children have less contact with the adult world and are inclined to be less dependent than Pakeha children. From an early age they share responsibilities and problems with each other. A type of consensus leadership and solidarity develops in many peer groups. Children of all ages have contact with each other. The Western ideals of individual achievement and competition conflict with Polynesian ideas of working together with others and social interdependence. Peer status does not depend as much as it does among Pakeha children on personal achievement."
>
> (Smith, 1982:196-7)

This issue of the importance of the peer group leads naturally to the third broad suggestion for teachers of science; namely,

(iii) Teachers' styles of teaching science need to be examined. The science teacher needs not only to explore the nature and extent of the 'communal' outlook on science but may also need to deemphasise the Pakeha (Western) attention to the individual and recognise the saliency of ethnic grouping within his/her classroom. The teacher also needs to be aware that virtually all current assessment procedures require the individual student's abilities to be distinguishable from those of others and that this requirement often induces an individualistic competitive emphasis which is inimical to the Maori or Pacific Island group dynamics based on cooperation. Alternative assessment procedures which recognise the integrity and validity of group performances need to be developed (e.g. group projects and presentations).

The science teacher's 'style' of presentation needs to encompass, not only the recognition of the importance of the social context but, also the Maori or Pacific Island student's preference for a visual (relational?) learning style - a learning style characteristic of an oral tradition of learning:

> "This is much more so for Pacific Island children, especially the (recent) immigrants whose (island) demonstrators, or teachers, are always performing and the learners are silent. They watch, they listen. There's no little dialogue between the learner and the instructor - that's one of the characteristics. So the implications for a science teacher setting up an experiment, be it say filtration or condensation or distillation, or what-ever, are that the steps he takes in setting up the experiments, from the putting up the retort stand to putting the filter paper in the funnel, are all significant because of a Pacific Island child's cultural makeup. Particularly important is the use of silent language. When I say 'silent', I mean the gestures, the eyes, the looks, even the expression on the teacher's face, communicate a lot to the child."
>
> (Ioane, 1980)

The importance of recognising the role non-verbal cues, and the possible cross-cultural misunderstandings these can create where such as a gesture may have different meanings in different cultures are discussed in some detail by Metge and Kinloch (1978).

Several interviewees (e.g. Aroha's father, & John's father - both quoted in Section 5.3.1) remarked on the importance of the teacher-pupil relationships. Aiao (1980), a Nuiean Island interviewee, heavily emphasised this:

> "The European brought up in the educational system knows what is going on in schools but the Nuiean parents do not know ... and they depend on the teachers to make sure the children are taught the things they are supposed to be taught in a school so they always hold the view that if the children have lost interest in what they do in school that reflects on the teachers ... if the children aren't interested in school there must be something wrong with the relationship between the child and the teacher."
> (Aiao, 1980 - emphasis added)

Many Maori and Pacific Island students have low academic self esteem (Section 5.2.3; Ranby, 1979) and their outlooks on science (as with any subject) are influenced by the nature of the interaction they have with their teachers. The repertory grid analysis of the people in Sandra's life (see Appendix 5.1) clearly revealed the particular importance to her of teachers who were 'patient', 'interesting', 'helpful' and who 'do listen to me'.

Sandra's experiences would suggest few of her teachers had checked the nature of their relationship with her, and her science teacher had not explored with her what her outlook on science was - she had been positively disposed towards her intermediate school level science in the previous year but had become ambivalent towards it during her first term at secondary school.

Also, the science teacher may not have explored his own expectations concerning Sandra's outlook on science and scientific ability. St George (1980) had discussed the possibility that teachers' expectations of pupils' abilities may be affected by such 'stable factors' as the pupils' ethnic group. She suggests teachers need:

> "... to continually check expectations for pupils and adjust them (and consequent behaviour) accordingly. The difficulty is that when expectations become strong and stable there is a tendency to notice only those aspects of a person's behaviour that 'fit' the expectations. Also, the interpretations of what is seen may be influenced by one's expectations. It is important to test out our assumptions about how capable pupils are and what they can learn."
>
> (St George, 1980:26-7)

The cultural inequalities recognised by this study highlight the necessity for teachers (those of science, as well as those within the other disciplines) to heed St George's suggestions.

(iv) Maori and Pacific Island parents' own outlooks on science need to be developed.

> "Well you take aspects of coaching rugby or rugby league, there's a certain amount of science in that and a lot of Maori people are taking coaching positions and roles in that particular area, so they have to analyse things, so they have an analytical approach in the teaching of skills in rugby, in tennis players, golfers - there's quite a bit of science in golf."
>
> (Aroha's father)

Very few parents (European or Polynesian) were able to express such 'positive' beliefs about the application of science as Aroha's father (above). As parental beliefs have been found to be very influential in determining those of their children (Kremer & Walberg, 1981; Stamp, 1979) it is important that science teachers are aware of the role they can play in shaping their pupils' beliefs through working with their pupils' parents.

It is particularly important that parents are provided with a wide awareness of how science can (and does) contribute to their community (the statement made by Mahuta, above is well noted!) and that those parents with limited experience of the New Zealand education system (such as recent Pacific Island immigrants) are given practical support in assisting their children develop appropriate study skills and, consequently, a positive outlook on science.

The strength and status of the Maori and Pacific Island social context needs to be utilised in order to accommodate the expression of different cultural values. With this in mind, consideration could be given to marae-based horticultural/agricultural schemes run on a 'home-and-school' collaborative basis; 'homework' evenings held in community centres where teachers and parents work together with the children; and to the use of various Maori and Pacific Island people, with skills and interests with aspects of science (such as motor mechanics, building and boat construction, traditional food preparations, craftwork, Polynesian navigation, etc) to work alongside science teachers so all could learn with and from each other.

The possibilities for challenging the stereotyped (and sterile) image of science abound. The nett outcome, that of enhanced outlooks of science held by many more Maori and Pacific Island students, would do much to redress the current under-representation of Maori and Pacific Island students in science.

7.3.3 Concluding comments on the methodology used in the current study.

(a) The sample used and research plan

The declared emphasis on the individual student focussed attention almost wholly upon the students, and later, to some extent, upon their parents. This narrow focus was necessary in order to be able to describe the current outlooks on science held by specific individual students, but, in order to answer the research question more adequately, a wider focus was required. In order to answer the research question, 'why the under-representation ...?' an understanding of the development of the students' outlooks on science and how these outlooks were maintained, or altered, was also necessary. For these aspects of the problem to be thoroughly explored, a broader research plan was required. This would have required the emphasis to have been moved from the individual to the total context in which the individual functioned. That is, the family, the school, the neighbourhood and the community contexts all needed exploring.

Researchers interested in documenting the educational experiences of students need to move beyond the boundaries of formalised schooling and observe their behaviour in a variety of settings. It is likely that many of the skills and competencies of many students with poor outlooks on science (particularly Maori and Pacific Island students) do not emerge in the classroom environment but would be revealed in particular <u>social</u> settings such as the home, in church, on a marae, or on the playing field/court.

The importance of observing individuals in a variety of contexts may be linked with Kelly's notion that personal constructs are not always able to be articulated and, if they are, the verbal labels used by the individual to communicate his/her meaning may not equate with the underlying constructs. Pope and Keen (1981) suggest:

> "... looking at what people <u>do</u> alongside what they say about their thoughts and feelings will enrich our understanding of their construing."
> (Pope & Keen, 1981:161. Emphasis added)

Pope and Keen's suggestion is a salient one. The emphasis within this current study was on what the interviewee <u>said</u>, rather than what he/she <u>did</u>. Whilst the <u>manner</u> in which events were described was noted and the interviewee encouraged to express how he/she <u>felt</u> about them, the opportunity to observe the students at length <u>in situ</u>, was not taken.

This study may also have been enhanced by including in it explorations of the personal construct systems of those girls and Polynesian students who did profess to have positive outlooks on science. For example, it has been observed (Section 2.2.3) that girls from single-sex schools are more likely to continue with a study of science than girls from co-educational schools. Perhaps a study of a group of F4 and F5 girls, with positive outlooks on science, from a single-sex school would have provided specific insights into the way the school context might have influenced the development of such outlooks? Similarly, the personal construct systems of Polynesian students with positive outlooks on science (probably from a private school with a strong emphasis on Polynesian cultural values) could have been investigated. By comparing and contrasting such students' personal construct systems with those already obtained from the more heterogeneous populations of students examined in this study additional lines of inquiry for further research may have been suggested.

(b) The theoretical perspective

The rationale for using Personal Construct Psychology and aspects of the Theory of Reasoned Action was expressed in Chapter 3. Here it is appropriate to pass comment on the value of using these particular approaches in this research.

Not only did the TRA provide an instrument capable of providing quantitative data, but, in the planning stage of this research, it appeared to this investigator to complement a PCP approach. TRA is readily interpreted within PCP. PCP's fundamental postulate - 'an individual's processes are psychologically channelized by the ways in which he/she anticipates events' - can be viewed as a variant of the TRA's assumption that an individual's intention to perform a behaviour is determined by his/her attitudes towards that behaviour and his/her perception of what other people will think about him/her performing that behaviour. That is, a person's intention may be considered to be one consequence of that person's anticipation of certain outcomes should the behaviour in question occur. The 'attitudes' and 'social standards' which determine intention (in the TRA model) may be construed as effecting the 'psychological channelization'.

Another way of looking at this is to view the TRA model as focussing on individual construct systems with a lower powered 'lens' than does PCP when it (PCP) focusses on constructs. Constructs may be viewed as the prior psychological units from which the 'objective' and 'social beliefs' of the TRA model derive.

In adopting this relationship between the two approaches, the issue of 'value', or usefulness, of viewing the findings of this research from essentially a PCP perspective warrants comment.

A 'useful' perspective may be described as one which adequately

(i) provides explicit guidelines for the consumer of the research;

(ii) describes the findings in a systematic and complete fashion;

(iii) explains what the results mean in accordance with a theoretical framework, theory, or model;

(iv) relates the findings to other research of a similar kind; and

(v) generates ideas and hypotheses for future research.

In this particular research, the first 'criterion' is very important for science teachers, school administrators, curricula developers, and media developers (e.g. textbook writers). This investigator believes the suggestions offered in Section 7.3 satisfy this criterion, and the remaining criteria are adequately met in the results and discussion chapters of the thesis (Chapters 4 to 7).

Within a PCP perspective, the final criterion listed above hardly requires expression for it is the sine qua non of us all as we go about our daily lives. Theorising, hypothesising, predicting, testing, re-evaluating and so on, are not characteristics specific to a particular group of 'intellectual, cold, impersonal, European men' but are fundamental traits of all functioning humans, regardless of personality, colour, or sex.

All our students are 'scientists' (Stead, 1980b) but the development of their outlooks on science requires systematic attention. It is anticipated the development of positive outlooks will go a long way to redressing the current under-representation of girls, and of Maori and Pacific Island students, in the sciences.