MATHEMATICS AND PHYSICAL SCIENCE CHOICES MADE BY PUPILS IN SELECTED EASTERN CAPE HIGH SCHOOLS: AN INVESTIGATION INTO THE FACTORS INFLUENCING THE DIFFERENT CHOICE PATTERNS OF BOYS AND GIRLS

THESIS

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ABSTRACT

The disparate numbers of boys and girls who elect to continue with mathematics and/or physical science in the higher standards of the school system has recently attracted much research attention and the complexity of the interrelatedness of causal factors has become obvious.

The broad aim of the study was to investigate the significant drop-out rate of girls at the end of the junior secondary phase of education (approximate age of fourteen to fifteen). This was to be carried out for mathematics and physical science and undertaken using a cross-sectional and a longitudinal study.

The cross-sectional study entailed administering mathematics and physical science attitude questionnaires to 3531 standard six, seven and eight pupils from 4 co-educational, 2 all-girls' and 2 all-boys' schools, from middle and upper socio-economic communities with similar language and cultural backgrounds.

The longitudinal study involved pupils from two co-educational schools and one all-girls' school. It was a progressively-focused study starting with questionnaires administered to 358 standard six girls and boys, narrowing down to questionnaires and interviews used with 50 girls and 28 boys in standard seven and finally to interviews with 10 girls from standard eight. The parents of these ten girls were interviewed at the end of the study.

The attitude questionnaires yielded strong sex differences which favoured the boys in both subjects for all the attitudes measured and also pointed to a progressive deterioration of attitudes over the three-standard span. They also established significant differences in attitudes which favoured the pupils from single-sex schools. It was further concluded that the girls were more strongly guided by their attitudes when making their subject-choice decisions.

In the longitudinal study, reasons were suggested for pupils either taking or dropping mathematics and physical science. The introduction of algebra in the first year of high school presented a problem to pupils. In physical science, electricity was singled out as giving the subject a male bias.

Socialization influences in the home were the main issue dealt with from the parent interviews. Sex-roles and stereotypes were dealt with in depth.

Recommendations were made involving classroom strategies, curriculum possibilities, school policies and further research.

TABLE OF CONTENTS

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It is with much pleasure that I write this section of the thesis. Pleasure because I have come to the end of what has been a long and arduous road, pleasure because I have benefited immeasurably from having trodden the uncertain path of a research study, but also pleasure because of the willing assistance that has been given me by so many people. In particular I would like to thank the following:

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LIST OF TABLES, GRAPHS AND FIGURES

GRAPHS

FIGURE

CHAPTER ONE

AN OVERVIEW OF THE RESEARCH

1.1 Introduction

In primary school and in the first two years of high school, most subjects are compulsory and pupils first encounter options at the age of thirteen or fourteen. The choices made at this stage have far-reaching consequences, in that the decisions involving mathematics and physical science in particular, structure pupils' educational directions as well as in many cases their lifetime careers.

The idea that mathematics and physical science should be part of every child's educational experience as well as being vocational subjects for future specialists, is widely accepted. This of course has not always been the case and one wonders if in fact it really is true today.

In 1906, W.L. Felter argued that girls should not be taught physical science, even at the most elementary level, because "the expenditure of nervous energy involved in the mastery of analytic concepts would be injurous to their health". E.R. Gwatkin in a 1912 British Board of Education Report asserted that "there can be no doubt that the majority of girls find mathematics hard", and she suggested that "a girl should do less work at all times than a boy, and she should be protected against strain during the years of development".

Such statements may seem ludicrous today, but how far have we really progressed? Even now far fewer girls than boys study physical science and mathematics. Is the present-day rationale any more tenable than that at the beginning of the century?

The situation seems even stranger when we consider what Plato had to say in THE DIALOGUES, (The Laws - Book 7)

> *Nothing can be more absurd than the practice which prevails in our country of men and women not following the same pursuits with all their strength and with one mind, for thus the state, instead of being a whole, is reduced to a half.*

Any investigation is usually sparked by some knowledge or experience which then gives rise to a question which needs to be answered. It is common opinion, that physical science and mathematics at high school level are difficult subjects for many pupils and they are very often seen as subjects which belong to the 'male domain' and so should be avoided if at all possible, but by girls especially.

The writer being a deputy principal and a physical science and mathematics teacher, has for a long time been exposed to this thinking, both in the classroom and in consultations with pupils and with parents. The obvious lack of confidence of many girls as to their ability to cope with and feel at ease in these apparently 'male' subjects is thus of considerable concern and interest. This attitude has manifested itself not only in the choice of subjects, but also in the area of careers. Avoidance of these subjects blocks the entry of girls into scientific, technical and other mathematics-related careers and thus contributes greatly to the drastic shortage of manpower in these fields. Experience as a physical science examiner for the Joint Matriculation Board, has only served to reinforce the writer's disquiet in this regard.

The reason why mathematics is in the centre of such a large amount of controversy is because it is a key to so many doors and in fact was described by Sells (1978) as the "critical filter" of the careers-field. Pupils that choose to drop mathematics, dramatically curtail their career opportunities, and not only in science and technology, because mathematics has long been a prerequisite for many tertiary courses other than for mathematics itself. As a filter it is thus often an unwanted and undesirable one, because mathematics is frequently used as a test of general intelligence `g', and not for the specific reason for which it was intended.

Armstrong (1980) says that among U.S.A. women who pursue careers outside the home, very few choose science, medicine or engineering.

> *Social, educational and cultural barriers have prevented women from entering such technical fields. These barriers have existed for years, and despite hopeful rhetoric, they have changed little during the last half century. Only one-tenth of one percent of engineers are women; only two percent of physicists are women; only five percent of chemists are women.*

She quotes further statistics from a 1978 College Entrance Examination Board, that approximately 63 percent of college-bound males had taken four or more years of high school mathematics, while only 43 percent of females were similarly qualified. Most colleges and universities require four years of high school mathematics in order to take calculus, which in turn is required for virtually every technical or science major. "Thus without remedial work, more than half of all college-bound women are unable to major in the technical fields."

Ernest (1980) at a leading U.S.A. university found that less than one-third of the women in their first year had followed the necessary high school mathematics courses in order to be able to register for <u>any</u> undergraduate course of their choice (i.e. more than two-thirds were restricted in the subjects which they could take), while two-thirds of the men were sufficiently qualified in mathematics in order to opt for <u>any</u> course of their choosing. Sells (1978) in fact found at a Californian university that fifty seven percent of the men had adequate qualifications in order to take the first-year mathematics course, while only a staggeringly low eight percent of women were eligible.

In the United Kingdom similar under-representation is also evident at many different levels in mathematics and science. The following statistics (Table 1.1) are quoted by the Nottinghamshire LEA (1985), as part of their "Girls Education in Mathematics, Science and Technology Project (GEMSAT)". They give the percentage representation of boys and girls in mathematics, physics and chemistry for certain grades obtained in national examinations. (DES Statistics of Education, 1983)

TABLE 1.1

PERCENTAGE REPRESENTATION IN CERTAIN SUBJECTS

	CSE (Grades 1-5)		O-LEVEL (Grades A-C)		A-LEVEL (Grades A-E)	
	Boys	Girls	Boys	Girls	Boys	Girls
Mathematics	47,8	52,2	56,5	43,5	70,7	29,3
Physics	78,3	21,7	72,3	27,7	79,1	20,9
Chemistry	56,5	43,5	60,7	39,3	64,8	35,2

(Note that mathematics is compulsory to 16+, but is optional thereafter, unlike physics and chemistry which are optional for all the above.)

It is obvious that physics is consistently the most 'male dominated' subject, but once an option can be exercised in mathematics, it also tends very rapidly towards the same large imbalance (as seen at the A-level stage). Chemistry shows the least variation, but nevertheless is still taken by approximately twice as many boys as girls.

Kelly (1981a) gives some interesting statistics (Table 1.2) which cover virtually the whole of the educational spectrum. The data refer to schools in England and to British universities and are given as *the ratio of number of males to number of females in the relevant area.*

TABLE 1.2

MALE/FEMALE RATIOS IN VARIOUS AREAS

	Mathematics	Physics	Chemistry	All Subjects
Attempt CSE	1,0	7,5	2,1	1,1
Attempt O-level	1,5	3,8	2,1	1,0
Attempt A-level	3,8	4,9	2,4	1,4
Obtain first degree	2,6	7,2	4,7	2,0
Do post graduate research	8,0	9,6	7,0	4,1
Obtain Ph.D	3,8	17,1	9,7	6,3

It is clear that the proportion of women is generally lower at higher levels of qualification and that the upper reaches of the educational system are dominated by men in all subjects and not only in the scientific fields. This being so, it is reasonable to ask whether girls are specifically under-represented in science or whether their position in science merely represents their position in the educational field generally. This can be examined by looking at the next table (Table 1.3, also from Kelly, 1981a), which shows the under- or over-representation of females in each branch of science, relative to their representation in education as a whole. (Kelly's use of 'science' includes physics, chemistry, biology and mathematics.)

The figures in this table are:
number of males for every female studying the subject, divided by the *number of males for every female studying ALL subjects at that level.*
A value greater than 1 indicates that there is a higher ratio of men to women in that subject than in education as a whole at that level, i.e. women are less well represented in that subject than in education as a whole.

TABLE 1.3

MALE/FEMALE RATIOS IN RELATION TO ALL SUBJECTS TAKEN

	Mathematics	Physics	Chemistry	Biology
Attempt CSE	0,9	6,8	1,9	0,4
Attempt O-level	1,5	3,7	2,0	0,6
Attempt A-level	2,8	3,5	1,8	0,8
Obtain first degree	1,3	3,7	2,4	0,7
Do post graduate research	2,0	2,4	1,7	0,6
Obtain Ph.D	1.5	2,7	1,5	0,6

As can be seen, the increasing dominance of men at succeeding levels of the educational spectrum is no longer evident. In Table 1.3 each subject has a characteristic ratio which remains fairly constant at the different stages. Girls are relatively over-represented in biology, under-represented in mathematics and chemistry, and drastically under-represented in physics. This imbalance is evident at O-level, and persists through to doctoral level. Kelly (1981a) interprets this as "... women's position in science, *relative to other subjects*, does not get any worse at higher levels of the educational system." She sees two distinct sets of variables in operation: The factors which cause girls to drop out of education between O-level and Ph.D operate in science as in other subjects and "account for the sharp increase in the ratio of males to females" as found in Table 1.2, but "the factors which are specific to girls dropping science appear to operate before O-level". It appears therefore that measures to encourage girls to study science would be most effective if applied to the O-level stage, but measures to keep girls in the educational system as a whole should operate at later stages. It is the former which forms the basis for this investigation.

Kelly (1981e) in analysing data from an international study -the IEA survey of Science Education in Nineteen Countries (Comber and Keeves, 1973), found that girls' under-achievement in the sciences was not confined to England. "It is a common phenomenon, particularly, but not solely confined to the Western world. ... Girls in some countries achieved better in science than boys in other countries. Nevertheless within each country studied, girls achieved worse than boys." These sex differences were more pronounced in physical science than in the biological sciences.

A similar situation with regard to the ratio of the number of girls to boys in mathematics and physical science, exists in South Africa as can be seen from Table 1.4 which contains statistics as provided by Swanepoel (1982) in a report resulting from a project undertaken at the request of the Scientific Advisory Council of the Prime Minister. This project investigated the teaching of mathematics, physical science and biology at schools under certain Education Departments in the RSA. The statistics are expressed in percentages and all refer to the education departments of the Cape, Transvaal, Natal, Orange Free State and South West Africa/Namibia as well as Private schools. The size of the sample was 4 906 (9,6%) of the maximum possible 51 304. It will be noted in the table that there are various grades in which candidates are examined. There are in fact three (higher, standard and lower grade) and all examining bodies conform to these as they all fall under the Joint Matriculation Board. Lower grade statistics have been excluded from this study, because this grade has only been introduced recently and in addition there are very few candidates offering mathematics and physical science on this grade.

TABLE 1.4

STANDARD 10 PUPILS WHO TAKE MATHEMATICS OR PHYSICAL SCIENCE (PERCENTAGES)

	Mathematics		Physical Science	
	Boys	Girls	Boys	Girls
Higher Grade	32,1	20,8	30,7	13,0
Standard Grade	37,3	20,8	20,6	5,5
Other Courses	9,8	2,2	9,6	0,5
Do not take	20,8	56,2	39,1	81,0

In this sample, approximately twice as many boys as girls take mathematics, while three times as many boys compared to the number of girls take science. Generally speaking, these figures are much the same as those quoted earlier and are worrying to say the least.

In schools under the jurisdiction of the Cape Education Department, the breakdown of pupils taking mathematics and physical science in 1986 is given in Table 1.5 . Separate data are given for boys and girls, higher grade and standard grade, and also for English- and Afrikaans-speaking pupils. In addition, the ratio of the number of boys to girls taking mathematics and physical science has been calculated for each standard. This has been done for the <u>combined</u> higher grade and standard grade numbers in order to give the overall ratios of the pupils taking the two subjects, as these will be more representative of the boy/girl ratio.

TABLE 1.5

SOME CAPE EDUCATION DEPARTMENT STATISTICS FOR 1986
STANDARD 8, 9 AND 10 PUPILS
TAKING MATHEMATICS AND PHYSICAL SCIENCE

		English		Afrikaans		English		Afrikaans	
Std	Grade	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
8	HG	1858	1471	2300	1929	1921	918	2121	1150
	SG	1279	668	1312	592	473	91	656	66
Total		3137	2139	3612	2521	2394	1009	2777	1216
Boy/Girl ratio		1,47		1,43		2,37		2,28	
9	HG	1297	1112	1701	1354	1492	735	1757	913
	SG	1607	933	1555	905	807	145	675	135
Total		2904	2044	3256	2259	2299	880	2432	1048
Boy/Girl ratio		1,42		1,44		2,61		2,32	
10	HG	913	676	1250	958	1104	538	1281	668
	SG	1607	1191	1808	1209	1007	275	994	319
Total		2520	1867	3058	2167	2111	813	2275	987
Boy/Girl ratio		1,35		1,41		2,60		2,30	

It is interesting to note that there is no real difference in the boy/girl ratios for either of the language groups within either of the two subjects. Similarly the three standards show remarkable consistency and in keeping with all other data given earlier, the sex differences in mathematics and physical science participation, differ considerably.

Policy makers in South Africa have with increasing concern noted the decline in the numbers of those in the technical, scientific and mathematical fields, and in particular the large discrepancy between male and female representation. This is abundantly endorsed in the report by Swanepoel (1982) mentioned earlier. The drastic shortage of mathematicians and physical scientists in the RSA has been discussed at the highest levels and a 'Report of the Main Committee of the HSRC -Investigation into Education' (1981), noted "Research has shown that Physical Science and Mathematics are unpopular subjects at school and that for quite a few years now there has been a sustained decrease in the percentage of Bachelors degrees awarded in the basic natural sciences." This report makes numerous recommendations concerning the problems in mathematics and physical science education, all of which are extremely sound and entirely feasible. However, a major shortcoming is that none of the recommendations seems to take into account the large boy/girl discrepancy in the numbers choosing the subjects, and that <u>attitudes</u> towards the subjects seem to play no part in finding a remedy for the crisis. All the 'right' answers are given, e.g. changing the syllabuses, guidance, teacher education, in-service training, facilities, etc. The feeling that one gets though, is that the <u>need</u> for these changes is based purely and simply on statistical evidence of numbers and that the real <u>reason</u> as to why they are required and what is required are not sufficiently addressed - if at all. Marland (1983a) argues that "there is virtually no curriculum planning in the United Kingdom" and "lack of overall planning leaves the subjects at the mercy of extraneous influence, and sex stereotyping is one of these". Burton (1986) commenting on Marland's statement, maintains that "the curriculum for mathematics is not planned so much as imposed, usually through the restrictive control of syllabus exercised by a chosen `scheme' or text series".

Several studies which have dealt with attitudes towards mathematics have been conducted in the Rhodes University Education Department. Noble (1974) in a study involving certain schools in Grahamstown, came to the conclusion "It would seem that the attitude of girls towards mathematics, even more than that of boys, is a factor that should be taken into account when teaching Mathematics to Standards 7 and 8." (Note that when this study was undertaken subject choices were made at the end of standard 6 and not at the end of standard 7 as is the case at present.) Light (1984) studied certain personality factors and attitudes to mathematics in primary school children (standards 3 to 5) in Port Elizabeth, which was an extension of the work of Noble (1974) and Ilsley (1977). He found that "in the main these pupils displayed a positive attitude towards mathematics", but there were certain areas where there were sex differences, and it would appear that it could be at the standard 3 stage that the attitudes of the girls towards mathematics begin to change. Oberholster (1985) in a study involving standard 6 and 7 high school pupils in East London also found sex differences in attitudes towards mathematics, but found that "there is a definite tendency for the standard 7 girls to have less positive attitudes towards mathematics than standard 7 boys."

A considerable volume of research has been undertaken and is in the process of being undertaken throughout the world. Many of these investigations address the problem of sex differences which exist in various aspects of mathematics and physical science in order to determine what factors are responsible. The majority of the research has been undertaken in the U.S.A. and the U.K., but certainly is not confined to these countries. It would seem to the writer that much more research in the area of *attitudes to mathematics and physical science* is required in this country before any meaningful advances can be made. The fact that so many girls fall by the wayside at junior high school level is surely a logical starting point and it is for this reason that this particular study was embarked upon.

It was also decided to investigate mathematics and physical science together, as these two subjects are so closely interlinked and because physical science is so dependent on mathematics both as a tool and as the `critical filter' mentioned before. In addition, while there are numerous studies which deal separately with the two subjects, there are none which integrate the two, although they are to a limited extent sometimes dealt with in parallel.

1.2 Aim of the Study

The broad aim of the study was to investigate the significant drop-out rate of girls at the end of the junior secondary phase of education (standard 7) in both mathematics and physical science. At the outset, this was to be done by:

(i) conducting a cross-sectional survey of the attitudes towards mathematics and physical science of standard 6, 7 and 8 pupils in 8 white co-educational and single-sex schools in Port Elizabeth and East London, and

(ii) by means of a longitudinal study of a smaller progressively-focused purposive sample drawn from a sub-group of the population mentioned above. This aspect would involve following a group of boys and girls from standard 6 through to standard 8, leading to in-depth individual interviews of some of the pupils and their parents, as well as additional group testing by means of questionnaires.

As the gathering of data proceeded and these were analysed, more specific directions were indicated which then made it necessary for more detailed information to be obtained, as well as shifts in emphasis to be accommodated. These will be covered in detail within the thesis.

CHAPTER TWO

RELATED RESEARCH

2.1 Introduction

It is only in the last two decades that the significant sex differences in mathematics and physical science participation have really been questioned, probably because it has been an accepted truism 'that boys do better than girls'. Consequently, research has increased markedly during this time and as is the case with so many studies, the more research that has been conducted, the broader the area has become and increasingly greater uncertainty has resulted. The various factors involved continue to show an even greater interaction and no one piece of research can cover the entire spectrum of the topic, but inevitably and by necessity must confine itself to specific (certain) parts of the spectrum. Always remembering of course that while one section can be thoroughly researched and analysed, the interaction it has with the other parts must be borne in mind when attempting to interpret its effect. The writer has attempted to cover the whole gamut of work in reviewing the relevant literature, but a detailed report and discussion of this would in itself be a significant document and considerable brevity is thus indicated. In attempting to classify the various factors which could have a bearing on the apparent sex differences in achievement and participation in both mathematics and physical science, it would appear that there are as many differing ideas as there are researchers. While there is obviously considerable overlap, much depends on the <u>definition</u> and <u>interpretation</u> of the various terms used. The following division would seem to be suitable in reporting on the various areas of research relating to the universally observed sex differences in both mathematics and physical science participation:

1. Cognitive Variables
2. Affective Variables:
    - Attitudes
    - Sociocultural
3. Educational Variables.

2.2 Cognitive Variables

2.2.1 Spatial Ability

It has been argued that the marked decline in mathematics achievement of girls at adolescence is causally linked to deficiencies in spatial ability. As in the case of mathematics, girls and boys show little difference in performance on spatial tasks during childhood. However, at approximately 13 - 14 years old, boys begin to perform at a higher level than girls and they tend to increase this advantage throughout their adolescent period (Maccoby and Jacklin, 1975). Since spatial tasks are considered more of a measure of innate ability than of achievement (although even this is in contention) it can be argued that the lower performance of girls in mathematics can be accounted for by their comparative lack of spatial ability, and according to Badger (1981) "the extent of the discrepancy in performance between the sexes may be contingent on the degree to which mathematics is dependent on this ability."

A fundamental problem in spatial ability does, however, seem to be that its definition is itself tenuous and that like all constructs that attempt to define intellectual abilities, it is operationally defined by its measures as well as by more logical or intuitive means. Factor analytic studies have not grouped these spatial measures together as well as might be expected when they are intercorrelated in order to determine their underlying structure and there seems to be consensus amongst reseachers that there is more than one spatial factor (Lord, 1985; Fennema and Tatre, 1985; Badger, 1981; Petersen and Wittig, 1979; McGee 1979). There is a tendency in much of the literature to refer to <u>any</u> spatial test as a measure of 'spatial ability' and it could be this that accounts for the inconsistent results obtained and possibly cast doubt upon the implications drawn from them.

Lean and Clements (1981) see spatial ability as "the ability to formulate mental images and to manipulate these images in the mind."

A particular subset of spatial ability is <u>spatial visualization</u> and it is in this area where sex differences have been most consistently found. Spatial visualization involves the visual imagery of three-dimensional objects, their movement and changes in their properties. The relationship between mathematics and spatial visualization is logically evident. Fennema (1983) states "In mathematical items, spatial visualization requires rotation, reflection or translation of rigid figures. These are important ideas in geometry. Many mathematicians believe that all of mathematical thought involves geometrical ideas." It would seem therefore that spatial visualization and mathematics are inseparably intertwined.

Spatial abilities have in a number of studies in several <u>scientific</u> disciplines, been strongly linked to the obtaining of academic mastery. Lord (1985) reported on six studies from various scientific disciplines all of which linked spatial ability to successful science students. While not providing conclusive evidence, the link between spatial ability and both mathematics and physical science cannot be denied and it is obviously important that the spatial abilities of pupils be developed as it is such an important cognitive operation. We know that females score lower on spatial visualization tests than do males, but Fennema (1983) questions whether or not females differ from males "in their ability to visualize mathematics - in the translation of mathematical ideas and problems into pictures." Fennema and Tartre (1985), after a three-year study concluded that "although students who are discrepant in spatial visualization and verbal skills differ in the processes they use to solve problems, they do not differ in their ability to solve problems." (see also Golbeck, 1986). Sherman (1980) found that spatial visualization scores were more highly predictive of mathematical attainment for girls than for boys and Badger (1981) reported other studies which found that spatial ability distinguished between those girls who continued their mathematical study and those who did not.

It would seem therefore that whatever influence spatial visualization skills have on the learning of mathematics (and hence science) it is extremely subtle and while this difference in abilities may help explain sex-related difference in both mathematics and physical science, one must not fall into the trap (as some people appear to) of believing that <u>all</u> girls are less able than boys in using their spatial visualization skills appropriately. Maccoby and Jacklin (1975) note that generally women's visuo-spatial skills are poor relative to those of men, but "where both sexes are allowed independence early in life, both sexes have good visual-spatial skills." They also noted that for a child with poor visual-spatial skills, "one should <u>not</u> attempt to teach him exclusively by verbal means, but should attempt to improve his visual skills." Lord (1985) notes that many researchers have suggested that visuo-spatial ability cannot be <u>taught,</u> but using a sample of eighty-four college undergraduates he obtained results which indicated a statistical improvement in visuo-spatial cognition with the experimental group, in both spatial visualization and spatial orientation and that "the weekly intervention sessions had a positive effect on the students' visuo-spatial awareness." Fennema (1983) feels though, that while intervention strategies would bring about an improvement, she does not foresee that this "will do very much to eliminate sex-related differences in mathematics." This feeling is echoed by Chipman and Wilson (1985) who write: "There is little evidence either that spatial ability is important to mathematics achievement or that it contributes anything to the explanation of sex differences in mathematics achievement."

2.2.2 Genetic Factors

In order to account for these sex differences in spatial ability one area of research has been that of the possibility of a genetic influence. The interaction of the genetic and environmental influences in producing the observed sex differences in cognitive functioning are widely accepted and it is as well to note Wittig's (1979) comment that sex as such "is a stimulus variable as well as a subject variable" and that "the psychologist can never study sex as a biological entity unaffected by its social-psychological context." While there is this interaction, however, performance in spatial tasks would, relatively speaking, be far less affected by environmental factors and more so by an inheritable component. As far back as O'Connor (1943), when he observed that only approximately 25% of the females in his sample scored above the male median on a test of spatial ability, a genetic sex linkage was proposed. He suggested that spatial ability is carried by a <u>recessive gene</u> on the X chromosome. Since males have only one X chromosome (while females have two) it follows that whenever the recessive trait is present, it will be manifest in male behaviour. Thus more men than women will receive a high spatial ability in the same way that more men suffer from red-green colour-blindness. Stafford (1972) and Bock and Kolakowski (1973) provided some evidence to support this hypothesis, but later researchers could find nothing in its favour (Vandenberg and Kuse, 1979 and Sherman, 1979). Maccoby and Jacklin (1975) in one of the 'earlier' publications note:

> *There is evidence of a recessive sex-linked gene that contributes an element to high spatial ability ... The existence of a sex-linked genetic determiner of spatial ability does not imply that visual-spatial skills are unlearned. The specific skills involved in the manifestation of this ability improve with practice.*

A difficulty with the recessive-gene theory is that sex differences only begin to appear at adolescence. Even if the theory is a viable one, these sex-related differences should appear from a much earlier age. To reconcile these facts then, the developmental aspect of spatial ability has been linked to the levels of sex hormones during adolescence. The hypothesis that the observed sex differences result from the effects of different levels of androgen and estrogen has been investigated by various researchers. Vandenberg and Kuse (1979) came to the conclusion that even this hypothesis could not really be supported. The evidence of course, is not easy to interpret in that the effects of these hormones are complex and according to Badger (1981), "their influence can only be inferred from correlational evidence."

2.2.3 Brain Lateralization

Other theories have been attempted in order to explain sex differences in spatial abilities. One of these is the differential rate of brain lateralization between the sexes. It has been known for more than a century that damage to the left hemisphere of the brain leads to speech defects, something which does not result from similar damage to the right hemisphere. It is also known that each hemisphere specializes in particular cognitive functions and abilities, but nevertheless they interact to control higher cognitive processes. Verbal tasks are processed by the left brain while the right brain (about which very much less is known) is very much more involved with spatial and visualization processes. Simple conclusions about the right hemisphere as far as lateralization is concerned are indeed difficult to make. Lateralization is of course a relative term, because both hemispheres play a role in virtually every function, and further it is affected by environmental influences and (according to recent research) by sex as well (Visser, 1985b). Another problem concerning most investigations in this area of research is the methods that are used. The results obtained are therefore not necessarily reliable.

Bryden (1979) reports that there is very little evidence to support a theory that males are less completely lateralized than females, and that the opposing view that males are more lateralized "finds somewhat more support. The present view indicates that this hypothesis is at least tenable." Badger (1981) produces similar evidence and comes out in agreement with Bryden. Bryden (1979) puts forward three possible explanations for differences in brain lateralization:

(i) A real biological difference in cerebral organization between males and females.

(ii) The test procedures used might cause females to use different strategies to perform the behavioural tests used to measure cerebral lateralization.

(iii) An interaction of strategy effects with cerebral organization (i.e. females pursue different strategies because their cerebral organization is different).

While there are no clearly discernable deductions that can be made from all the available information, the path has been pointed out quite clearly and an awareness of what the important factors could be, has been created.

2.2.4 Cognitive Development

The development of mathematical and scientific ability can to a large extent be determined by the successful formation of mathematical (scientific) concepts such as number, conservation of number, length, area, volume, mass, speed and probability. The term concept is often used, but seldom defined and the numerous attempts to do so have produced practically as many variations (see Sowder, 1980). One version (Visser, 1985a) is that a mathematical concept could be an intellectual end-product, and is that structure with which a person thinks, observes, communicates and organizes his world. It would also seem that there have to be a number of experiences which have something in common if a concept is to be formed. In fact Farmer and Farrell (1980) define it as "a classification of ideas, objects, or events into a set by mentally abstracting the common essential characteristics/ attributes which define that set." The difficulties that children experience in learning and understanding mathematics (and science) could be attributed to difficulties encountered in building up conceptual structures. All too many children try to learn mathematics according to rote-memorised unconnected rules (instrumental learning) which are much harder to remember than an integrated conceptual structure (Skemp, 1971). It is interesting to note here that learning of mathematical concepts probably begins even before the commencement of formal school instruction. With this as background, it is obvious why Jean Piaget's contribution to developmental psychology has provided such an excellent framework within which both mathematical and scientific development can be discussed.

2.2.4.1 Piaget

To Piaget, knowledge is the transformation of experience by the individual, not just the accumulation of pieces of information (Farmer and Farrell, 1980), i.e. the child plays an active role in the acquisition of concepts. He formulated a two-pronged theory, both aspects of which continue to be tested. One aspect of this theory, designated the *stage-dependent* theory, is that qualitatively different intellectual abilities appear in a sequence of stages related to age and occur in an unvarying sequential order, but the rate at which individuals advance from one stage to the next is not necessarily constant. The second aspect of Piaget's theory, designated the *stage-independent* theory, includes his explanation of the development of intellectual structures and his view on the nature of knowledge and the nature of knowing. In this latter aspect of his theory he holds that individual intelligence develops through the person's interaction with his or her environment (Farmer and Farrell, 1980). Knowledge is 'active' and requires that the student manipulate an idea either physically or mentally and thereby transform it. At the different developmental stages, this activity of transforming knowledge takes on different forms.

A baby might be shaking, feeling, tasting or looking at a toy and thus transforming the object and 'knowing' it, while an adult could be sketching, discussing asking or thinking about a business problem.

Piaget proposed in this stage-dependent theory that cognitive growth takes place in developmental stages, meaning that "the nature and make-up of intelligence changes significantly over time" (Sprinthall and Sprinthall, 1977). They continue, "the stages of growth are distinctly different from one another, and the content of each stage is a major system that determines the way we understand and make sense of our experiences (particularly the experience of learning from someone else)." Each of the four stages is unique although it does depend on the previous stage for its own development. The time for their appearance varies depending on both biological growth and the extent and timing of experiences. The stages lie within broad age ranges and are as follows:

(1) 0 - 2 years - Sensorimotor
(2) 2 - 7 years - Intuitive or Pre-operational
(3) 7 - 11 years - Concrete operations
(4) 11 - 16 years - Formal operations

It must be remembered that the thinking of each stage is markedly different from the preceding one and the change from one to the next is a major leap forward, not a gradual process.

2.2.4.1.1 Sensorimotor Stage (0 - 2 years)

During this stage, behaviour is dictated by the senses and motor activity. The child's impression of the world is formed by the perceptions of his or her senses or by his or her own increasing manipulations of the environment. It is during this stage that babies begin to develop the concept of 'object permanence', because babies knowing only themselves, believe that objects only exist if they can see them. Activity is therefore practical, without language to label experience, or to symbolize and hence remember events and ideas.

2.2.4.1.2 Pre-Operational Stage (2 - 7 years)

Here the child learns to represent objects or events by symbols - particularly in the form of language. However, this symbolization also takes the form of imitation, symbolic games and drawing. The ability to form mental images also appears. Children at this stage are essentially egocentric, that is they have implicit belief in their own ideas and view everything in relation to themselves.

2.2.4.1.3 Concrete Operational Stage (7 - 11 years)

Many of the differences which appear between the sexes in mathematics and in physical science, occur between the ages of 11 and 14. It is important therefore to examine the concrete operational and formal operation stages of cognitive development more carefully than the previous two stages.

The greater majority of Piaget's work has dealt with the concrete operational stage and as a result more researchers have investigated this stage of development than the others. The stage begins at the age of seven or eight and the children have developed the concept of conservation and can concentrate on more than one dimension at a time. They begin to become logical in their thinking and are able to test their answers to problems. Their logical thinking is only at its beginning though and they can only solve problems that are set in concrete terms and cannot extend their logical deductions to imaginary situations. If their teacher desires something to be done in a particular way, then the children can see no other possible way in which it can be done, and this is a concept which teachers and parents so often fail to realise and comprehend. In other words their thinking becomes operational in that now their actions can be internalized in thought. These operations are essentially reversible which is why conservation is possible, i.e. recognizing the invariance of quantities under certain transformations which change their appearance. Piaget and his fellow-researchers set up tests to measure conservation of number, length, area, volume, mass, etc. The ability to conserve is task oriented. Conservation of number could begin at about seven years of age and gradually extend through to conservation of mass (weight) at about nine, while volume conservation would probably only be reached at about eleven or twelve years of age. This phenomenon of the same operation applying to varying tasks at different ages is termed horizontal decalage. This all demonstrates how concrete the child's thinking is during this stage (Ginsburg and Opper, 1979).

From the point of mathematics and science teaching, it is important to note that the child now develops the ability to classify objects as a result of interaction with sufficient experiences that require multiple classification. This occurs gradually and also requires the ability to order. (i.e. 5 is bigger than 4 which is bigger than 3, thus 5 is bigger than 3 would be a deduction that a pre-operational child would not be able to make.) The concrete operational thinker collects results, classifies and orders them and establishes one-to-one correspondences (Farmer and Farrell, 1980), with his reasoning being limited by his experience with material reality.

2.2.4.1.4 Formal Operational Stage (11 - 16 years)

Here the child enters the final stage of development where he/she becomes freed from the constraint of material reality, and what is of particular importance is that it coincides with adolescence. The children are now able to think about abstractions, visualize logical solutions internally and develop formal patterns of thinking. This stage is further marked by a higher level of reversibility and language usage becomes of even greater importance. The adolescent who develops in a rich environment, will by the age of approximately fifteen have acquired all the concepts of the formal operational stage. He or she will be in a position to generate hypotheses and test them. Some children only reach this stage later than this and others possibly never reach it at all (Visser 1985a). It is this that probably explains why formal logic and mathematical deduction and induction are never grasped nor understood by a number of pupils. Research has shown that most children of normal intelligence reach the concrete operational stage, but that this is not the case for formal operations (Martorano, 1977). Piaget has identified four characteristics of the formal operational stage, all of which depend on one another. They are:

(i) the treatment of the real as a subset of the possible,
(ii) combinatorial analysis,
(iii) hypothetico-deductive reasoning, and
(iv) propositional thinking.
(Farmer and Farrell, 1980).

Whereas the concrete operational child only draws hypotheses from observed or experienced reality, at the formal level reality is seen as a <u>subset of the possible</u> with the result that hypotheses may proceed from the non-observed and non-experienced phenomena. This characteristic of the formal stage, frees the formal thinker from the restrictions of his or her senses.

Inhelder and Piaget (1958) describe responses to a set of experiments on floating bodies. The solution implies the understanding of weight, volume and density, the latter two not being realized until the early, and even later formal stage in the case of density. It should be noted that the formal operational child has the capacity to use formal operations, but is not compelled to do so (Farrell and Farmer, 1980).

The formal operational thinker has the capacity for *combinatorial analysis*. That is, when combinations of variables are involved, he is able to consider all possible combinations of these in a systematic manner by varying one factor at a time while holding the others constant. The concrete thinker on the other hand, is usually unable to separate the variables in a systematic way, and may alter two or more at a time. Here Piaget's 'pendulum experiment' and his 'solutions' experiment bear this out. The potential for combinatorial analysis does not imply that the youngster thinks about the system itself, but rather "it implies the kind of awareness in which he or she displays a motivated attempt to consider all possible combinations of a set of elements before experimentation has occurred" (Farmer and Farrell, 1980).

Both the combinatorial analysis and the real-possible relation are apparent in the *hypothetico-deductive reasoning* and 'if this were true, then ......' becomes part of the formal operational thinkers reasoning, but of course he/she is not restricted to experience-based situations as is the concrete operator. According to Inhelder and Piaget (1958), this quality is a distinguishing mark of formal thinking and they found that the formal operational adolescent searched for necessary causes and was not content with sufficient ones. Thus the concrete operational child makes deductions from the observed or experienced situation while the older child's thought results from a union of possibility, hypothesis and deductive reasoning.

Finally, formal operations are characterized by *propositional thinking*. The elements manipulated by the formal thinker are logical propositions and statements containing data rather than raw data by itself. In other words he/she is forming propositions (say based on concrete operational thinking) and then operating on these propositions. This is what Piaget calls second-degree thinking; operations which result in statements about statements.
Farmer and Farrell (1980) summarise the formal operational thought of the mature adolescent as follows:

> *Presented with a new situation, that adolescent begins by classifying and ordering the concrete elements of the situation. The results of these*

> *concrete operations are divested of their intimate ties with reality and become simply propositions that the adolescent may combine in various ways. Using combinatorial analysis, the student regards the totality of combinations as hypotheses that need to be verified and rejected or accepted.*

A basic concept of Piaget's theory is that each developmental stage has to be successfully completed before the child can reach the next, but the ages at which these stages are reached vary from child to child. Children that reach the formal operational stage at the same age do not necessarily acquire all the structures of formal reasoning at the same time. A significant educational implication of cognitive development is that growth at any of the stages depends on activity. A logical consequence of Piagetian stages should be an active school and if one accepts these developmental stages, educators should bear in mind the cognitive level of the pupils and always remember that the thought processes of adults are very different to those of children. (See also Saunders and Shepardson, 1987).

Although Piaget's model is generally regarded as providing the best structure for analysing mathematical and scientific development, in the interests of a better balance the contribution of some other researchers will be discussed briefly.

2.2.4.2. The Learning Theory of Thorndike and Ballard

Although Thorndike (1922) didn't deny the role that maturation played in learning, they believed that mathematical reasoning, and in fact all learning, resulted from the accumulation of correct and appropriate associations. The development of mathematical competence rested chiefly on successful teaching which stressed repetition and reinforcement. This 'successful teaching' of mathematics implied that the underlying mathematical principles had to be thoroughly investigated in order to establish what the best method would be to convey these principles to the child in order to improve his/her associative learning.

2.2.4.3 Concept Acquisition through Experience - Dienes

Dienes (1959) proposed a development process which encouraged the growth of mathematical concepts in children through experience, meaning "that the techniques they learn are preceded by an understanding of the corresponding mathematical structures." These learning experiences would be sufficiently varied "to allow children to form their own concepts in their own way, instead, as we now tend to do, of trying to teach them in ours." Dienes made use of apparatus which permitted them to establish the relationship and acquire the concepts by themselves.

2.2.4.4 Some Soviet Studies

Like Piaget's research, much of that of the Soviet's has relied on qualitative methods and according to Carpenter (1980), "has focused on mental operations and other processes that children use to solve problems." However, whereas Piaget and most Western psychologists have focused on concepts that develop independently from the school curriculum, "the Soviets maintain that the cognitive development and school learning are inexorably linked." Carpenter goes further and quotes El'Konin and Davydov as maintaining that a pupil's mental development is determined by the content of what he is learning. Thus the stages of development are not absolute and it is believed that changes in the school curriculum could result in changes in the developmental pattern (see also Krutetskii, 1979).

Whereas in Piaget's work there is a `unified theory', this is not apparent in the Soviet Studies. However, Carpenter (1980) quotes the work of Vygotsky which he says "provides a counterpoint to Piaget", and where he (Vygotsky) develops a useful construct involving the distinction between spontaneous and scientific concepts.

Spontaneous concepts are generated by each child on the basis of concrete experience and the child's own mental effort, while scientific concepts are the product of direct instruction or interaction with adults. The interplay between these two is what leads to development.

2.2.4.5 **Ausubel**

Ausubel is concerned with the distinction between rote learning and meaningful learning. Meaningful learning implies that the new content is "substantively (nonarbitrarily) related to ideas already existing in the cognitive structure of the learner." Rote learning means "the new content is arbitrarily (nonsubstansively) related to the existing cognitive structure of the learner" (Ausubel as quoted in Farmer and Farrell, 1980). All learning would fall therefore somewhere on a continuum ranging from *rote* to *meaningful* learning. New (meaningful) knowledge would thus be assimilated into existing relevant concepts by interacting with these concepts. He calls this process subsumption.

Ausubel's assimilation theory is termed *progressive differentiation* which implies that as new knowledge is subsumed, concepts are not acquired (Novak, 1978), but are part of the differentiation process. His process of subsumption differs from Piaget's concept of assimilation in that to Ausubel: (i) new knowledge is linked to specifically relevant concepts or propositions and (ii) the process is continuous and major changes in meaningful learning occur, not (as Piaget propounds) as a result of various stages of cognitive development, but rather as a result of growing differentiation and integration of specifically relevant concepts in cognitive structure (Novak, 1978). An older child thus possesses a far more elaborate cognitive structure which is capable of greater abstract thought, but which is not associated with a unique cognitive capability and in turn with maturation.

A logical consequence of this theory is thus that advancement through the Piagetian stages of development could be accelerated if there is adequate training, because the appropriate higher formal reasoning ability could be acquired (Novak, 1978). However, there appears to be little empirical evidence to show that attempts to implement developmental acceleration can be successful and lead to desirable outcomes (Carpenter, 1980).

2.2.4.6 Bruner

As did the Soviets, Bruner (1964) underlined the importance of language as a means to abstract thought. Much of Bruner's work has been concerned with instructional theories and have taken into account the cognitive growth of children. Here he identifies three stages of intellectual development which correspond with his three modes of representation of knowledge. These are:

(i) The *enactive* stage where any knowledge received cannot be used unless it is translated into physical action.
(ii) The *iconic* stage where knowledge is translated into images of concepts or principles contained in the knowledge.
(iii) The *symbolic* stage where language becomes increasingly important at adolescence as the medium of thought, but does not entirely replace actions or images (Bell, 1978).

There is some similarity between these three stages and Piaget's pre-operational, concrete and formal operational stages. Like Piaget, and unlike Ausubel, Bruner believes that cognitive growth is not a constant gradual process, but is discontinuous with transitions between the stages only being effected when certain cognitive capacities develop.

However, he does not link these stages to particular ages and feels that advancement results spontaneously with maturation, influenced only in a general way by experience (Novak, 1978). Another area of disagreement with Ausubel, is in 'meaningful learning', which Bruner feels can emanate from guided discovery learning, but which Ausubel regards as inefficient and that it can result from expository teaching if approached in the correct manner (Farmer and Farrell, 1980; Bell, 1978). In addition, Bruner "through his enactive, iconic and symbolic levels of knowing, decrees that experience with concrete, or at least pictorial representations should precede symbolic work, especially with young learners" (Sowder, 1980).

2.3 Affective Variables

Affective variables deal with feelings, attitudes and values and until recently variables of this type received very much less attention than the cognitive variables have, but their importance in the learning of mathematics and physical science is being realised increasingly. Variables within this domain are difficult to measure and understand (Fennema, 1983) and all too often all affective variables have been lumped together into one large group and labelled as attitudes. This generalisation consequently often leads to masking more precise information. The overall interaction of all the various variables will probably always be a severely complicating factor and as Nash (1979) maintains: "For some people, cultural myths are translated into personal beliefs which can affect cognitive functioning in sex-typed intellectual domains." She goes further and theorises as far as sex-related differences in intellectual performance are concerned, that they "may be the product of a biological predisposition, which if inherited, is fully or partially realised as a function of attitudes developed over years of socialization."

With this as background, it would seem appropriate to address the affective variables in two separate sections: attitudes;

and sociocultural factors.

2.3.1 Attitudes

2.3.1.1 Definition of Attitudes

The attitude hypothesis is that attitudes towards mathematics and physical science, either favourable or otherwise, affect the achievement in and/or selection of these subjects at the appropriate times. Attitudes towards mathematics and physical science are used by many researchers as broad, all-embracing terms and can (and usually do) include many more <u>specific</u> attitudes. What is particularly noteworthy is the dearth of attempts to define what precisely is meant by the term 'attitude'. Those that do, however, have set it down in very general terms such as 'feelings', 'disposition' or 'willingness to respond'. Reyes (1980) refers to attitudes as "feelings about mathematics and feelings about oneself as a learner of mathematics" which would apply equally to physical science. These 'feelings' could of course be either positive or negative and vary immensely in intensity. Attitudes are of course simply measures of what the particular questionnaire or investigative technique yields. Like the measurement of intellectual abilities, it is operationally defined by its own constructs. This doesn't mean that any results obtained from research are meaningless, far from it. However, whenever attempting to interpret a particular report, care must be exercised in analysing the results and the consequences thereof. All things considered, the fact that everyone has an intuitive 'feeling' as to what any specific attitude means is almost certainly the most important (and eminently acceptable) factor. After all, when a person responds to a particular question or situation, it is that person's <u>own</u> <u>definition</u> of his or her feelings that determine the relevant response.

2.3.1.2 Self-Concept and Confidence

Self-concept as a construct has potential as a good predictor of achievement and consequently many definitions are in fact linked to achievement (Shavelson et al, 1976). It is a person's observation of himself/herself and is formed by his/her interaction with the environment, particularly as a result of reinforcement from experiences and important people in his or her life. It must also be expected that the more closely self-concept is linked to a specific situation, the stronger will be the relationship between self-image and behaviour within that situation (school subject). One could hypothesise therefore that self-image in mathematics would correlate higher with mathematics achievement than it would with other specific subjects (eg. languages). It is almost certainly the evaluation of the child by his or her parents, teachers and peer group that are important influences on self-concept. Brookover et al (1964) established a positive relationship between academic self-concept and the child's awareness of the evaluation of important others. Coopersmith (1967) maintained that the most important factor in the formation of a child's self-concept is the self-esteem of the parents themselves. It would certainly seem that as far as mathematics and physical science are concerned, the parents' own relationship with the subjects would have a vital influence on the child, especially in a case where the child's identification with the parents is strong. Lorenz (1982) feels that teachers' low opinions of their pupils' abilities are likely to result in an unwillingness to interact with or give help to these pupils. This then leads to disastrous effects on the pupils' mathematical (physical science) self-concept. Very often this has started with previous poor performances in the subject and ending with a self-fulfilling prophecy also known as the Pygmalion effect.

According to Forsyth (1987) the self-fulfilling prophecy was first introduced by Robert Merton in 1948 and he "speculated that a perceiver's inaccurate beliefs about other people can evoke new behaviors that make the original inaccurate conceptions come true". The term 'Pygmalion effect' came into being in 1968 when Rosenthal and Jackson published their book titled Pygmalion in the Classroom which investigated this issue.

Self-esteem and self-concept are concepts much bandied about in the literature, but it would seem that little or no distinction is made between `confidence' and these two. Fennema (1983) writes "confidence in learning mathematics is related to self-esteem in general .... Confidence in mathematics is a belief that one has the ability to learn new mathematics and to perform well on mathematical tasks." Confidence *per se* has not been given much attention in its relation to mathematics except where the Fennema - Sherman Mathematics Attitude Scales are used (Fennema, 1983). However, "self-concept which appears to be defined in many scales as self-confidence, has received much study" (Fennema, 1979). High confidence in mathematics or physical science is probably located at one end of a continuum with `anxiety' towards the respective subject being found at the other end. It is, however, appropriate to discuss anxiety separately and this will be done in the next section.

In the majority of investigations dealing with adolescents, it has been found that boys have more positive self-concepts than do girls. (Fox et al, 1979; Haladyna et al, 1982; Robinson-Awana et al, 1986.) These manifest themselves towards the end of the primary school years and it is suggested that increasing awareness of sex role stereotypes is a major factor in causing this (Burns, 1979). Maccoby and Jacklin (1975) came to the conclusion that there aren't sex differences in <u>general self-concept</u> below university level, but when it comes to specific tasks and subjects (or subject areas), girls have a much lower self-confidence in their ability to carry out a given task than do boys. Brookover et al (1964) investigated academic self-concept in certain subjects and found significant correlation between specific subject self-concept and achievement in that subject. This correlation was higher than the correlation with general academic self-concept (Deboer, 1986; Talton and Simpson, 1986; Haladyna et al, 1982). This is in keeping with

Shavelson et al's (1976) hierarchical theory of self-concept in which "facets of self-concept may form a hierarchy from individual experiences in particular situations at the base of the hierarchy to general self-concept at the apex". In the Fennema-Sherman study (1978) boys at each grade level from 6 to 11 were more confident in their abilities to deal with mathematics than were girls. In most instances this happened when there were no significant sex-related differences in mathematics learning. "In addition, confidence in learning mathematics and achievement were more highly correlated than any other affective variable and achievement ($r \simeq 0,40$)", (Fennema, 1983).

A major uncertainty of all this is whether a positive self-concept is the <u>cause</u> of academic achievement or whether it is the <u>result</u> thereof (Peterson et al, 1980). Calsyn and Kenny (1977) in analysing Brookover et al's (1964) longitudinal data, decided that there was more of a tendency for achievement to affect self-concept rather than the other way round. If indeed the academic self-concept of girls relating to their ability in mathematics (and physical science) is less positive than that of the boys, as it is for general self-concept, then this could well be a possible explanation for the lower achievement of girls in these two subjects and also their avoidance of these when subject choice becomes possible.

Confidence and anxiety have been defined as separate traits, but as was stated earlier, they would appear to be very strongly linked. In the Fennema-Sherman study (1978) there was a very high correlation of 0,89 between high confidence and low anxiety. Maccoby and Jacklin (1975) reported that "girls tend to underestimate their own intellectual abilities more than boys do". It would seem therefore that lesser confidence or greater anxiety on the part of females is an important variable which would help explain sex-related differences in studying mathematics and/or physical science. With this as background, it is appropriate to consider anxiety (or possibly low confidence) and what the relevant literature has produced.

2.3.1.3 Anxiety

Sheila Tobias (1976) in an article in Ms. magazine and in her book 'Overcoming Math Anxiety' (1978), was one of the first to bring to the general public the concept of 'math anxiety'. This book had a significant impact on the public and almost certainly because it was written by a 'non-mathematical, non-researcher' in non-technical terms. The term 'mathophobia' had already been coined by Lazarus (1974) and others, but of course this so-called dread of, and uncertainty towards mathematics, had been around for along time without having to be defined or named. The above-mentioned publications as well as Tobias and Weissbrod (1980) and Tobias (1982) use anecdotal evidence to show that more women than men admit to mathematics making them nervous and worried. There is always the possibility though that males are simply less willing to admit any feelings of anxiety that they might have, especially in subjects which are seen as 'male domains' and this remains a problem as yet unanswered. Maccoby and Jacklin (1975) comment though that "the very willingness to assert that one is afraid may lead to fearful behaviour, so the distinction may not turn out to be important."

Science Anxiety has received very much less attention and only very recently at that. Research in science anxiety has undoubtedly stemmed from the strong indications obtained from results in investigating maths anxiety. Mallow and Greenburg (1982) wrote: "Science anxiety is a phenomenon of national scope that is well known but little understood. Like its relative maths anxiety, it paralyses students (especially women and disadvantages minorities)."

Mathematics anxiety is defined by Tobias and Weissbrod (1980) as the "panic , helplessness, paralysis and mental disorganization that arises among people when they are required to solve a mathematical problem." Lazarus (1974) sees it as an irrational and retarding worry. Tobias (1982) also describes it as the "I can't" syndrome and by others as a tendency to feel that certain situations may be too much for them to cope with and that in certain circumstances they may be made to look foolish and their self-esteem consequently reduced. This latter view is particularly interesting when viewed in relation to the Sherman-Fennema concept of the confidence-anxiety continuum. All of these symptoms described above obviously have spin-offs into any area (or subject) which has a component of mathematics in it. As such it affects physical science in particular, and many other aspects of the educational spectrum. Consequently it has a major effect on a child's general educational progress and is not entirely restricted to mathematics. While the effects of mathematics and science anxiety possibly manifest themselves in similar ways, it would seem likely that they could arise for different reasons, but the common component of mathematics is undeniably strong. Buxton (1983) puts forward a simple model for the causation of panic. Based on Skemp (1983) where he proposes that the feedback of success leads to emotional responses on the pleasure-unpleasure spectrum, Buxton proposes that panic results from a variety of elements which could be grouped under the two main headings of 'authority' and 'time'. Broadly, this implies that in a situation, if a pupil does not have a plan or is not able to provide one sufficiently quickly in order to solve the problem, a state of immobility is produced and the person then panics. It is almost as if the person has a 'reservoir of panic', and if it is breached, it all pours out together creating a possible crisis situation. The panic thus produced can be seen as a culmination of intense anxiety.

Much of what follows will only make reference to maths anxiety, but for the reasons given above, can be transferred into the science anxiety field.

Mathematics anxiety can begin at any age during a child's schooling, but once it has manifested itself it is unlikely that the intensity will diminish (Visser 1985a). This latter point is under the spotlight at the moment and some intervention strategies have been attempted. These strategies will be dealt with in a later section.

People differ in the level of mathematical attainment that they reach before mathematics anxiety sets in, and it would seem that the cause of this is multidimensional: stage of maturation; developmental stage reached; mathematical ability; and many external factors such as socialization factors and stereotypes could all be involved.

What is unusual about mathematics anxiety is that most people are quite prepared to admit freely the feelings they have about it and that they 'can't do it'. It is one of the very few areas where people will admit to intellectual shortcomings and in fact talk quite freely about them. It would appear that mathematics is set apart as a subject (or activity) that is quite unique and can be compared with say 'being able to run fast' - you have either been blessed with the genetic ability or you haven't. Thus there is no shame attached if mathematics is your 'Achilles heel' and you simply take part in a different 'activity'. By openly displaying your feelings you show that it's not all that important to be able to 'do' mathematics. However, in the writer's opinion there aren't any children (or adults for that matter) who wouldn't rather have been good at mathematics - even though they might not admit to that or even be aware that it was in fact the case. This "I can't do it" syndrome is in the writer's experience particularly prevalent amongst adults and rare amongst primary school children, often making its presence felt for the first time during the high school years. It is entirely possible that a person might not even be aware of his or her own anxieties and according to Visser (1985a) could cope with the problem for a certain period of time by rote learning of formulae and mathematical methods (procedures). The writer's experience is that this situation manifests itself when the pupil encounters a so-called 'new example', i.e. one that hasn't been seen before in the identical form. The pupil's response to this then is often "I'll work harder" thus throwing up a smokescreen which usually placates a parent and sometimes satisfies a teacher.

It appears that the strength of the reported anxiety relationships depends to some extent on whether "the content of the anxiety measures used are specifically related to learning activities typical of school and classroom settings" (Sepie and Keeling, 1978). These researchers established that "under-achievers in mathematics are more clearly differentiated from their achieving and over-achieving peers in mathematics-specific anxiety than in either general or test anxiety." Richardson and Suinn (1972) note that "mathematics anxiety exists among many individuals who do not ordinarily suffer from any other tensions."

There are a number of different mathematics anxiety tests available and obviously they all measure different things depending on the questions asked and the technique used. Dew et al (1983) investigated various aspects of four of the more common tests: Sandman's Anxiety Toward Mathematics Scale (ATMS); Suinn's Mathematics Anxiety Rating Scale (MARS); Fennema and Sherman's Mathematics Anxiety Scale (MAS); and the Spielberger Test Anxiety Inventory. Results from the study indicated that MARS and MAS possess acceptable internal consistency and test-retest reliability. This was reasonably similar to the findings of Richardson and Suinn (1972) and Fennema and Sherman (1976). The MAS is in fact one of nine Likert-type scales from Fennema and Sherman's (1976) Mathematics Attitude Scales. Because of a correlation of 0,89 obtained between the MAS and the Confidence in Learning Mathematics Scale (one of the nine Mathematics Attitude Scales) Fennema and Sherman have subsequently only used the latter test.

As far as physical science attitudes and specifically anxiety are concerned there is not the same amount of investigation taking place. There are a number of tests available, but they are not used extensively and only seem to be used in their countries of origin and more often than not, only by the compilers themselves. Some examples of the test are: the State-Trait Anxiety Inventory (STAI) which is a general anxiety questionnaire (1970 - see Westerback, 1984); the Attitude towards Science and Science Teachers (ATS & ST - see

Moore and Sutman, 1970); the NFER Science Attitude Questionnaire (1971 - see Ormerod and Duckworth, 1975); in Australia, Fraser's Test of Science Related Attitudes (TOSRA, see Fraser and Fisher, 1982); in Israel, the Physics Attitude Scale (PAS) and the Chemistry Attitude Scale (CAS) developed by Tamir et al (1974); the Brunel Attitude Scales developed by Ormerod (1979 - see Ormerod, 1981); and the scales which Kelly used in 1978 to analyse the IEA Data (Kelly, 1981e). Lewin and Fowler (1984) adapted the Fennema - Sherman Mathematics Attitude Scales and used this as The Science Attitude Packet. There are many other scales which were even more area-confined, but even the above have either not been used for the last ten years or so, or are only being used by one institution. Some of them have been tested for reliability and validity, but this is not widely reported. No doubt there are many attitude (anxiety) scales in use for both mathematics and physical science. They seem to have much in common and to be measuring much the same thing, but always within the limitation that they are operationally defined by their own constructs and the methods used in applying the tests.

As mentioned earlier there have been many instances of strong correlations between confidence (low anxiety) and achievement in mathematics or physical science. These have been achieved with various measures and the hypothesis has been reasonably firmly borne out. (Richardson and Suinn, 1972; Fennema and Sherman, 1977; Fennema, 1979 and Betz 1978; Resnick et al, 1982; Clute, 1984.) The role that mathematics (physical science) anxiety plays in a pupil's choice about continuing in that subject has not been fully researched. Generally speaking low confidence (high anxiety) pupils are less likely to choose to continue with mathematics at school level and also at university (Fennema and Sherman, 1977; Sherman, 1983a) Tobias and Weissbrod (1980) and Pedro et al (1981) have shown that even in situations of males and females showing equal anxiety, the males are still more likely to continue with mathematics than are the females. Tobias (1978) felt that mathematics avoidance was a classic symptom of mathematics anxiety. The complicated complex of attitudes towards mathematics or physical science is further illustrated in that the fact that more females than males avoid mathematics (physical science) at school and tertiary level could possibly be explained as follows: Even where males and females show similar anxiety levels, other attitudes such as perceived usefulness or regarding the subjects as unavoidable or essential to future careers could override the feelings of anxiety.

There is a considerable amount of evidence pointing to the higher incidence of anxiety (low confidence) among females as far as mathematics is concerned, with not many finding no sex differences. Those that have borne out this hypothesis are Maccoby and Jacklin (1975), Fennema and Sherman (1977), Betz (1978), Fox et al (1979), Fennema (1979, 1983), Visser (1985a), Kelly and Tomhave (1985). However, no sex differences were found in the studies of Fulkerson et al (1984) and Resnick et al (1982).

As far as sex differences in physical science anxiety is concerned there is virtually no evidence available at all. Levin and Fowler (1984) using The Science Attitude Packet found that males exhibited slightly more confidence with regard to physical science than did females, but this difference was not statistically significant. No other references to physical science anxiety were found.

The <u>extent</u> of mathematics anxiety is not well documented and has attracted only a small amount of research. Lazarus (1974) speculated that the majority of all children and adults felt uncomfortable dealing with anything mathematical. This was the feeling of Tobias (1978, 1982) as well. Tobias and Weissbrod (1980) put forward the idea that while there might be sex differences in mathematics anxiety levels, males exhibited anxiety in significant percentages as well. As stated earlier, Richardson and Suinn (1972) found that mathematics anxiety was present in people that exhibited no other anxieties. Betz (1978) found in a sample of three separate student groups that all three groups showed symptoms of mathematics anxiety, but in fact there was an inverse relationship between their anxieties and their mathematical background. She found in fact that nearly seventy percent of students enrolling for mathematics courses experienced fairly high levels of mathematics anxiety. Resnick et al (1982) found in their sample very much lower levels of anxiety (using MARS) than other studies had obtained in other institutions. Absolute measurements of anxiety are obviously not possible and it would appear from the above-mentioned studies that anxiety levels vary from institution to institution. Researchers need to be wary of interpretations made of any data and it seems that mathematics anxiety cannot be viewed as a unique and isolated affective factor.

2.3.1.4 The Nature of Mathematics and Associated Learning Difficulties

As already stated, mathematics anxiety is a consequence of the interaction of many factors, but the nature of the subject itself is almost certainly an important factor. In mathematics, a large amount of continuity from week to week or from year to year is required, whereas the majority of other subjects (including physical science in many instances) can to varying degrees be handled from a fresh start each time. The mathematics anxiety bogey is however, always a problem in any mathematics-related content that these other subjects might have. It is necessary therefore, to look at various aspects of the nature and history of mathematics in relation to the bearing that they might have on course selection and mathematics anxiety.

During the sixties there were numerous 'reforms' in mathematics syllabuses in many countries in the world and these reforms were advocated and often planned by committees in which 'academic mathematicians' were dominant. The arguments they used "advocated that children should learn the basic language and structures of mathematics as soon as possible", but these usually "tended to be naive variations on the traditions of syllabus planning by university professors" (Griffiths, 1978).

It is theorised that one of the influences which gave rise to this 'reformation' was the works of Nicholas Bourbaki. This name is a pseudonym used by a collective authorship of French mathematicians which has been organizing and codifying the whole approach to mathematics since the late 1930s. It is thought (Griffiths, 1978) that his approach had been a very valuable instrument in mathematical discovery, but that its contrasting approach when used by the disciples of Bourbaki often led to a 'severe culture shock' to university students because of the contrast with the differing school syllabus approach. The school syllabuses usually view mathematics in complete isolation, and with a course starting with set theory and proceeding from there in logical, linear progressions, the stress being on structure rather than problem solving, the Bourbaki influence is clearly discernable. All of this is more than likely to result in great confusion in the rank and file of school mathematics pupils in terms of relevance, and readily fuel the 'anxiety flames' when a gap in mathematics continuity appears as a result of absence, poor teaching, lack of confidence, or indeed any one of many other factors.

An aspect of all of this that is almost ironical, is that while the Bourbaki influence has probably produced a detrimental effect as far as girls and mathematics is concerned, one of the influences on Bourbaki was in fact a woman. "Emmy Noether (1882 - 1935), to many, the greatest woman mathematician of all time", (Watson, 1974) made many contributions to twentieth century mathematics and she has been credited by some people with shaping the whole style of thinking in the field of algebra. Watson (1974) writes further that "she protested vigorously against those who prophesied that the axiomatic method was coming on hard times because the material which it used was becoming exhausted." This, in reply to the conflict that still in fact exists, between "the general and the specific, the abstract and the concrete, the axiomatic and the constructive". It is this 'abstractness' of mathematics which would appear so often, to be the very source of unease, particularly as far as girls are concerned.

The nature of mathematics is such that there will inevitably be learning difficulties associated with the subject. These difficulties are not simply the result of poor teaching or bad curriculum organisation, but quite obviously they would compound the problem. They stem rather "from the nature of the subject itself, its thought processes and its symbolism" (Macnab and Cummine, 1986). These writers separate the various aspects of the learning difficulties into eight areas and these will be discussed under their appropriate headings.

The abstract nature of the concepts involved is the aspect of mathematics which in the eyes of most people, sets it apart from all other subjects. "It is a land of mystery where the clear outlines of the everyday world of experience are replaced by cloud-like structures whose boundaries are uncertain and whose forms change." (Macnab and Cummine, 1986). Multiplication is taught initially as an INCREASE. The very dictionary definition reinforces this view and when multiplication begins to produce smaller or even negative quantities, confusion is invited and is certainly present in many children. This phenomenon is in no way confined to multiplication and particular features which are associated with the introduction of a new topic or concept are often permanently associated with it. Seeing all triangles as being acute-angled, or as is the case in trigonometry, as being right-angled only, is for most children something which is difficult to abandon and particularly in times of stress or uncertainty. Another compounding of the problem is (as is usually and quite understandably the case) the introduction of a concept using 'real' examples and then at a later stage attempting to extend the concept into the abstract. The non-specialist teacher is less likely to be able to cope with this transition from specific to abstract and the 'mystery of mathematics' will consequently deepen.

Much of what has been written in the last paragraph applies to a difficulty presented by *the complexity of the concepts*. (Macnab and Cummine (1986) suggest three ways in which teachers attempt to get around the problem of complexity. <u>Simplicity</u> <u>by</u> <u>abstraction</u> is the first and the approach here is to present definitions, theorems and techniques in as abstract a framework as possible, because when they are introduced by using particular contexts, their simplicity is masked by the contexts themselves. An obvious difficulty in using this approach though would be the student not knowing the relevance or purpose of the concepts and thus not being able to apply them in the current situations. A second approach is simplicity through analogy, where a new concept is linked to a known or familiar situation in an attempt to introduce it. A major disadvantage with this is the inability of the pupil to extend the concept into other unfamiliar or even abstract situations. Thirdly, simplicity through authority which can best be summed up as the 'Do as I tell you' approach, doesn't attempt to elicit understanding, but rather the 'rote-learning' approach of teaching the rules and letting the pupils practise them. This method is of course used notoriously by weak or lazy teachers or by those who for whatever reason are unequal to the task.

The hierarchical nature of mathematics presents difficulties for the learning process by building on an ever-increasing base of previous knowledge. Mathematics is probably the most hierarchical of all subjects and this presents quite widely differing problems: The 'quick' pupil will encounter boredom and the apathetic or 'absentee' pupil will have gaps in his or her knowledge that will be difficult to bridge.

The logical nature of mathematics is an aspect which is universally thought to develop from learning mathematics. This anticipated result is very much itself the problem, in that it is the difficulty in learning to be logical which creates the uncertainty and apprehensiveness amongst the pupils. Macnab and Cummine (1986) are of the opinion that "logical deduction becomes confused with algorithmic procedures" and that by performing the necessary manipulations in solving equations or simplifying expressions, they are under the mistaken impression that they are developing their logical abilities.

The formal notation of mathematics presents further learning difficulties in the use of mathematical notation and/or what it means to the individual pupil. Formal notation is in fact the visible part of mathematics and "separation of this visible appearance from the underlying meaning" is where the difficulties arise (Macnab and Cummine, 1986). They give the example of $3x - x$ giving an answer of 3, because removing x from $3x$ leaves 3, as typifying this difficulty.

Formal algorithms do not really present a learning difficulty as such, but rather a misconception. An algorithm being a numerical process which could be performed on a calculator does not require any mathematical or reasoning ability. As seen in this light, much of the primary school syllabus does not really entail mathematics and consequently pupils, and in certain cases teachers, often don't separate algorithms from mathematical ideas and see algorithms as epitomizing mathematics.

The variable in mathematics is a very confusing and difficult concept for even the good pupil to grasp. One of the problems is that for the first four years of algebra, the contexts in which variables are presented do not have much (if any) variability attached to them. More typically they are situations involving a fixed unknown or at best, the substitution of several fixed values into an expression. This invariably would lead a pupil to reason (or reinforce the idea) that algebraic symbols always have specific values. When a situation involving a 'true' variable is then introduced or encountered in a new context, being unfamiliar, it is absolutely puzzling and confusing and could have a sudden detrimental effect on the attitudes that that child has towards mathematics.

The final area proposed by the two authors was that of *spatial concepts and geometric thinking*. This particular topic is one that has been thoroughly researched and was dealt with comprehensively in section 2.2.1. The difficulties presented by the spatial nature of geometry are summarised by Macnab and Cummine (1986) as arising because;

(a) geometrical truths have to be distinguished from accidental/irrelevant features of particular diagrams,

(b) observation must be distinguished from logical consequence,

(c) exact theoretical calculation must be distinguished from practical measurement,

(d) reflective insight is necessary to perceive implicit aspects of geometrical diagrams,

(e) it is necessary to be able to comprehend three-dimensional objects and their properties through two-dimensional representation.

A desirable outcome in teaching mathematics would be that the pupils would realise that "mathematics is the classification and study of all patterns" (Noble, 1987). Thus for example recognizing sequences and patterns and consequently being able to make predictions, is a procedure that would establish a person as a mathematician.

Wilson (1977) and Noble (1978) both seek to describe the nature of mathematics by considering five possible approaches. All of these are fundamentally different ways of viewing mathematics and in many cases any one approach would be seen by individuals or specific groups (eg. parents, pupils, teachers, commerce and industry, etc.) as the only possible reason for the teaching of mathematics. More often than not, this would be the only possible viewpoint and they would not be aware of the others.

The first approach they suggest is that mathematics is an *art-form* and that the intrinsic interest of the pupil, the thrill of the elegance of mathematics and the beauty of its structure would provide the aesthetic satisfaction for him or her. This would probably appeal to the well-established mathematician, but it is highly unlikely that it would be conveyed by many school teachers to their pupils, because in the writer's opinion it is present in so few of them. Certainly those teachers who are not properly qualified or who themselves have been subjected to questionable teaching, are highly unlikely to bring this about. The constant 'threat' of examinations probably produces tensions or anxieties which must surely severely hamper any development of aesthetic appeal that the subject might have for the pupil.

If one takes the view that a science is a systematic study of some aspect of nature and that number and space are part of nature, then it follows that mathematics is a *science*. It has also been termed 'the Queen of the Sciences' in view of its importance to other sciences and their dependence on it. One of the ways in which it differs from the others and especially physical science, is in the use of the words *theorem* in mathematics and *theory* in physical science. Farrell and Farmer (1980) note that "whereas theorems are proved in the idea world by deductive logic, theories are tested by returning to the real world and checking their correspondence with real-world data. Theories are not proved, they are tentatively verified."

Another viewpoint is that mathematics is a *game of skill* where elements behave or are manipulated according to certain rules. This type of mathematician would explore all the possibilities of a situation and gain his/her enjoyment from 'playing the game of mathematics'. The creation of new 'games' would of course be an obvious consequence. This attitude would seem to have strong appeal to pupils with a more adventurous type of nature and the literature would immediately point to boys as being in this mould (Murphy, 1978). Girls therefore would probably not find mathematics all that appealing if it was presented in this manner.

Mathematics can also be considered as a *language* in that it enables the mathematician to communicate ideas in an unambiguous manner. It is concise and neat and viewed in this way it almost becomes an art-form because of its aesthetic appeal and elegance. Unfortunately many mathematics textbooks are dreadfully dull and devoid of human interest. This makes them, and the subject too, far less attractive and particularly so as far as girls are concerned. The human interest area is one which would be particularly appealing to girls and its absence therefore is all the more regrettable. Grattan-Guinness (1986) puts forward the theory that ignoring the historical aspect of mathematics as being a human activity, could be a significant causation of mathematics anxiety. He felt further that the mode of assessment was important in that a partly historical course which was "appraised by essay writing" would help "the student to develop skills which employers often desire but which educators usually ignore". This could well be another area which would attract more girls to the subject as they have been shown to answer essay-type questions better than do boys (Harding, 1977 or 1981 or 1983).

The fifth approach to mathematics is one which is markedly different from the other four as it is the one that is considered by most people (without realising it) to be the only reason for teaching mathematics in the school. This of course is seeing mathematics as a useful *tool* or *device* which is the easily visible aspect of the subject. It is what most parents and potential employers view as the reason for its existence and this is strongly conveyed to the children by 'society'. Many teachers and educational institutions fall prey to this approach, and the consequent effect on the way in which the subject is presented and taught, excludes any possibility of the other approaches being employed or considered. It is here that the 'perceived usefulness' of the subject, as providing entry into many fields, is an associated factor. Pupils (and it would seem that more girls than boys fall into this category) who have a low perceived usefulness of mathematics and who fail to see another 'use' for the subject are therefore, when given the opportunity, going to elect not to carry on with it. How often the comment in a school (possibly a principal) "so-and-so is a good mathematics teacher" when what is really implied is that so-and-so gets good results and keeps his or her pupils working steadily and systematically with the pupils knowing that they will 'do well at mathematics'. The good results then produce good marks not necessarily good mathematicians, and rarely anyone who will have any other appreciation other than for mathematics as a device. Not all teachers fall into this mould though, but even for those that don't, the pressures are extremely strong to 'teach properly'.

There are other areas of the teaching of the nature of mathematics which are neglected. The *interrelated nature of the subject* is usually ignored by teachers that require (and sometimes insist on) only one method of solving a problem. This is always a problem for the less-able teacher who often retreats into the security of 'the right method', but is something that is easily overcome by even the average mathematics teacher. Another area of neglect and probably more difficult to remedy, is the mistaken idea of '*generalisations* leading to theorems'. In other words a particular example with fixed values, will in many eyes be entirely adequate as a proof. This is of course a particular problem for a pupil who is lost in the abstractness of the concept of a variable. A third aspect that is usually ignored is the *axiomatic structure* of mathematics. Euclidean geometry provides an excellent means to achieve what is so often ignored or not fully perceived by teachers.

It would seem that the reasons for pupils doing mathematics at school are different as seen by different sectors of the population, but possibly very few of them being all that complete. Many employers (and parents) have a notion that mathematics (especially geometry) will develop logical thinking (mentioned earlier). Noble (1986) notes though that this is "a very powerful argument based more on hope than evidence". It is highly unlikely that the 'average' mathematics teacher would succeed in this area, particularly in the lower standards and up to standard eight, as any teaching which relies on drill and rote learning can definitely not produce this very desirable effect. Probably an even stronger attribute that a pupil who has 'done' mathematics is seen to possess is a different and higher intelligence. Tertiary educational institutions and the business sector at large are all guilty of using mathematics as a measure of general intelligence (as yet unsubstantiated) and as long as this persists (rightly or wrongly) mathematics will be taught as a subject to be passed because of the number of doors that remain open for such a pupil.

As long as "maths is just a matter of facts being hammered into you .... it's not a subject you can humanize" (Russell, 1983). Viewing it this way would undoubtedly make it a subject which would be a deterrent to many, and especially to girls.

2.3.1.5 Reduction of Anxiety

Anxiety itself is of course difficult to measure, but it would appear from the literature that it has a profound effect on numerous aspects of mathematics and physical science. If any of the so-called 'intervention techniques' prove to be successful, then this success would manifest itself in these various related 'symptoms'. In reviewing this section it must be noted that while it is extremely difficult, if not impossible, intervention techniques involve in most cases more than anxiety only, and attempt to deal with <u>all</u> negative attitudes towards the subject. This section will confine itself wherever possible, to the reduction of mathematics and physical science anxiety.

Most of the studies which were reviewed involved remedial action encompassing guidance or mathematics courses or both. Bandura (1977) put forward a theory whereby he maintained it would be of no consequence to persuade a person to tackle a task unless that person was confident (certain) that he or she could in fact successfully undertake the task. There cannot be only one approach that would apply in all situations, because much would depend on a person's level of anxiety as well as his or her mathematical knowledge or ability. Tobias and Weissbrod (1980) "note that those who treat math anxiety, teach coping techniques as well as mathematics." Some mathematics anxious pupils are simply not ready to do mathematics whereas others might be in a situation to commence with problem solving and acquire their anxiety -coping techniques at the same time or even later. One of these techniques is "learning how to learn mathematics, that is, how to replace debilitating habits with self-instruction and self-encouragement" (Tobias and Weissbrod, 1980). Pedersen et al (1985) see this as promoting "a sense of positive well-being and success in the activity." A study by Hendel and Davis (1978) also came to the conclusion that "maximum effectiveness in reducing mathematics anxiety was achieved when participants both enrolled in a mathematics course and attended a multifaceted counseling support group."

In the United Kingdom there do not appear to be any programmes aimed specifically at reducing anxiety, but rather at developing attitudes towards mathematics and physical science in general. These intervention programmes which exist for both mathematics and physical science will be discussed later. In the United States the approach is far more specific and other contributors to the various strategies are the 'anxiety clinics'. The Math Anxiety Clinic is one of these and it is based at the Wesleyan University. This clinic offers mathematics courses to students with poor mathematical backgrounds as well as workshops which deal specifically with mathematics anxiety and a 'popular approach' to statistics and differential calculus. Fennema (1979) notes that "while many participants in such programmes express great enthusiasm for them their effectiveness is largely unevaluated." Auslander (1979) was involved in an evaluation of the work done at the Math Anxiety Clinic and she found that there were reductions in mathematics anxiety amongst the students. Sex differences which existed before commencement of the courses, had disappeared when the students were retested at the end. Problems that face any intervention programme which attempts to improve confidence (or any attitude for that matter) are that changes may or may not be immediate and that they might only be effective for a short period of time or may endure for a substantial period of time. These variables made evaluation of various approaches very difficult indeed and their effectiveness uncertain at times.

Two studies by Battista (1986) and Sovchik et al (1981) both achieved significant reductions in mathematics anxiety in primary school student teachers as a result of their taking mathematics method courses. Battista puts forward two possible reasons for this change. Firstly the possibility that the students had become aware of a `personal usefulness' of mathematics as far as their own careers were concerned, and secondly the realization that they could deal with mathematics effectively and need not fear it. Clute (1984) found that a `discovery' method suited low anxiety pupils but the more controlled and structured `expository' method was better suited for the more anxious students. This was similar to the findings of Larson (1983) with regard to teaching approach.

Okebukola (1986) in a science anxiety study in Nigeria employed three models of class interaction: co-operative learning; indirect teacher interaction; and a combined co-operative - indirect method. In the co-operative technique the pupils worked in mixed ability groups and decisions were made by consensus while help and assistance came primarily from the group themselves. The indirect teacher approach involved lessons given to the whole class, but the accent was on positive reinforcement of any ideas or comments made and criticism and the justification of authority was avoided. Both of these groups showed significant improvements in their science anxiety levels, but a third group which combined both of these methods, showed an even bigger significant improvement. Westerback (1982) found a similar result to that yielded by the investigations of Battista (1986) and Sovchik et al (1981) mentioned above, but this with a science method course for primary school teachers. Here attitude towards teaching science and anxiety about teaching science were both improved and this finding was replicated with later groups following the same methods course.

The literature does however, contain very few evaluations of the treatment of anxiety with regard to mathematics and physical science, but it seems that whatever method proves successful, there will always be a need for 'positive mathematics experiences' if any intervention strategy is to succeed. This would appear essential, but other experiences involving the affective domain will always be contributing factors.

2.3.1.6 The Nature of Physical Science and How It is Incorrectly Interpreted

One way of looking at the nature of science is to consider it as being made up of *processes* and the *products* of these processes (Farmer and Farrell, 1980). By processes they mean ways of discovering or finding out about science. Numerous relationships result from these processes and their products are effectively a system of ideas which have resulted from the various types of discovery and learning activities. Farmer and Farrell organise the various processes and products along a continuum which stretches from the 'general' to the 'specific', but each within categories which represent either deductive or inductive reasoning.

Science is therefore seen as a complex structure with many interwoven and interrelated components. Consequently it should be taught in such a way that all (or at least many) of these aspects are acquired and understood by the pupils. Unfortunately many of these processes and their products are not fully appreciated even by many university students and probably not by many teachers either.

The danger is that science will be seen by many (particularly pupils), as simply being a collection of <u>facts</u> which need to be learned. Any pupil who has this outlook is misinterpreting the reality that science is <u>based</u> on facts and this person believes instead that science <u>equals</u> facts. Facts are a vital part of the system of ideas (the products of the processes), but are not science in its entirety. Too often (and this is the writer's experience as well) one hears from teachers that many of the pupils (possibly the majority being girls) simply want to know what (facts) they must learn for examinations and thus they demonstrate that the real reasons for teaching physical science are completely lost on them. It means also that when it comes to making decisions about continuing with the subject in the higher standards, the basis for any decision will in no way be founded on any appreciation for, comprehension of, or skill in real science. All that is important in their eyes is that they get good marks in the examinations and these results and the pupils' perceived usefulness of the subject will be all that will be considered as being of any consequence and the nature of science as such will be completely passed by.

There are many similarities to the nature of mathematics (Section 2.3.1.4), but the dependence of physical science on mathematics is an important issue. However, too much emphasis is often put on this aspect and very often a pupil's lack of confidence in mathematics can spill over into physical science to the detriment of the pupil's performance and enjoyment.

Physical science is much *less hierarchical* than mathematics, but the *interrelated* nature of its content is often ignored both in teaching and in examining. Much is lost when all too often teachers insist that there is only <u>one</u> correct way of arriving at an answer. This is damaging to the development of an appreciation of the subject and also to a pupil's ability to think laterally.

A major difference between the two subjects is that physical science is *conceptually* more difficult. This arises because science has to be able to explain something that already exists and thus a theory has to be constructed which will hold good until either it is disproved or until new evidence is found which cannot be explained by that theory. A good example of this is the development of the theory of atomic structure. Theories in science are not proved, but are simply verified with all data available at that time and are subject to amendment. Contrary to popular student belief, science does not have 'laws' which need to be proved. In pure mathematics, however, theorems are <u>proved</u> in the idea world by deductive logic (Farrell and Farmer, 1980), proceeding from sets of axioms chosen by the mathematician.

Another aspect of physical science that makes a big difference to the pupils, is the extent of their experience or *background* in science. Those pupils who are at least familiar with 'electricity' (usually boys) are far more confident about tackling the subject at school, but particularly when it comes to practical work. This doesn't only apply to electricity and while some pupils adapt quickly to experimental work, others (very often girls) can take several years to become comfortable and confident about approaching a new practical situation. This lack of confidence caused by a poor background knowledge is not confined to practical work only, but manifests itself when the pupil encounters an unfamiliar hypothetical situation as well.

Thus physical science has its own inherent problems, but when the subject is taught in a rigid 'only one method is correct' framework, much of the unique appeal and value of science are lost.

2.3.1.7 Liking

Research material on liking (enjoyment) for mathematics or physical science is extremely scarce and that which has been produced is not very detailed.

Liking for mathematics does not yield any sex differences in any of the research studied. Fox et al (1979) came to the conclusion that "in terms of attitudes it is the perceived usefulness rather than the expressed liking for mathematics that differentiates between the sexes". (See also the Assessment of Performance Unit Research (APU, 1982a).) Preece (1979) did, however, find sex differences, not in liking for mathematics, but in the relationship between liking and success in the subject and states "liking cannot in general be predicted by success for the girls." (See also Schofield, 1982). Bell et al (1983), Armstrong and Price

(1982) and Kempa and McGough (1977) in their studies did not report on any sex differences, but all agreed in that liking for mathematics strongly identified students with a bias towards studying (choosing) mathematics. The subjects in these studies were all high school pupils up to as far as sixth form. Perhaps the most meaningful of all the researches consulted was one by Hadden and Johnstone (1982, 1983a, 1983b). Their research involved a longitudinal study beginning with the subjects in primary school prior to their transfer to high school. They were tested again at the end of their first year in high school and then finally at the end of their second year when they were making their subject choices for further study. The results yielded clear indications of a strong liking for mathematics in the primary school. This attitude persisted through to the first two years of high school, but there was a marked decrease in liking for mathematics (and the other attitudes measured) over the three-year period (Hadden and Johnstone, 1983b). No sex differences were evident, but girls did show bigger (but not significant) drops than did the boys.

As far as liking of physical science was concerned, the Hadden and Johnstone study covered this as well. Here, exactly the same findings were made as for liking for mathematics. i.e. a decrease in liking over the three years, but always a favourable disposition towards the subject (Hadden and Johnstone; 1982, 1983a, 1983b). A difference though, was that at the end of the first year in high school the girls showed a significantly lower liking for physical science then did the boys (Hadden and Johnstone, 1983a).

Two other studies were both undertaken by Kelly (1981e and 1986). The former study was the further analysis of the IEA study and one of the attitude categories yielded by this international sample of fourteen year-old boys and girls was labelled LIKESCI. In this attitude there was a significant difference between the sexes except for Hungarian children, where the difference was small. Kelly in this study found that of all the attitudes yielded by the test, "LIKESCI was more strongly related to achievement .... and the correlations were somewhat larger for boys than they were for girls." In another survey - this time involving 13 000 pupils at ten schools - she tested attitudes-to-science at age eleven and then two and a half years later. This is similar to the Hadden and Johnstone (1982, 1983a, 1983b) project and here Kelly (1986), as did Hadden and Johnstone, also found a significant decline in LIKESCI as well as in most other attitudes.

There is considerable agreement in all these investigations, and what disagreement there is could probably be put down to differences in the tests themselves and possibly even the samples (cultures). Of all the different attitudes measured, liking for physical science or mathematics is one of the most general and probably comes closest to being an overall view of the particular subject by the child.

2.3.1.8 Interest

As far as attitudes towards physical science are concerned, interest has been investigated by some researchers with a strong consistency of findings being reported. However, interest in mathematics is scarcely reported, but results are in line with the findings for physical science.

Hilton and Berglund (1974) undertook a longitudinal study stretching from fifth grade through to eleventh grade with the subjects being tested every second year. They established a growing difference in mathematics achievement between the males and females which does "as predicted, take place in concert with increasing differences in interest". They also examined interest in science, and found that "as the boys' interest in science increased relative to the girls', their achievement in mathematics increases relative to that of the girls". The Assessment of Performance Unit (A.P.U. 1981b) also found sex differences as far as mathematics interest was concerned, but established that while boys' performance was not related to topic interest (number, measures, algebra, geometry), for girls it was.

Further they noted that the difficulty of a topic had little to do with interest as far as the boys were concerned, but that the perceived usefulness of a topic was "highly related to the extent of interest expressed in both boys and girls."

The Hadden and Johnstone study (1982, 1983a, 1983b) discussed in the previous section also produced results of mathematics and physical science interest. These were exactly the same as those for 'liking'. Interest declined over the three-year period, but remained positive nevertheless. Sex differences for science interest were found during the middle year, but not in the final year when subject choices were made. No sex differences were apparent for mathematics interest in any of the years.

A study by Duckworth and Entwhistle (1975) yielded sex differences in interest towards science, with the boys interest stronger than that of the girls. Similar findings were obtained by Robinson (1980), Warburton et al (1983) and Kelly (1986). The Kelly study was longitudinal over a two-and-a-half-year period and the sex differences stayed much the same. The Duckworth and Entwhistle investigation (1975) also confirmed the fairly obvious hypothesis that pupils who elected to continue with a number of science subjects at high school showed a greater interest in science than those who chose fewer or no science subjects at all.

Research by Hamrick and Harty (1987) into the effect of changing the sequence of science topics for sixth grade pupils in Indiana and also clarifying the content structure and the relationship between them, produced some interesting results. The experimental group exhibited significantly greater interest in science than did students in the control group. This 'resequenced' group also produced significantly higher levels of science achievement and one can reasonably speculate that as there was no change in subject content it could well have been as a result of the greater individual interest shown. There might well have been other reasons such as an improved teacher attitude or approach, which played a part as well, but the fact remains that an increased interest (whatever its origin) appears to have produced better achievements.

2.3.1.9 Perceived Usefulness

There has been a fair amount of attention given the perception that pupils have for the usefulness of mathematics. The majority of this has been conducted (mostly in longitudinal studies) by the team of Fennema and Sherman, either separately or together. Almost all the other studies also make use of the Fennema-Sherman scales which specifically measure the perceived usefulness of mathematics. Fox et al (1979) quote one of the earliest studies as being conducted by Haven, in which it was found that the perceived usefulness of mathematics was one of the two best predictors of course taking. The other attitude considered vitally important was a greater interest in natural sciences than the social sciences (Fox et al, 1979). That perceived usefulness is an important predictor of pupils choosing to continue with mathematics courses, has been investigated and borne out by a number of researchers, this being seen as the most important aspect requiring investigation. Fennema (1983); Sherman (1979, 1982a, 1982b, 1983a); Fennema and Sherman (1977); Sherman and Fennema (1977); Armstrong (1980); Armstrong and Price (1982) and Pedro et al (1981) all confirmed this and also that it applied equally for males and females.

Sex differences in perceived usefulness of mathematics have been established in many studies as well: Hilton and Berglund (1974); Fennema and Sherman (1977); Sherman and Fennema (1977); Sherman (1979) and Fennema (1983). Hilton and Berglund (1974) reported that these differences could in fact appear as early as grade 7. The Assessment of Performance Unit (APU, 1981b), Pedro et al (1981) and Kempa and McGough (1977) report specifically that no sex differences could be found for this attitude.

Other studies found that there was a marked variation in the level of perceived usefulness of mathematics. Sherman

(1982b) suggested that the "low stability of perceived Usefulness of Math is surprising and suggests that students were poorly informed in Grade 9." These pupils were tested in Grade 9 and again in Grade 12 and of all the attitudes tested, perceived usefulness had the lowest stability. The APU (1981b) noted that "pupils find mathematics ... less useful .... as they grow older," but that this applied equally to boys and girls. Sherman (1980) stated that "girls showed more and deeper declines ... on the Usefulness of Mathematics scales."

Investigations into the perceived usefulness of physical science are rare. An interesting observation by Kempa and McGough (1977) in a mathematics study was that the "usefulness and importance of mathematics seemed to differentiate more clearly between science and non-science sixth-formers" than between biases towards further study in mathematics.

One of the reasons for the dearth of research material in this area is almost certainly because those science attitude questionnaires which have been developed, do not have perceived usefulness as one of their measures. Levin and Fowler (1984) adapted the Fennema-Sherman Mathematics Attitude Scales and produced the Science Attitude Packet mentioned earlier. Here males scored higher than females, but the difference was not significant. This study involved tenth, eleventh- and twelfth-grade pupils and there were statistically valid differences between the grades with the eleventh-graders being the most positive and the twelfth-grade pupils not far behind. The only other research report that produces a measure similar to perceived usefulness is the important/unimportant scale from the Hadden and Johnstone (1982, 1983a, 1983b) study. This three-year study produced no sex differences, but showed a steady decline in the attitude for physical science importance. However, for perceived importance of mathematics there was actually a fairly consistent level of perceived importance of the subject.

In conclusion then, not much can be deduced with regard to the perceived usefulness of physical science, but as far as mathematics is concerned there seems to be no doubt that the perceived usefulness of mathematics is related to career aspirations and interests, but fewer girls than boys are oriented towards careers which have a mathematical or scientific basis.

2.3.2 Sociocultural Factors

2.3.2.1 Sex Roles and Stereotyping

All of the attitudinal variables which have been discussed thus far, could to varying degrees be related in some way to stereotyping in general and more specifically to mathematics and physical science being perceived as `male domains'.

Sex roles are seen by Ornstein and Levine (1982) as defining the way in which males and females "are `supposed' to behave", or as Nash (1979) puts it, sex role is "broadly defined as any behaviors, traits, attitudes, or expectations characteristically thought to differentiate the sexes." Sex role stereotypes, however, are "tenaciously held, well defined concepts that prescribe how each sex ought to perform" (Nash, 1979). It can be seen that Ornstein and Levine's definition of sex role is much the same as Nash's definition of sex role stereotypes. In much of the literature reviewed it would appear that stereotypes, sex roles and sex role stereotyping are all very loosely used terms, rarely defined, and very often referring to the same thing.

Social theorists have suggested the fact that the greatest differentiation of intellectual functioning occurs during adolescence, could be "primarily the result of boys' and girls' initiation into the adult roles which are dictated by society" (Badger, 1981). In a society which differentiates role in terms of gender, individual behaviour would consequently be influenced by whatever is considered to be sexually appropriate.

A number of investigations have established that sex role stereotypes are in evidence in children as young as 2 years of age (Kuhn et al, 1978; Vockel, 1981), and that these stereotypes increase in strength with age (Robinson-Awana et al, 1986). Stein and Smithells (1969) in a study involving second, sixth and twelfth grade children found that sex role standards gradually became more definite and extreme with age, but "the age trend was not always linear." How then do these sex differences come about? Stockard (1980) suggests that "most of the sex differences are learned."

2.3.2.2 Sex Role Learning

Various theories and approaches have been suggested and used, but the following framework would seem to cover most if not all of them. It should be noted that these three theories are not contradictory or mutually exclusive, but instead tend to complement each other.

The psychoanalytic theory of *identification* is that "the child identifies with the same-sex parent and learns the detail of a sex role through imitation of this parent" (Maccoby and Jacklin, 1975). Because the mother spends more time with the young child than does the father, a girl would identify more strongly with her mother and thus directly observe and imitate the role of the female. Many boys, however, also identify strongly with the mother and they probably don't have much opportunity to observe and imitate their father's behaviour. Ornstein and Levine (1982) thus conclude that "boys seem to have more difficulty than girls in arriving at a proper sex-role identification, particularly in a female-headed household where the father is completely absent." Maccoby and Jacklin (1975) are of the opinion that this theory is unsatisfactory as "children have not been shown to resemble closely the same sex parent in their behavior." Also children's sex-typed behaviour does not closely resemble that of adults in that they choose all male play groups without observing their fathers avoiding the company of females.

A second theory is named the *social learning theory* which to a certain extent also emphasises imitation, but argues that children are more often *reinforced* when they imitate a same-sex than an opposite sex model, "so they acquire a generalized tendency to imitate not only the same-sex parent but the other same-sex models as well" (Maccoby and Jacklin, 1975). Stockard (1980) writes that this theory grew out of "stimulus-response theory or behaviourism. ... In contrast to the pure behaviourists, theorists of social learning do not believe that all behaviours must be directly rewarded in order to be learned." Rather, they recognise that people can learn from observing what happens and extending this to future situations. This theory can be separated into two sections : social reinforcement and modelling.

Social reinforcement occurs mainly through parents whereby positive feedback follows sex-appropriate behaviour and negative feedback follows sex-inappropriate behaviour. It occurs of course in any social setting and social learning theorists "stress the importance of early childhood - a time when behaviour patterns are first learned" (Stockard, 1980). Sayers (1984) maintains that three- and four-year old children "criticize, and are less willing to play with other children who indulge in activities associated with the opposite sex ... and that nursery school teachers criticize their pupils for playing with opposite sex-typed toys."

Modelling as dealt with by more recent research is effectively the same as the psychoanalytic theory reported by Maccoby and Jacklin (1975) although Stockard (1980) lists it under a separate title, but admits that it is "usually seen as part of social learning theory" and involves "behaving like other people who are taken as models." Modelling, like reinforcement, holds a good deal of appeal as an explanation for sex role learning, but research support has not been very forthcoming (Maccoby and Jacklin, 1975; Stockard, 1980;

Sherman, 1982a; Licht and Dweck, 1983; Sayers, 1984).

A third theory is a *cognitive developmental* one, termed by Maccoby and Jacklin (1975) as "self-socialization". Kohlberg (1966) suggested that sex roles develop because children understand or decide what behaviours are appropriate for their sex rather than because of reinforcement. Through cognitive development, children first categorize themselves as boy or girl, then they begin to perceive and understand what attributes belong to males and females respectively and to accept or develop these. Stockard (1980) claims that support for this theory is gained from the many studies which show "that young children hold more rigid stereotypes of sex roles than do older children." As children grow older and develop more complex views of the world around them and of the nature of sex roles, they develop more flexible views of the possible roles for males and females. Maccoby and Jacklin (1975) were also of the opinion that Kohlberg's cognitive developmental view was more acceptable. (See also Sayers, 1984).

2.3.2.3 Stereotyping of Mathematics and Physical Science as Male Domains

Traditionally, mathematics and physical science have been regarded as male provinces (Fox et al 1979). According to Burton (1979) this stereotype turns out to be a self-fulfilling prophecy.

> *Women do not enter the field of mathematics; thus mathematicians and engineers tend to be men, and the fiction that mathematics is an esoteric science women cannot understand is reinforced.*

It has been believed that the sex stereotyping of mathematics starts in primary school, becomes stronger during the adolescent years and is entrenched as a male domain by adult years. Stein and Smithells (1969) and Stein (1971), however, provide evidence that mathematics is not considered as a male

domain until adolescence and even then it is not rated as highly as are spatial, mechanical and athletic tasks. Stein and Smithells (1969) maintain that by the time the females had reached the twelfth grade they realised the 'reality' of the situation and were then responding to this.
Sherman and Fennema (1977) with high school pupils (tenth and eleventh grade) found that boys were more inclined to see mathematics as falling in the male domain while girls once again denied that it was such. However, these girls were from an area where the feminist movement receives much publicity and they hypothesised that the girls responded positively to items such as "Studying mathematics is just as appropriate for women as for men." While overtly agreeing with this statement, when it came to electing maths courses, they behaved in a more stereotyped way. The males in this study were apparently not convinced by the feminist movement that mathematics was not a male domain, but not all that strongly so.

A Fennema-Sherman follow-up study (1978) examining pupils in grades six to twelve, also established that the females denied that mathematics was a male domain while the males did not stereotype it strongly at all, but at each grade they nevertheless stereotyped it at significantly higher levels than did the females. This strengthening of their determination that mathematics was NOT a male domain while still not electing to take as many courses as the boys did, is interesting and Fennema (1979) saw this as meaning that "since males stereotype mathematics as a male domain, they undoubtedly communicate this belief in many subtle and not so subtle ways to females which influences females' willingness to study mathematics". Fox et al (1979) also feel that parents, teachers and guidance counsellors "seem to believe that careers and courses in mathematics should be encouraged for males rather than females". This is a fairly widely held view.

Sherman (1980), in a longitudinal study involving pupils from grade eight to grade eleven, using cross-lagged panel correlations, established that the stereotyping of mathematics as a male domain negatively affected mathematics learning for the high school girls and further that it was an important causal attitude for predicting problem-solving ability. This finding was not the same as those by Sherman (1979) and Sherman (1982a, 1982b) where she established in the latter that girls in grade twelve taking four years of mathematics "stereotyped mathematics as <u>more</u> of a male domain than the other girls (in grade nine)." As a group though, the girls still stereotyped mathematics as less of a male domain as they became more mature, but this was not statistically significant. Sherman's (1982b) explanation for the fact that girls taking more mathematics and yet stereotyping it as more of a male domain than others was that "some of these girls felt that they were personally different and able to handle tasks in a 'male domain' even if the rest of their sex could not".

Schildkamp-Kundiger (1983) maintains that there exists a lot of empirical evidence supporting the hypothesis that sex typing of mathematics is related to achievement differences "in such a way that the linking of mathematics to the male domain can explain a great deal of any inferior achievements and engagement of women in mathematics". The fact that there are obviously contradictory findings in this area, simply points to the need for more research and what is required is far more control over the numerous independent variables involved.

Very little research has been done outside of the U.S.A. and what little has been done in physical science has generally been done in Britain. Even this though is very general and has not been done in any real depth at all. Vockell and Lobonc (1981) and Baker (1984) showed that physical science is a masculine domain leading to masculine careers. Smithers and Collings (1981) showed that girls studying science in the sixth form saw themselves as significantly more masculine than arts specialists did. The 'Girls into Science and Technology' (GIST) programme (Whyte, 1986) has provided much data for analysis and Kelly (1986) obtained sex differences in the maleness of science with the boys showing significantly high scores on the SCIMALE attitude. This was the case in their first year in high school and still held true in their third year, but both groups showed a drop in the stereotype. With the same data Kelly and Smail (1986) found that "girls who saw themselves as feminine had a tendency to see science as masculine, and so, presumably, not for them". Another more worrying aspect was that children who endorsed sex stereotypes, "showed less interest than other children in learning about the areas of science traditionally associated with the opposite sex". This means that they are limiting their horizons on the basis of their sex stereotypes before they have even experienced the subjects at school. This can only lead to deeper entrenchment of the sex role stereotypes in both physical science and mathematics and positive action is essential if the vicious circle is to be broken. Sherman (1983b) has an interesting comment to make.

> *After several years of research, it is my opinion that it is neither anxiety nor lack of ability that keeps women from mathematics. It is a network of sex-role influences which makes mathematics, and the careers mathematics are needed in, appear incongruent with the female role, especially with motherhood. When girls see that motherhood and demanding careers can be combined, a major source of resistance to mathematics will disappear.*

2.3.2.4 Fear of Success

> *"My nightmare", one woman remembers, "was that one day in a math class I would innocently ask a question and the teacher would say, 'Now that's a fascinating issue, one that the mathematicians spent years trying to figure out.' And if that happened, I would surely have to leave town, because my social life would have been ruined." This is an extreme case, probably exaggerated, but the feeling is typical. Mathematical precocity, asking interesting questions, meant risking exposure as someone unlike the rest of the gang.*

This quote from Tobias (1978) represents a feeling which many people have about the construct often termed 'fear of success'. Sharpe (1976) saw it as "if you want to attract boys, don't start by showing how clever you are" and "A girl who competes and succeeds in a male-dominated area, is often not regarded as a 'normal' woman." This attitude of fear of success would almost certainly be a hindrance to performance, but the research evidence is not all that consistent in its findings.

Nash (1979) quotes earlier researchers as linking fear of success to "societal norms of sex-role appropriate behaviour", but sees it rather as "the fear of deviance from sex-role standards". Leder (1980) in a study with grade eight pupils found that the mean fear of success scores of the girls was higher than that of the boys and those girls who intended taking as many mathematics courses as possible had a lower mean score than the rest of the girls. The mean scores of girls intending to pursue a career in mathematics did not differ much from the others.

Reviewing studies earlier than the above, Fox et al (1979) claimed that anecdotal data had not related fear of success to achievement in mathematics. Contrary to this Fennema and Sherman (1977) reported that girls said that they did not pursue the advanced mathematics courses because taking such courses might hamper their social relationships with boys and/or make them appear masculine. They could however, not validate this with paper-and-pencil assessments. Sherman in a number of studies (1979, 1980, 1982a, 1982b, 1983b) examined various aspects of fear of success using anecdotal as well as questionnaire methods. She established (1980) that is was "but one factor in a system of sex-role influences, and is less important for mathematics than some of the other attitudes." In a longitudinal study involving grades nine and twelve, Sherman (1982b) using the Fennema-Sherman Mathematics Attitude Scales, found that the girls became less fearful of success over this time span (see also Sherman 1982a, 1983b). As was the case for the stereotyping of mathematics as a male domain, it could be that this is a maturational effect and attributable to greater experience. It in fact turned out that the fear of success of the brighter girls was sufficiently strong to produce the effect that 'attitude towards success' in grade nine proved to be a negative predictor of achievement for grade twelve, three years later (Sherman, 1979).

It would seem then that fear of success as a construct relies a lot on intuition and anecdotal evidence for its justification, but sufficient evidence exists for it not to be discarded as significantly affecting mathematics and physical science performance, attitudes towards the subjects and the sex role stereotypes which exist.

2.3.2.5 Parental Influences

A child's early experiences are almost all contained within the family and from their earliest years, children's ideas about appropriate roles and behaviour have been influenced by the actions and attitudes of their parents and other adults in their environment. "Many facets of pre- and extra-school experience combine to form in children concepts of mothering, fathering, sex-appropriate behaviour, manliness and womanliness" (Weiner, 1980). According to Maccoby and Jacklin (1975) these pressures are so pervasive that toys and activity preference of children according to sex is significantly evident as early as the age of four years and increasingly so as they move into adolescence. They also concluded that "there is a remarkable degree of uniformity in the socialization of the two sexes", with boys probably having more intense experiences and having to endure greater pressures against engaging in sex-inappropriate behaviour, but getting more attention, more punishment and more praise (see section 2.3.2.2 on sex-role learning).

The point at which sex differences begin to become apparent, and the age at which boys and girls begin to be treated differently, is the subject of considerable and varying opinion. Deem (1978) quotes various research and concludes that the evidence suggests that "if children are not stereotyped according to sex in early infancy, it is not long before sexism is visible to these children". Kelly, E (1981) notes that the evidence of sex differences in very small children is damaging to socialization theories, but points out that it should not, however, be assumed that these differences are innate, because "from the time of birth girls and boys are treated differently".

Poffenberger and Norton (1959) wrote that parents influence their children's achievement and attitudes in mathematics in three ways: their own attitudes; the encouragement they give; and their own expectations. As far as parental *attitudes* are concerned, their results showed that the children's attitudes correlated with their father's attitudes but not with their mother's. This latter part was because very few of the students indicated that their mothers liked mathematics. The studies of Sherman and Fennema (1977), Sherman (1980) and Sherman (1983a) all yielded similar findings in that boys perceived their parents being more positive towards them as learners of mathematics than did the girls. Sherman's 1980 longitudinal study established that from grade eight to grade eleven the males felt that their mothers became more positive towards them as mathematics students more than the girls felt this, and that this was also true for the males as far as their fathers were concerned, but not for the girls. All of these relationships were statistically significant. Fennema and Sherman (1977) also established that boys perceived more favourable attitudes from their parents than did the girls. In two of the schools involved this came from the fathers, but in the other three schools it came from the mothers.

As far as *encouragement* is concerned, Poffenberger and Norton (1959) established significant relationships between parental encouragement and the ensuing attitudes of the children. Their results showed significant correlations for both fathers' and mothers' encouragement. Armstrong and Price (1982) with a sample of grade twelve students found that participation in mathematics was also significantly correlated with the encouragement given by both fathers and mothers.

Parental *expectations* in the Poffenberg and Norton study gave rise to strong differences in the positive and negative attitudes of the pupils and Armstrong and Price (1982) also found that "those students, especially males, whose parents had high academic expectations for them took more mathematics." Fox et al (1979) believe that "if parents sex-type mathematics, they should have differential expectations for sons than daughters and there is some evidence to this effect". An interesting point quoted by Fox et al (1979) is that in a particular study 75% of the mothers of girls earning poor grades in mathematics accepted this as inevitable because of their own lack of ability in mathematics. Parents of a boy earning poor grades in mathematics were likely to say that he was lazy. "It seems that perceptions of the parents' expectations of the child's mathematical ability is lower for girls than boys." Kelly et al (1986) found that parents' expectations for children were remarkably egalitarian as far as school was concerned, but outside of school their expectations showed strong divisions along sex-lines.

Getting assistance with mathematics homework has not been widely reported, but Sherman (1983b) reports a "tendency for girls to consult with their fathers rather than their mothers for help with mathematics". Sherman (1982a) confirms this, but states that a friend is more likely to be consulted than either parent or a teacher.

From the preceding evidence it can be concluded that both parents have a considerable effect on the attitudes, achievements and participation in mathematics and physical science of their children by means of encouragement, their own attitudes and their expectations, but that fathers probably have a more critical role in the sex stereotyping of these subjects. This is possibly an area where much can be done in developing the positive attitudes in physical science and mathematics that are so essential and it is an area which might prove to be more effective than many others.

2.3.2.6 Peer Group Influences

Socialization takes place as a result of a child's interaction with adults as well as the peer group. Traditionally it is believed that the child's relationship with adults is more important than the peer group influence, but Visser (1985b) quotes researchers who believe that the peer group relationship is more important in the process of maturation and also has a more positive effect.

There is no doubt that the support, approval and encouragement of the peer group is a major factor in a pupil's decision as whether or not to continue with mathematics (and possibly physical science). Swanepoel (1982) in a national survey in South Africa involving high school pupils established that the peer group (and adults) played a significant part in pupil participation in mathematics. Armstrong and Price (1982) found low, but significant correlations between peer influence and participation, and this for a large sample of 1788 twelfth grade pupils. An interesting aspect of this latter study was that for girls having an older brother who was good at mathematics there was a statistically greater chance of that girl taking advanced courses in mathematics. Keeves (1975), in an Australian study using 242 final year primary school children, established that the three best friends of a pupil in mathematics and science activities contributed to attitudes in both these subjects, but not directly to achievement. Kremer and Walberg (1981) in reviewing pertinent literature, came to the conclusion that as far as science learning and the peer environment were concerned, the number of investigations was very limited, but that "home and peer environment factors appear to be important correlates of science learning".

Serbin (1983) quotes several studies as determining that "the influences of peers as agents of differential reinforcement may thus be considerable." She also reports on a study in which she was involved which investigated the stereotyping of toy selection choices. Here it was established that when girls (or boys) were left on their own to choose toys, they were quite happy to experiment with 'cross-sex' toys. However, if another child was in the room with them (especially one of the opposite sex), they did not relax their obviously learned toy sex stereotypes. She continues by noting that sex-typed activities could easily be reversed with these young children if the teacher denoted approval or consent of any cross-sex, co-operative play by means of simple encouraging comments.

Although not confirmed, it would seem unlikely that girls would get much support from their peer group to engage in the study of mathematics and physical science even if they are talented and interested in the subject. This is likely, simply because of the extremely strong stereotype that these subjects have as being male domains - an outlook which has been shown to be universal in all groups who contribute to the attitudes of both boys and girls towards these two subjects.

2.3.2.7 Textbooks and The Media

Another source of socialization influence on children, even before they reach school-going age is the media. Television, radio, children's literature and textbooks all typically reinforce traditional sex-role stereotypes. "Some of them convey distinct messages about females and mathematics" (Fox et al, 1979). Physical science does not escape this treatment either. Jacklin (1983) notes that "books, radio and television programmes all portray many more boys and men than girls and women". (See also Stockard 1980c.) Role models for children on TV frequently depict females in a derogatory manner, "rarely having jobs, and usually in romantic and/or family roles" (Fox et al, 1979). Perhaps one of the strongest reinforcers is the medium of advertising. Here girls will be seen helping their mothers with the washing up, whilst their brothers are playing cricket with their fathers, or repairing something mechanical or electrical. Weiner (1980) claims that the advertising industry has long been criticized for "its general stereotypical portrayal of the average consumer". The scientist is someone who has probably suffered most at the hands of television and the film industry. This stereotype of a mad, scatter-brained, weird looking and egocentric individual is well entrenched. Bradley and Hutchings (1973) report this negative image, but their findings pointed to a more encouraging image. Schibeci (1986) in a substantial review of the image of science and scientists sums the situation up very neatly "There is sufficient evidence to indicate that scientists engage in a very diverse range of behaviour, of which the more outlandish have been seized upon by those who control the images presented in popular culture."

Jacklin (1983) maintains that children's books also provide "stereotypic and unrealistic views of the world" with women almost always represented as mothers in the home while the men were assigned a variety of jobs and roles. Fox et al (1979) quotes a study involving researching 135 books in order to find non-stereotyped readers. "They could not find one series that was acceptable." (See also Kelly, E., 1981 and Garratt, 1986.)

Secondary school textbooks have received a lot more attention and the findings on all aspects of stereotyping have been unanimous. In both mathematics and physical science textbooks, girls are typically portrayed as being passive observers while the boys are active and involved. (Jay and Schminke, 1975; Fox et al, 1979; Taylor, 1979; Walford, 1980; Stockard, 1980b.) There is a clear tendency in the books to define these subjects as the province of males. Adult women are largely absent, and "by the age of thirteen, girls have joined them in near oblivion (Northam, 1986). She notes further that the decline in interest in mathematics between seven and sixteen years of age has an interesting parallel with "the gradual disappearance of girls from maths books". Nibbelink et al (1986) make some suggestions to authors and publishers as to how this serious stereotyping problem could possibly be alleviated, but wonder whether in fact society really wants these stereotypes to be challenged. (See also the Royal Society and the Institute of Mathematics and its Application, 1986.)

Smithers and Smithers (1984) in a study involving six and seven year-old children felt that the children fed back to them "what they had heard (rather) than giving personal views ..... From the people in their lives, story books and the media they seem to have received strong hints that it is proper for men and women to do different things." The causal link between this area of sex-stereotyping and the children's own stereotyping has not yet been established (Kelly, 1981d) where she states "such sex-stereotyping can be deplored on the grounds that it is discriminatory and frequently offensive, but we cannot be sure that it directly promotes sex-typing in children". The cumulative impact of all these messages must have an impact but determining the effect that they have is virtually impossible because of the difficulty of obtaining adequate control groups.

2.4 Educational Variables

2.4.1 Co-Education or Separation?

2.4.1.1 Co-Educational and Single-Sex Schools

Dale (1974) in an enormous investigation and review of co-education during the sixties fuelled much speculation and debate as to the merits and demerits of mixed-sex schooling. More recently, single-sex classes in co-educational schools have been the central topic in a revival of the mixed-sex, single-sex speculations.

During the 1960s when the debate was at its height in England, the examples of the United States and the Soviet Union seemed to suggest that it was a natural, normal and successful policy. There had been some research which had suggested that co-education was good for boys and bad for girls, but Dale (1974), an enthusiastic supporter of co-education, swept aside all opposition with an argument based on the social atmosphere of schools. He based much of this on the views of teachers in both types of schools (many with experience in both) who almost all preferred the co-educational setting. There is of course no one way of judging the 'success' of any particular school or type of school, but for the purposes of this study, participation in, attitudes towards and achievement in mathematics and physical science will be reviewed briefly. There has been a large amount of research in this area, but there is a large number of aspects to consider so some areas have been considerably less researched than others. According to Sutherland (1985) "One of the distressing effects of the move to co-education is that few single-sex schools are available to provide control groups for methodical studies" and much of the research relies on anecdotal information.

As far as <u>preference</u> for (or <u>participation</u> in) mathematics and physical science is concerned, reports have been extremely clear-cut, but they need, according to Marland (1983a), to be interpreted cautiously. All of the following researchers obtained results which showed that more girls in single-sex schools opted for mathematics and/or physical science than did girls in co-educational schools (Dale, 1974; Ormerod, 1975* and 1981a*; Taylor, 1979; Smithers and Collings, 1981 and 1982; Harvey, 1984; Lee and Bryk, 1986*). Those studies marked with an asterisk established that the difference between the types of schools applied for the boys as well, but usually not as strongly . What this means is that in the co-educational schools there is a polarization of the sexes in mathematics and physical science and this could well be as a result of these subjects being accorded a more masculine image than is the case in the single-sex schools. (See also Vockell and Lobonc, 1981). In addition, the co-educational girls might be more conscious of so-called sex-appropriate behaviour and so they establish their 'femininity' by rejecting these two subjects. A warning must be sounded here though, because Smithers and Collings (1981,

1982) established that when the science data were controlled for ability, the differences between the two types of schools mainly disappeared. They report a study by Kelly which yielded similar results and suggest that "the importance of the sex composition of school in science choice has been exaggerated" (Smithers and Collings, 1982).

Attitudes towards physical science were shown by Harding (1979, 1981), Ormerod (1981) and Lee and Bryk (1986) to be less positive for the girls in the mixed schools then for those in the all-girls' schools. Harding (1979) demonstrated this for mathematics and the GEMSAT project (Nottinghamshire LEA, 1985) using anecdotal evidence found similar differences in attitudes for girls towards physical science. However, contrary evidence in science was presented by Harvey (1985a) who could not detect any difference in attitudes between the two groups of girls.

As far as achievement is concerned, evidence for differences in physical science were presented by Harding (1979, 1981) as follows: boys from mixed schools were more successful than girls from these schools; girls from girls' schools were more successful than girls from mixed schools; weak support for boys doing better in mixed schools and girls in girls' schools doing better than boys in boys' schools. Once again Harvey (1985b) presented contrary findings of no differences, but Lee and Bryk (1986) found that single-sex school pupils performed better than co-educational school pupils (in most subjects), but that this was more marked for girls than for boys. The Assessment of Performance Unit (APU, 1981b) studying fifteen year-olds, found no difference in performance for either boys or girls, between pupils in single-sex and mixed comprehensive schools. For the grammar and secondary modern schools, differences were found between the co-educational and single-sex schools for both boys and girls, but the sample was unbalanced in terms of the types of schools and thus possibly not suitably reliable.

It is not surprising that there has been serious thought given to the possibilities of introducing more single-sex education during mid-adolescence at least. Marland (1983a) feels that two points need to be made:

> 1. *The assumption that all aspects of progressive educational thinking inevitably lead to mixed-sex education cannot be sustained. .... the mixed schools were less good: they had lower emphasis on academic success and it could be argued that the 'social' benefits he found (by retrospective discussions with adults) are no more than stereotypical pressures in thin disguise.*
>
> 2. *With the current pattern of subject take-up and differential success, some measure of single-sex learning needs considering, even if particular schools reject it.*

A move to single-sex schooling would be so contrary to current thinking in educational circles and also impose a significant financial burden on the authorities (particularly in South Africa) that it is unlikely to be seriously considered. Taking into account the present situation, it is uncertain whether or not the advantages would outweigh the disadvantages. The latter point made by Marland above is a consideration though for the introduction of some single-sex classes in co-educational schools by way of obtaining some justification for such a move.

2.4.1.2 Single-Sex Groups

There is a handful of research reports which deals with experiments to evaluate the possibilities that exist for teaching mathematics and physical science in single-sex groups within co-educational schools. Groupings of this nature are relatively easy to implement, but evaluation of their achievements is not easy, because of the numerous educational, intellectual and social variables. The experiments reported on here have, with one exception, all been done in England. An Australian study (Rennie and

Parker, 1987) dealt with small groups of two or three pupils being taught and involved in, an activity which was based on an electricity topic. The study was directed at teaching skills as well, and in the control group lower participation rates were found for girls in the mixed-sex groups. Here the teachers had low levels of skills and awareness in relation to non-sexist learning environments. In the mixed-sex experimental groups where the teacher had 'acquired suitable skills', these sex differences in participation were not observed. Single-sex groups in both the control and experimental groups nevertheless demonstrated the same patterns of involvement. This study makes a case for single-sex grouping for girls where their teachers have a low level of awareness of non-sexist learning environments.

Two co-educational schools have investigated single-sex mathematics classes and in both of these the all-girl classes showed significant improvement in performance in relation to the girls in the mixed-sex classes. Smith (1980) at Stanford High School established single- sex and mixed-sex sets which were taught by the same teacher. At the beginning of the first year in high school, the performance of the groups in the tests showed no difference. By the middle of the second year the all-girls set was still scoring nearly as high as the boys, but the girls in the mixed-sex group had dropped behind the boys by as much as twenty percent. As yet positive results with a clear statistical significance have not been shown, but the experiment continues. Eales (1986) writing about a similar experiment which was conducted over four years at Beauchamp College was not able to produce as strong an effect as Smith had. What was obtained though was an improvement (statistically verified) that there had been an increase in the enrolment for A-level mathematics compared to previous years.

While results of some significance were obtained from the Smith and Eales studies, Harvey (1985a, 1985b) in two science studies with the same sample, one involving attitudes and the other attainment, found no differences at all. In his attitude study (1985a) his evidence showed no significant improvement in the physical science attitudes of girls who were allocated to single-sex classes, but the experiment was only conducted over a period of one year. In the other study (1985b) the single-sex groups for science did not improve in science attainment during their first year in high school. Contrary to all other findings though he established that girls in mixed-sex schools actually did better than girls in the all-girls school. These latter two investigations do not inspire much confidence in single-sex groupings, but while they dealt with a large number of pupils they did represent a young sample and many more investigations over a longer period of time and at a later stage in the school structure are essential. An experiment at Ellis Guilford School reported by Price and Talbot (1984) has shown positive results in increasing the numbers of both boys and girls taking physical science as a result of creating single-sex teaching groups in the upper ability band of the third year. Very little detail has been given, but other reasons could be the cause of the shift as other approaches have been introduced as well, viz. additional input of careers advice and renewal of third year syllabuses (making them more relevant). Any <u>one</u> of these could of course have accounted for the improvement in course selection for science, but what is possible is that a combination of all these factors is the most likely reason.

Marland (1983a) sees the possibility of renaming subjects as "physics for girls" or "home economics for boys" as presenting a good opportunity of utilizing group identity and sex stereotypes positively. Same-sex teachers and subject slants towards that sex would then all be possible if needed. This single-sex arrangement would only be needed in a particular school if the participation or performance of either of the sexes was proving to create discrepancies. Marland continued by pointing out drawbacks of this type of arrangement. He thought that it would feed stereotypes, slant the curriculum and teaching styles and also increase the strength of the socializing of stereotyped attitudes. It also assumes (as does any form of grouping, or even <u>no</u> grouping at all) that everyone in the group (in this case all the boys or all the girls) would have similar needs and so advantages for some would be outweighed by disadvantages for others. Perhaps the main problem though, is that it merely masks establishing what the real problems are and treats the effect rather than the cause.

It appears that single-sex classes have some value in certain situations, but perhaps in the long-term they would turn out to be rather dangerous. It certainly is an area which can't be abandoned at this stage of investigation, but a lot more research is required before anything concrete (if at all) can be established.

2.4.2 Teacher Effect

Teachers have a major impact on the pupils' learning of mathematics and physical science. Their day-to-day interaction is probably more powerful than most other effects and influences the pupils attitudes and feelings about themselves as learners of the subjects and their perceived usefulness, and their willingness to continue with them. There is much evidence though which suggests that teachers are differentially influencing males and females in the classroom situation.

In investigations of this nature it is always difficult to establish which is the cause and which is the effect. Aiken (1970) showed that pupils who do badly in mathematics develop negative attitudes and consequently blame their teachers for their lack of success. Aiken and Dreger (1961) had earlier established that male students in recollecting their feelings about their mathematics teachers linked positive attitudes to the patience and friendliness of their teachers. Women students, however, needed far more positive characteristics from their teachers in order to feel positive about mathematics. These characteristics were: patience; kindness; clever (not dull); knowledgeable; knowing how to teach mathematics and high standards of teaching. It is quite amazing how much greater were the requirements of the females and even if girls were to receive equal attention (compared to the boys) it would seem that they would exhibit more negative attitudes towards mathematics than the boys would.

An interesting study in England was conducted by Spear (1984) which involved using 306 teachers from a variety of types of schools to assess six samples of physical science work written by three pupils (two samples from each pupil). These were then marked by the teachers, but half of them were denoted as being written by a boy and the other half by a girl. In addition to the marking, there were various questions concerning the work they had assessed, which the teachers were asked to answer. There were two clear trends which were obvious from the marking. Firstly, written work attributed to a girl was often given a lower mark than the identical work attributed to a boy. Secondly, female teachers often gave higher marks than did male teachers. Thus the combined effect of teacher sex and pupil sex would mean that boys' work marked by females would be most likely to produce a generous assessment, whereas girls' work marked by males the severest. A number of other aspects of the marking process were evaluated and it was obvious that sex bias was prevalent. Stated generally this would suggest that teachers have higher expectations for boys than they do for girls and their actions fulfill the prophecy of which they are probably unaware even though its basis might be unfounded.

Becker (1981) in a study involving high school mathematics pupils, investigated the teacher-student interaction between ten teachers and students from three schools. She came to the conclusion that girls were being treated very differently and cited the areas of;

(a) afforded response opportunities
(b) open questioning
(c) cognitive level of questions
(d) sustenance and persistence
(e) praise and criticism
(f) encouragement

(g) individual help

(h) conversation and joking

"The differences found generally work in a positive way for males - they received more teacher attention, reinforcement and affect." Females received less of all three. The conclusion was that "the classroom environments on the whole reinforced traditional sex-typing of mathematics as male "and that there was nothing in teacher language and behaviour or the physical environment which could be discerned as encouraging the girls to continue their study of mathematics. Becker (1981) proposed a three-step pattern which summed up the teacher-pupil interaction from her study. Firstly teachers have different <u>expectations</u> of students based on the sex of those students. Secondly teachers <u>treat</u> them differently on the basis of sex in a manner consistent with these differential expectations. Thirdly these pupils will <u>respond</u> differentially in accordance with these different expectations and the different treatment. There is of course an interaction of all three of these steps and any differential pupil behaviour might in itself be the stimulus for the difference in expectations, but Becker (1981) was of the opinion that "teacher behaviors consistent with their expectations then reinforce societally prescribed sex roles rather than altering them to a more equitable view."

As far as reinforcement or reward of males and females for different types of behaviour, Fennema (1980) maintains that "males are rewarded for behavior stereotyped as male, and females are rewarded for behavior stereotyped as female". Because what is rewarded is probably what is learned it leads to an even deeper entrenchment of the sex stereotypes. Dealing with Becker's first point above of differential expectations, Davies and Meighan (1975) quote studies which are in agreement with this point as do Fox et al (1979). Benz et al (1981) investigating the sex role expectations of teachers from grade one through to grade twelve established that high achieving students were classified as androgynous and masculine while low-achieving students were classified as feminine and undifferentiated. They were of the opinion that "females may be fulfilling society's expectations for them". Likewise Parker (1984) in a science study states that "girls learn that they are not expected to achieve highly in science or to continue to study the 'hard' sciences beyond the compulsory years of study". She notes further that science teachers not only interact less with girls, but also that the quality of their interaction is inferior to that of boys and often the questioning is pitched at a lower cognitive level. Leinhardt et al (1979) also report that in mathematics teachers spent more cognitive time with boys and made more contacts with them. As far as classroom interactions were concerned Good et al (1973) stated that sex differences were mostly due to students and not the teacher. They agreed though that male and female teachers behaved differently and reported further that high achieving boys received more attention than any other groups in the classroom.

As far as teacher attitudes are concerned, Schofield's (1981) findings offered clear support for "the commonly assumed positive association between teachers' attitudes toward mathematics and pupil achievement in mathematics, but they do not support the contention that this association is achieved via pupil attitudes". Aiken (1976) in reviewing the literature in this connection, noted that a number of researchers could find no statistically significant results showing that teachers' attitudes affected pupils' attitudes in mathematics while he reported on one that had. This was Phillips (1973) who established that there was a relationship, but stated that the relationship was not evident if only the pupil's most recent teacher was considered and that the teachers of the previous two or three years needed to be taken into account. Koballa and Crawley (1985), however, note that as far as science is concerned "teachers' attitudes toward science influence their students' attitudes".

Teacher encouragement is a specific 'treatment' that has a positive effect and Armstrong and Price (1982) note that "students who perceived their teachers as encouraging also tended to take more mathematics". They also stated that differential treatment was one of the few variables that was significantly correlated to mathematics course taking but this applied to males and not to females. Tobin and Garnett (1987) reported on studies that noted that boys were spoken to more frequently and received praise for <u>quality</u> of work while girls were praised for form and neatness. They found in their own research "that males participated to a greater extent than females in the public interactions with the teacher". Further they established that the teachers in that particular study "were unaware that gender-related differences existed in their classes.

"Wait time, the duration of teacher pauses after questions is an important variable in research in science teaching" (Swift and Gooding, 1983). This aspect of teacher-pupil interactions has been fairly extensively researched recently and statistical significance of more wait time being given to boys and possibly having a negative effect on girls' mathematics achievement, was found by Gore and Roumagoux (1983). Riley (1986) and Tobin (1980, 1987) established similar differences for science teachers and Tobin (1987) noted that "an extended teacher wait time should be viewed as a necessary but insufficient condition for higher cognitive level achievement".

All things considered, it appears that teachers exert considerable influence as far as sex stereotyping of mathematics and physical science and also attitudes towards these subjects are concerned. "Teachers must become sex blind in the treatment of their students" writes Fennema (1980) and it is necessary for them to help their pupils, especially the boys to overcome the sex stereotyping of both mathematics and physical science.

2.4.3 Assessment

Examiners can hardly be held responsible for sex differences in the ability and performance of candidates or for the attitudes that the candidates have towards the subject being examined. It is however, possible that an examination can be set which contains a bias towards one sex or the other.

There is not a great deal of research which has been undertaken in this area, but it does stretch back as far as Milton (1959) who showed that problem-solving skills are related to the degree of sex role identification within each sex, i.e. the more masculine the individual, the better he or she would be at solving such problems. Graf and Riddell (1972) report that females took longer to solve a problem in a stock market setting than they did to solve the identical problem in the context of buying goods at a fabric store. They suggested that sex role stereotypes lead girls to perceive problems written in a male context to be more difficult, and that this perceived difficulty then affects the speed and success with which problems are solved. The male and female figures reflected in examinations questions reflect these stereotyped images of their sex. Sex bias in examinations is of concern because "mathematics teachers cannot select examination questions in the same way as they can select text books or examples in textbooks" (Royal Society, 1986). Sharkey (1983) lists some examples of sex bias, but what must be borne in mind is that it is not wrong to use masculine (or feminine) examples as long as these are balanced fairly.

As far as science examinations in particular are concerned, another way in which they can be sex biased is when different modes of assessment are used. Harding (1977 or 1981 or 1983) investigated the performance of boys and girls in six O-level science examinations. She established in three of the four multiple-choice papers that boys did significantly better than did the girls, although there were no overall differences in the percentage of passes in any of the examinations. In the one essay type paper, girls fared better than the boys, whereas papers utilising structured questions produced no sex bias at all. Murphy (1980) also established correlations between the type of assessment used and the results obtained for the different sexes. It appears therefore that multiple-choice questions create further difficulties for girls, but possibly only in science. English language examinations using multiple-choice testing in the comprehension section, do not deter the girls at all. It is suggested (Royal Society, 1986) that "possibly a bias introduced by mode of assessment is counter-balanced where a subject is 'girl friendly'." It is possibly the risk-taking element of the multiple-choice type questions that create this difference in science or that the boys with their more adventurous natures and greater confidence in their abilities, cope with this type of assessment more easily (see also Murphy, 1978). Structured questions seem to yield the best balance between the sexes in terms of testing, but this does not mean that any other type of assessment is invalid. It means rather, that a good balance between the different modes is necessary and further information on the different approaches to examining are also indicated. The problem of sex stereotypes presented in the questions themselves, can of course be addressed quite effectively and easily.

2.4.4 Intervention Programmes

Intervention strategies are designed to remedy situations where a group has already been shown to be at a disadvantage. There is nothing new about this as 'remedial teaching' is commonplace in most countries and certainly receives a lot of attention in South Africa as well. It is almost always employed at primary school level and deals with a number of skills both physical and cognitive, but reading is one of the major areas of application. Whyld (1983) notes though that no equivalent concern is shown for those who fall back in science" (mathematics should also be included) "and feels that it is because it affects girls more than boys which "is a facet of our culture which placed more importance on men than on women," and " where boys fail, special efforts are made to compensate, but in the case of girls, their failure is blamed on their 'biological deficiencies'".

In the United States there are a number of intervention programmes being used. They are mostly aimed at mathematics and involve the whole spectrum of ages as far as the target group of each is concerned. Becker (1987) has summarised very effectively most of the programmes that are being attempted in that country. The Lawrence Hall of Science at the University of California has developed a number of strategies, two of which are aimed at the elementary and middle school level. One of these aims to change the feelings and increase the problem-solving skills of six to fourteen year-old girls by means of eight sessions of approximately two hours each. It utilises minimal materials and involves mathematics only. No formal evaluation has been attempted, but the percentage of girls enrolling in after-schools courses at the university has shown an increase. Also at the Lawrence Hall of Science is the SPACES programme, which is aimed at grades three to ten and which seeks to improve career awareness and problem-solving skills by means of a series of thirty enrichment activities. Informal assessment of this programme is also positive.

At the middle and high school level the Math/Science Network in the San Francisco Bay area initiated one-day career conferences for girls in what are called 'Expanding Your Horizons in Science and Mathematics Conferences'. More than one thousand scientists, educators and community members have participated in this particular scheme. (See Becker, 1987; Fennema, 1983; Stage, 1983 and Kreinberg, 1983.) Surveys conducted six months later showed that the pupils actually did enrol in the mathematics and science courses which they indicated they would. Programmes involving visiting women scientists who provide on a national basis, encouragement to continue with mathematics and science as well as career information and who obviously are excellent role models for the girls are also being implemented.

Two of these are the NSF's Visiting Women Scientists Program and Women and Mathematics (WAM), a national lectureship programme. The number of postcards which have been returned by participants requesting information regarding scientific careers, have increased significantly, denoting a successful if somewhat limited intervention strategy (Poiani, 1983).

The Math Anxiety Clinics, where various counselling techniques were employed to help students overcome their negative feelings about mathematics, were mentioned in section 2.3.1.4. Usually these intervention sessions involved a counsellor and a mathematics teacher, but while they were successful in influencing course-taking trends they generally did not succeed in any long term attitude changes.

Another approach was that of the Teacher Education and Mathematics (TEAM) programme which by means of eight modules succeeded in showing an improvement in the confidence, perceived usefulness and skills in identifying sex role stereotypes of student teachers of mathematics. The EQUALS programme is one of the best known, and is an in-service programme for teachers, administrators and counsellors involved with all grades of pupils. It involves workshop activities of between ten and thirty hours where participants collect their own data, analyse it themselves and investigate ways of improving student attitude toward, and understanding of mathematics, as well as planning in-service presentations for other educators. Having assessed their own situation many became involved for some years after the introductory activities and in fact a handbook produced by the program has been used throughout the country and adaptations of the EQUALS approach are being used in at least six other states. (Becker, 1987; Stage, 1983 and Gilliland, 1983.)

Perhaps the most serious failing of the programmes mentioned above is that none of them take place in the classroom. One point of view is that the studying of mathematics and science are stereotyped as male and because sex role stereotypes are so deeply embedded in society, schools are powerless to do anything about the situation until society changes. The Multiplying Options and Subtracting Bias programme (Fennema, 1983) is an <u>integrated</u> scheme which has to a certain extent disproved the above point of view. It was designed by Fennema, Becker, Wolleat and Pedro and "aims to increase mathematics course selection by increasing females' knowledge about sex-related differences in mathematics, by improving females' attitudes towards mathematics, and by changing the attitudes of teachers, parents, counselors and peers of both sexes" (Becker, 1987). The programme is organised round four half-hour videotapes, each being part of a two hour workshop: one each for students; teachers; counsellors and parents. The videotapes focus on how much mathematics is needed for various careers, the number of women employed in mathematics-related careers, counselling, stereotyping of mathematics classes, family interactions, the sources of female's lack of confidence in mathematics and the way to change student course-selection behaviour. "An evaluation of the videotapes alone showed that the tapes were more successful with students than with the adults" (Becker, 1987). The female students not only reported intentions of studying more mathematics the following year, but actually did enrol in more mathematics classes. Increases noted among the male students in the experimental group were not as great as those noted with female students. Fennema (1983) notes that "it is possible to change female's mathematics behaviour, and to do so in relatively short periods of time."

In England intervention strategies are a more recent attempt to redress the situation. There appears to be more attention to physical science than there is in the United States, but the Girls (now Gender) and Mathematics Association (GAMMA) being heavily involved in most aspects of girls' participation in mathematics has drawn a lot of attention to the problem of the under-representation of girls in most aspects of mathematics education. Primarily it is a national association which aims to publicize the facts, evolve strategies and create resources aimed at improving the situation as well as set up a national network for the exchange and sharing of ideas (Nottinghamshire LEA, 1984; Burton and Townsend, 1985; Shuard, 1986; GAMMA Newsletters). The Girls' Education in Mathematics, Science and Technology Project (GEMSAT) undertaken by the Nottinghamshire LEA (1984, 1985) was a two-year project which ultimately involved thirty three schools. It had aims which embraced pupils, teachers and the schools, Curriculum opportunities, the acceptance of achievement, social and economic importance of mathematics and appropriate counselling were all areas which affected the pupils specifically. As far as the teachers and schools were concerned the objectives were: the support and development of the professional skills and attitudes of teachers; development of curriculum materials; and building a tradition of girls studying and succeeding in mathematics, science and technology. No formal evaluation has been undertaken for this project, but from the comments made it seems that one of the main successes is a much greater awareness of the need for different approaches to be attempted. In addition, learning materials had been and were still being produced, careers information and counselling had improved and pastoral work via Year Heads, tutors, etc. had made "a significant contribution to the opening up of stereotyping and gender issues in those schools which had developed them (Nottinghamshire, LEA, 1985). On the negative side it was felt that the great difficulty of influencing home and societal attitudes presented a considerable problem in attempting to change attitudes on a broad front. Staff turnover and industrial action severely affected the effectiveness of the programme.

Other intervention strategies were aimed at science <u>and</u> technology. The Women in Science and Engineering (WISE) project was a one-year campaign to advertise opportunities available to girls. The WISE Bus was in fact used (in a very limited way) in the GEMSAT project mentioned above. This is a specially converted double-decker bus which offers a mobile teaching and exhibition unit to schools. The Girls And Technology Education (GATE) also has a strong vocational aim and encourages competence in design and technology activities amongst girls in the hope that their interest in mathematics and physical science would be increased and their attitudes towards these subjects to be improved.

Probably the best known and most extensive project is an action-research programme known as GIST (Girls into Science and Technology; Kelly 1986, Whyte, 1986 and Kelly et al, 1984). It was an attempt over a four-year period to improve girls' achievement in these areas and also to investigate the reasons for their underachievement. Teachers at the eight schools involved, devised strategies for reducing sex stereotyping and two other schools were involved as controls. In these, attitude testing took place, but no intervention was employed. The interventions included a programme of visits by women who talked about their work and served as role models for the girls; posters and worksheets about women's contributions to science; curriculum development; observation of teachers in the classroom with feedback on how to increase girls' participation; discussions with staff and pupils about the limiting effects of sex role stereotypes; and careers advice linked to option choices in schools.

Results show that the impact on pupils' subject choices was slight, but "the results of the attitude testing was more encouraging" (Kelly et al, 1984). There was a small but consistent trend for children in the 'action schools' to show more positive (or less negative) attitude change than the children in the control schools. "The specific focus of interventions was the stereotyping of science and technology as masculine, and in this respect the children's attitudes were considerably modified" (Kelly et al, 1984). An important aspect was that changes in group behaviour were more likely to occur in schools and departments where the prevailing ethos was amenable to an intervention programme of this nature. It was acknowledged though that attempts to change attitudes by working in one part of the socio-cultural spectrum only, would almost certainly severely handicap any attempts to remedy the situation and that schools could not therefore act alone and expect to be entirely successful in their efforts. This latter comment is one that comes through over and over in any attempts at any non-specific intervention programmes.

CHAPTER THREE

RESEARCH DESIGN

3.1 General Aims

The starting point of this research was the fact that there is a disparity in the number of girls and boys who opt for mathematics and physical science in the senior high school phase of the educational structure. As is obvious from the literature, attitudes and other affective variables as well as certain educational factors, all play a part in producing this imbalance. Considering this, and also the fact that critical subject choices are made at the end of standard seven (average age of fifteen), it was decided initially to investigate the attitudes towards mathematics and physical science, of pupils covering the three-year span of standards six, seven and eight. This was to be done by means of a cross-sectional attitude survey, but in view of the findings reported in the literature review and particularly the results reported by Oberholster (1985), a longitudinal study over this same three-year period was also undertaken. The longitudinal study had the general aim of 'teasing out' the underlying causes of any differences in both the affective and educational domains that, on the basis of previous research, were expected to be obtained in the present study as well.

Broadly speaking then the study set out to investigate the following:

(a) Were there in this sample, differences in mathematics and physical science attitudes between:

- (i) the sexes?
- (ii) pupils in standards six, seven and eight?
- (iii) pupils in co-educational and single-sex schools?

(b) If so,

- (i) what were the possible reasons for these differences?
- (ii) what effect (if any) did these attitudinal differences have on course selection?
- (iii) were attitudes in fact the cause of any subsequent effects, or were they the result of other factors?

The flow diagram in Appendix H gives an idea of the sequence of events as they happened and gives some indication of decisions taken and changes in direction made, along the way.

3.2 The Type of Research Procedure

The nature of this investigation necessitated the use of ex post facto research as it was not possible to control any dependent variables and thus use more powerful experimental procedures. Ex post facto research can be seen as a method of extracting possible causes of events which have already occurred and therefore cannot be manipulated or controlled by the researcher. In other words the independent variable or variables have already occurred and the researcher thus starts with the dependent variable(s). He then moves on to the independent variable(s) in retrospect, in order to attempt to establish any relationships of cause and effect between the dependent and independent variables (Cohen and Manion, 1985).

Two kinds of design exist in *ex post facto* research:

- (i) Co-relational, sometimes known as causal research, and
- (ii) Criterion-group study, also termed causal-comparative research.

A *co-relational (or causal) study* is one in which the antecedents of a current situation are identified. Its value lies chiefly in its exploratory nature and of course it is not always adequate for establishing causal relationships, but it does yield measures of association. In the *criterion-group (or causal comparative) approach* the researcher attempts to find possible causes for a particular phenomenon by comparing subjects in whom the variable is present with similar subjects from whom it is absent (Cohen and Manion, 1985).

As will be seen by the more detailed explanations of the research method which follow in later sections, both of these designs were incorporated in the experimental procedures.

Two distinct types of research were used, viz. cross-sectional and longitudinal studies. Each type of course, has its own advantages and disadvantages, but it was felt that both had a part in the overall strategy. The investigation was one of developmental research in that it set out to describe the present relationships (if any) between the variables present and to account for any changes which might occur as a function of time (Cohen and Manion, 1985). Cross-sectional and longitudinal studies are both types of developmental research, even though they are so vastly different.

There are reasons for using cross-sectional research in an investigation, but for the present research the major reason was to identify at the outset whether or not there were any differences in the attitudes towards mathematics and physical science amongst standard six, seven and eight boys and girls in single-sex and co-educational schools. Because cross-sectional studies lend themselves to larger samples and easier and quicker information gathering, it was possible to use schools in two cities some 300 km apart. Findings in cross-sectional studies are produced more quickly and are also more likely to secure the co-operation of a large number of respondents on a 'one-off' basis. In addition they do not suffer from 'sample mortality' and are less likely to suffer from control effects.

The particular longitudinal study undertaken in this research is what Cohen and Manion (1985) refer to as cohort analysis. They maintain that it has an "important place in the research armoury of the educational investigator" and that it is "uniquely able to identify typical patterns of development and to reveal factors operating on those samples which elude other research designs". A cohort study is one in which successive measures are taken at different times from the same respondents. They are particularly appropriate when the investigator attempts to establish causal relationships, because this involves identifying changes in certain characteristics that result in changes in others. Cohort studies also permit the accumulation of a much larger number of variables extending over a much wider area, and allow at later opportunities, information about a variable that was omitted from a previous one to be gathered. Perhaps most important though is that trends or changes that become observable at a particular stage can always be delved into at a later stage. Provided the initial sample is adequately selected, later problems of sampling (despite the possibilities of 'sample mortality') are removed and the extensive use of sub-samples is possible - as was the case in the present research.

Two distinct methods of information gathering were used in this study. The questionnaire technique was used for the large-scale cross-sectional study and also for some aspects of the longitudinal study, but in this latter study the interview technique was mainly employed. Questionnaires were used for much the same reasons that a cross-sectional survey was required, viz. a large sample drawn from two separate cities, much quicker information gathering and easy co-operation of a large number of pupils.

The interview technique was chosen for the longitudinal (cohort) study also for a variety of reasons. One advantage is that it allows for greater depth than is the case with other methods of data collection and another is that probing or explanation of a particular aspect is possible. It also allows the interviewer to observe the manner in which a homogeneous and similar to that in the United Kingdom or North America middle to upper socio-economic groups in that the culture is largely supportive of the study of mathematics. It is at the family level that the experience of each child, even within the same family, is an individual experience. It is therefore at this level that an understanding of factors leading to a particular child's mathematics or physical science avoidance can be gained, and where intervention on the part of teacher or counsellor can be effective. Consequently it was decided to include this area as part of the final stages of the longitudinal study.

It was reported in Section 2.3.2.5 that both parents have a considerable effect on the attitudes, achievements and participation in mathematics and physical science of their children and that the parents' own attitudes as well as their expectations and encouragement are seen as important factors. In addition, sex stereotyping is thought to be strongly influenced by the parents. With this as basis, and noting the comments and feelings of the pupils during the interviews conducted during the standard seven year, it was decided that the parents of the ten girls involved would be interviewed once the pupil interviews in standard eight had been completed. The parents were contacted telephonically and all were very happy to participate. They were all (to different degrees) aware of the research programme as it affected their daughters and readily consented to be interviewed. The interviews were conducted with both parents together as their interaction was of vital importance, and these took place in their own homes. They were usually about forty five minutes in duration, but were preceded and also followed by a lot of discussion. Before the interview began formally, the reasons behind the research programme were given by the writer (who conducted all the interviews) and a brief discussion followed in order to clarify any problems and to create the necessary atmosphere for the interview. All the interviews were recorded on audio tape and were transcribed later. The format was very similar to that used for the pupils' standard eight interviews which meant that it was of the focused type. Certain general areas were covered (see Appendix E2), but response is made and to detect and follow-up any unexpected comments that might be made. Explanations that are needed in terms of uncertainties on the part of the interviewees (and the interviewer for that matter) are of course possible with this method, but it certainly cannot be bettered in that it allows the interviewer to get at what a person's values and preferences are (likes or dislikes) and what his or her attitudes or beliefs are (Cohen and Manion, 1985). They also list four kinds of interview that can be used as research tools: the structured interview; the unstructured interview; the non-directive interview; and the focused interview. Two of these were used in the different phases (viz. the structured and focused interviews), but these will be explained in sections 5.6.2 and 5.6.3.

3.3 The Sample

Effectively there were two samples, with the sample for the longitudinal study being a sub-set of that for the cross-sectional attitude survey. These will be described here, but will be expanded upon in the sections which follow.

The universal sample consisted of all the pupils in standards six, seven and eight from eight schools. Four of these schools are in Port Elizabeth and four in East London. Port Elizabeth and East London are some 300 km apart and although differing in size are cities with similar industrial, commercial and socio-economic structures. By including schools from both of these cities it enabled any local effects to be observed and also allowed for a greater number of similar single-sex schools to be included. All of the schools are white government schools and have English as their medium of instruction. The pupils are drawn largely from the middle, but also the upper socio-economic groups and have similar language and cultural backgrounds. The numbers of questionnaires completed by the various groups are as follows:

TABLE 3.1

BREAKDOWN OF THE SAMPLE

		Standard					
		6		7		8	
	School	Boys	Girls	Boys	Girls	Boys	Girls
Port Elizabeth	1	88	63	68	79	78	79
	2	81	112	92	118	68	110
	3	-	110	-	110	-	118
	4	128	-	127	-	116	-
East London	5	85	104	66	120	67	103
	6	79	85	94	103	87	67
	7	-	102	-	131	-	118
	8	124	-	128	-	123	-
TOTALS		585 1161	576	575 1236 3531	661	539 1134	595

3.4 The Hard Facts

During 1987, the participating schools were requested to provide the numbers of girls and boys in standards eight, nine and ten who were taking mathematics and/or physical science. The standard eights and nines were the standard sevens and eights respectively of the previous year when the attitude survey was carried out. Table 3.2 (mathematics) and Table 3.3 (physical science) give the numbers and percentages of the girls and boys taking mathematics and physical science, as well as the ratios of the percentages of the numbers of boys to girls taking the subjects in standards eight, nine and ten.

TABLE 3.2

THE NUMBER OF BOYS AND GIRLS IN THE SURVEY SCHOOLS TAKING MATHEMATICS

	Number Taking mathematics		Number in standard		Percentage Taking mathematics		Percentage difference (B - G)	Ratio of percentages (B / G)
Std	Boys	Girls	Boys	Girls	Boys	Girls		
8	456	380	581	657	78,5	57,8	20,7	1,36
9	446	369	575	614	77,6	60,1	17,5	1,29
10	417	345	495	548	84,2	63,0	21,1	1,34

TABLE 3.3

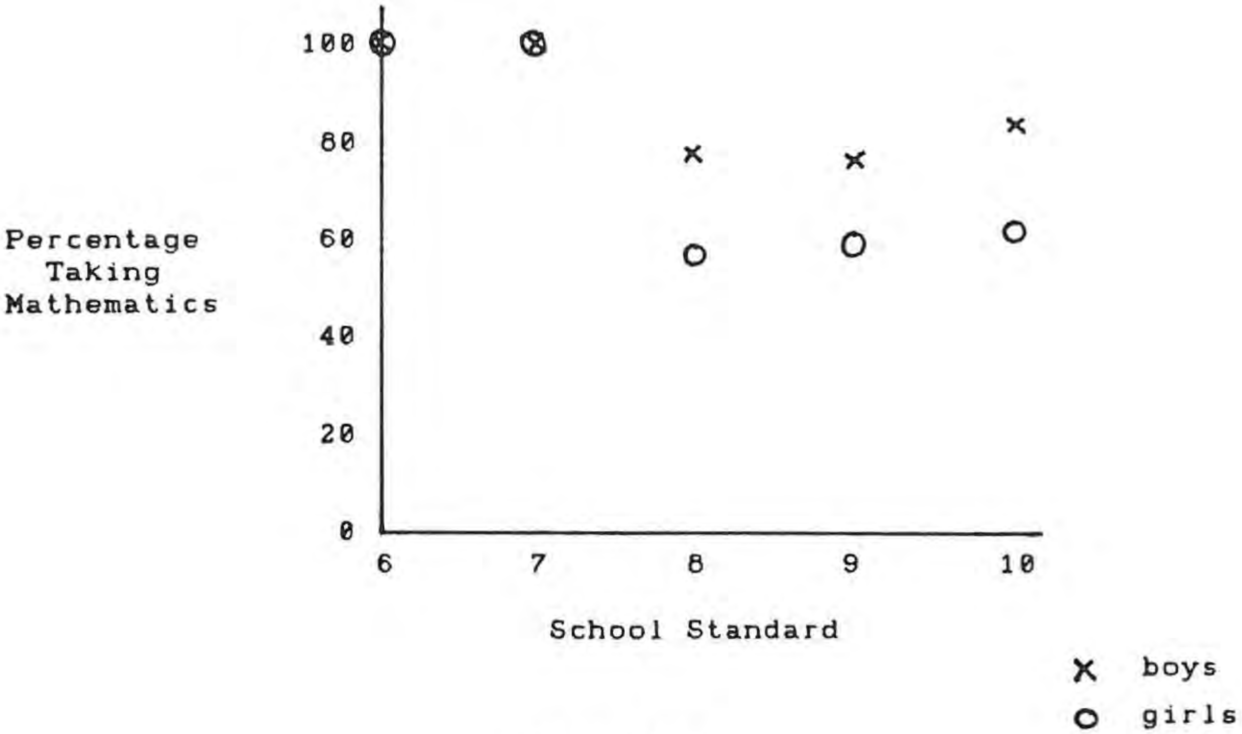
THE NUMBER OF BOYS AND GIRLS IN THE SURVEY SCHOOLS TAKING PHYSICAL SCIENCE

	No. Taking Physical Science		Number in standard		Percentage Taking Physic.Science		Percentage difference (B - G)	Ratio of percentages (B / G)
Std	Boys	Girls	Boys	Girls	Boys	Girls		
8	333	180	581	657	57,3	27,4	29,9	2,09
9	344	196	575	614	59,8	31,9	27,9	1,87
10	332	169	495	548	67,1	30,8	36,3	2,18

These numbers do not represent a longitudinal view of the situation in the three standards, but in fact a cross-sectional snapshot of the situation in 1987. The percentages of girls and boys taking mathematics and physical science over the three standards are very similar, and are in line with the data given in chapter one, in that they also reflect significant sex differences. By including all the girls and boys in the eight schools in the three standards, it can be seen from Table 3.2 that approximately twenty percent more boys than girls take mathematics, while for science (Table 3.3) the difference is roughly thirty percent. The above information is presented graphically in Graph 3.1 and Graph 3.2, making the differences in the drop-out rates between the sexes very obvious. (It must be remembered that it is not a logitudinal development that is presented in the graphs.)

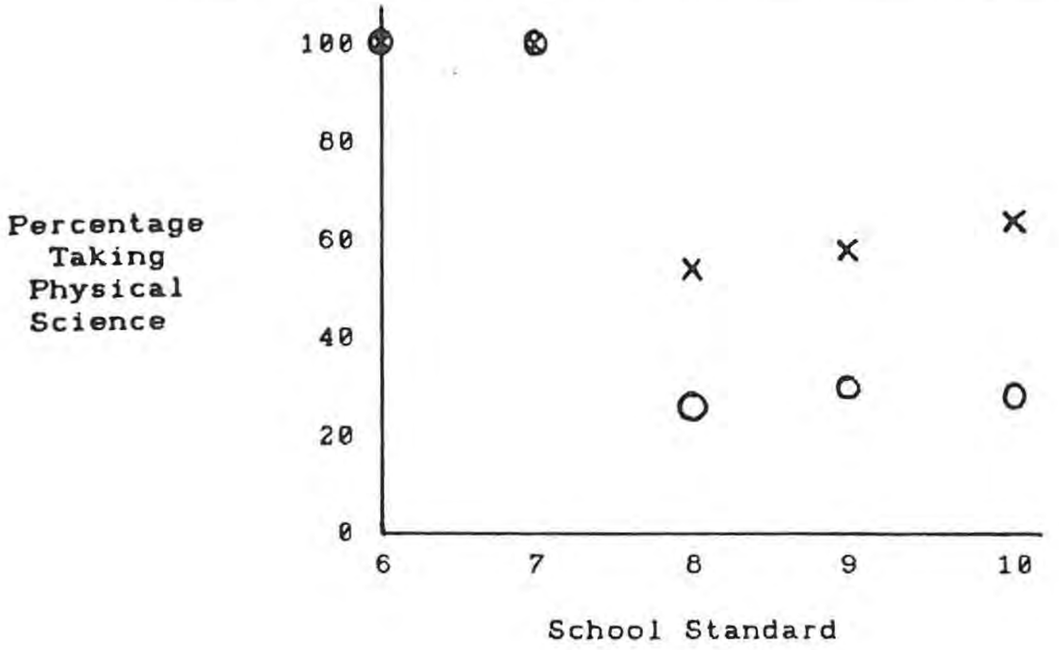
GRAPH 3.1

PERCENTAGES OF PUPILS TAKING MATHEMATICS



GRAPH 3.2

PERCENTAGES OF PUPILS TAKING PHYSICAL SCIENCE



A boy/girl ratio was calculated for the percentages of the boys and girls taking the two subjects rather than the numbers, because the total numbers of boys and girls in the various standards were not equal. These ratios are given in Table 3.2 (mathematics) and Table 3.3 (physical science). For the mathematics data these ratios were very similar to those calculated from the Cape Education Department statistics, while for the physical science data they were slightly better (approximately 2,0 compared to the 2,6 for the Cape data).

We see from the above information that the survey schools fit the pattern found in the rest of the country and indeed in other countries, and therefore any trends revealed by, or gathered from, the present study, might well be applicable further afield than the two regions to which this study was confined.

3.5 The Attitude Questionnaires

Two attitude questionnaires were administered to the entire sample given in Table 3.1. No standardised South African attitude tests for mathematics or physical science were available, so a modified version of the Riedesel Inventory of Children's Attitudes towards Mathematics (RICATM) was used (Riedesel and Burns, 1977). It is a Likert-type questionnaire and Light (1984) and Oberholster (1985) both used adapted versions for their investigations. The present study followed their line of omitting the *uncertain* option, leaving the pupils to choose from : *agree; strongly agree; disagree; strongly disagree*. This was done because the writer believes that the nature of the statements to which the pupils had to respond was such that it was advantageous to force them into polarising their ideas and not allowing them to avoid any issue. While it is obvious that there would have been some instances where there was some concern on the part of the subjects, it was felt that the advantages considerably outweighed any disadvantages. This specific aspect of the response sheet was dealt with in the pilot study and the subjects involved when questioned on this issue did not feel that it posed a real problem to them at all. The questionnaires consisted of fifty two statements about various aspects of mathematics (or physical science), approximately half of which were positive statements and the rest were negative statements.

In keeping with the studies of Light (1984) and Oberholster (1985) the 'agree' and 'strongly agree' responses were combined and for the purposes of the statistical analysis were taken as the same response. The same procedure was followed for 'disagree' and 'strongly disagree' responses. Obviously agreeing with positive statements was taken as a positive response as was disagreeing with negative statements. Agreeing with a negative statement and disagreeing with a positive statement were both taken as negative responses.

3.5.1 The Pilot Study

As mentioned above, the Riedesel Attitude Inventory measures attitudes towards mathematics, but for the present study only Part A was used. Light (1984) refined the questionnaire to make it more suitable for South African schools and it was used in this form by Oberholster (1985) as well. The writer felt though that some further minor changes were necessary. These were made and the questionnaire in its slightly revised form was then adapted for use as a physical science attitude questionnaire as well. This was done simply by replacing the word mathematics with the word science (explained to the testees as meaning physical science) wherever it appeared in the fifty two statements. Two of the statements needed very slight modification in order to make them relevant to physical science situations. These questionnaires were then administered to a pilot study group consisting of three classes, one each from standards six, seven and eight. The pupils were from a co-educational school of similar classification as the others, but were not used any further in the investigation. On the basis of comments either received or not received, no further amendments were deemed necessary. The final versions of the two questionnaires appear in Appendices B1 and B2.

3.5.2 Attitudes

When the fifty two statements of the attitude questionnaire are grouped in the arrangement as described by Riedesel and Burns (1977), they yield six separate categories of attitudes towards the relevant subject. These categories and the corresponding statements are as follows:

	Positive Statements	Negative Statements
Liking for the subject	8 22 25 42 49	12 27 29 33 45
Perceived Usefulness of the subject	4 15 26 28 37 50	19 23 31 39 44
Anxiety concerning the subject	3 10 24 35 48	18 32 40 46 52
Interest in the subject	5 16	9 21 41
Perceived Ability and Achievement in the subject	7 36 38 43 51	13 14 20 30 34 47
Understanding of the subject	6	17

These specific attitudes were then investigated and comparisons between the various groupings (sex, standard and type of school) provided the basis for the directions to be followed in the longitudinal study although this latter study did not confine itself to these areas.

3.5.3 Administering the Questionnaires

The testing was undertaken during the third quarter of 1986 and was conducted in varying group sizes according to the wishes of each school as well as the facilities that were available. The smallest groups were in fact single classes while the largest were complete standards. No problems were experienced in this connection at all. A set of instructions (Appendix A) was drawn up and used at each testing session, with particular importance being impressed upon them as far as honesty and the usefulness of their participation were concerned. From the pilot study and subsequent testing it was found that depending on the standard and ability of the pupils being tested, the time taken to complete both questionnaires varied between 12 and 28 minutes. The pupils having provided the information requested at the top of both questionnaires (date, standard and sex), merely had to respond to the fifty two statements in each of the two questionnaires by placing a tick in one of the four adjoining blocks which thus indicated their degree of agreement of disagreement with the statement. In addition, the standard eights indicated whether or not they were taking mathematics, physical science or biology. The questionnaires were checked and coded at a later stage. There were twelve which were discarded as they were either unclear or incomplete.

3.6 The Longitudinal Study

This aspect of the research was undertaken over a three-year period and a diminishing sub-group of the universal sample were the subjects involved. Essentially, the research was conducted on a personal interview basis, but each year was significantly different from the others so they will be discussed separately. The subjects were first involved in 1985 in their standard six year - their first year in high school. Some of them were then followed through into standard seven and some of these subsequently into standard eight - the year after their major subject choices were made. Although a general plan had been formulated as to the approach that would be followed, it transpired that this was merely to serve as a framework and a number of additional avenues were explored en route as well as some significant changes in approach being adopted.

3.6.1 Standard Six

In a longitudinal study, sample mortality can often present a major problem and in the present study this was even further highlighted by the nature of the information gathering (viz. personal interviews), and the fact that this necessitated a numerically smaller sample size. The problem was compounded by the need for there to be sufficient subjects in each of three categories by the time the sample group reached standard eight. These three categories were defined according to subject choice: those pupils who had opted for mathematics and physical science; those who had chosen to do mathematics only; and those who were doing neither of these two subjects.

All of these considerations, and the fact that in standard six subject choice is for almost all pupils something in the very distant future, it was decided not to conduct personal interviews in the first year, because this would almost certainly give rise to severe problems in the subsequent years of the longitudinal study - specifically in terms of the need for a well-balanced sample for the purposes of comparison. It was decided instead to substitute interviews in the standard six year with a questionnaire which would as effectively as possible provide all the information which would be required for the purposes of comparison in the following two years. It provided in addition much statistical information that would not have been possible if the interview technique had been employed. Further it was felt that the much broader base provided by this questionnaire would be a much better springboard for the research and the advantages would considerably outweigh the disadvantages. Accordingly a relatively large sample was possible and this was drawn from the standard sixes of three of the schools, all from the same town and all from the original sample. It consisted of all the girls from an all-girls' school, all the boys and girls from a co-educational school and three of the classes from another co-educational school. The breakdown was as follows:

TABLE 3.4

LONGITUDINAL STUDY - STANDARD SIX SAMPLE

School	Girls	Boys
1	90	76
2	38	34
3	120	-
Total	248	110

The reason for including more girls than boys was that the longitudinal study was effectively a study of the changes in attitude and the experiences of the <u>girls</u> and not the boys. The boys were included as a type of 'control' group and the girls were to be compared with them. This was because it was anticipated from previous research that the attitudes of the girls would change rather than the boys' and the reasons for these changes would be found in the girls' behaviour. Boys from an all-boys' school were not necessary to the investigation as the girls from the all-girls' school would be compared with the girls from the mixed schools.

The questionnaire was administered during the third quarter of 1985 (see Appendix C1) and consisted of ninety four questions which elicited, amongst other things: liking for and ranking of all subjects; attitudes (single questions); feelings about parents and teachers; percentages for mathematics, physical science and biology; thoughts about subject choice and possible careers; and also the sex appropriateness of mathematics, science and biology. The tests were administered to large groups of approximately fifty pupils, but the venues used were appropriate for the situation. Each pupil had a response sheet (see Appendix C2), the questions were displayed one at a time using an overhead projector and the relevant question was read aloud by the tester at the same time and explanations were given. Questions were permitted and were answered for the benefit of the whole group.

The information obtained by means of the questionnaire catered adequately for the purpose for which it was designed and enabled the selection of the sample for the second stage of the study to be carried out very effectively. However, it also permitted a substantial amount of statistical investigation which subsequently proved to be of great value as the study progressed.

3.6.2 Standard Seven

This second phase of the longitudinal study consisted of identifying the next division of the sample and then conducting personal interviews with the pupils involved. This was done at the beginning of the fourth quarter immediately after the pupils had selected their subjects for standard eight so that all their feelings regarding making their subject choice were fresh in their minds. Three groups of pupils had to be catered for and this purposive sample had to ensure sufficient numbers of those who had chosen mathematics and science, mathematics only, or neither of the two subjects. The pupils selected for this next stage were distributed as follows:

TABLE 3.5

LONGITUDINAL STUDY - STANDARD SEVEN SAMPLE

	Subjects Chosen							
	Mathematics & Science		Mathematics Only		Neither		Total	
School	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
1	8	6	5	5	5	10	18	21
2	4	3	3	3	3	3	10	9
3	-	6	-	5	-	9	-	20
Total	12	15	8	13	8	22	28	50

The interviews were conducted on a one-to-one basis and took place during the fourth quarter of the year. Each interview took approximately thirty minutes and followed a predetermined framework (see Appendix D1). This categorises it as a structured (or research) interview (Cohen and Manion, 1985), but because the writer conducted all the interviews himself, there was freedom to deviate from the set pattern and to delve into and clarify (in detail if necessary) issues that arose. Certain questions required structured or ranked responses, while other answers were more of the unstructured variety. Because there was prior knowledge of the interviewees in terms of the courses they had elected and information given in the questionnaire they had completed the previous year, parts of the interview fell into what Cohen and Manion (1985) refer to as a focused interview. Generally speaking though, the format was such that it allowed the best of both worlds: a rigid framework with flexibility at the disposal and under the control of the interviewer.

The information provided by the interviewees was recorded in two ways. All the structured and some of the unstructured responses were recorded in writing, but each interview was recorded on audio-tape. This was done so that firstly there would be a complete record of all the interviews, secondly so that transcriptions were possible and thirdly to utilise interview time more effectively.

Approximately one year had elapsed since information had last been obtained from these pupils and during this time many had formed, changed or consolidated their ideas and feelings about mathematics, physical science and their other subjects. This will of course, all be analysed in later sections, but what is of importance to this particular section is that there were such strong and consistent feelings about certain areas and issues that the writer decided to draw up what he has termed the 'post-interview questionnaire' and administer this to all the standard seven pupils in the three schools involved (see Appendix D2). The purpose of this was to gain more statistical evidence in certain areas which were indicated by responses made during the interviews (but not necessarily in the structured parts of the interview). Questions covered areas such as: reasons for taking/dropping mathematics or physical science; the so-called 'maleness' of mathematics and physical science; and some specific questions on electricity and chemistry. The pupils answered on a response sheet (see Appendix D3) and these results were analysed separately for all groups (viz. schools, sex and subject choice). The sample distribution was as follows:

TABLE 3.6

STANDARD SEVEN POST-INTERVIEW QUESTIONNAIRE

School	Boys	Girls	Total
1	68	86	154
2	68	96	164
3	-	110	110
Total	136	292	428

3.6.3 Standard Eight

3.6.3.1 The Pupils

The third phase of the longitudinal study saw a further decrease in the number of subjects, but a corresponding increase in the depth of the investigation. Only ten pupils were involved and these were all girls. Once again interviews were carried out, but they were of approximately fifty five minutes duration. A big difference compared to the standard seven interviews was that the format was much freer. It was much closer to the focused interview format, because at this stage a lot of information was available on each interviewee including their attitudes and opinions on many topics and subjects. There were certain areas which were covered in each interview (see Appendix E1), but there were also specific questions and/or probing of other domains which had arisen from information obtained in the standard six questionnaire or the standard seven interview. Only certain information was noted at the beginning of each interview and after this had been completed, an audio tape-recording was made of the remainder. No notes were taken, in order to ensure that the interview would be as flowing and continuous as possible and without interruptions. The interviewees were encouraged to be as 'chatty' as possible and this proved to be a successful as they offered information far more freely than before. However, it was almost certainly the different format which gave rise to this situation.

The girls chosen for this final stage were selected so that all three categories of course selection were covered (mathematics and science, mathematics only, neither of the two subjects), but also because comments they had made during the previous year's interviews were interesting and highlighted some directions that would be worthwhile probing and following up. The sample distribution was as follows:

TABLE 3.7

LONGITUDINAL STUDY - STANDARD EIGHT SAMPLE

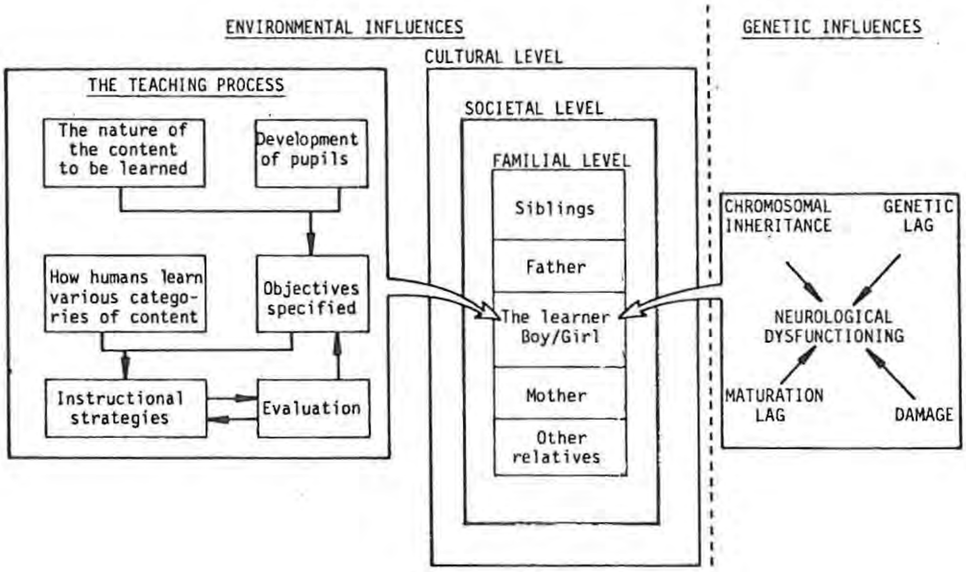
	Subjects Chosen		
School	Mathematics & Science	Mathematics Only	Neither
1	1	2	2
2	-	-	1
3	2	1	1
Total	3	3	4

3.6.3.2 The Parents

Success or failure in mathematics or physical science is the result of interrelationships between many factors. Heredity plays its part from the moment of conception and the environment from the time of birth. Noble (1986a) represented these factors by means of the following diagram (figure 3.1)

FIGURE 3.1

(Reproduced from Noble, 1986a)



This thesis is concerned with pupils at a stage when a child's development is being profoundly influenced by the teaching process (outlined in the left hand side of the diagram) as well as by the family, society and culture (shown in the middle) in which the child resides.

References have already been made to some of the adverse effects certain sex aspects of the teaching process can have and these will be discussed at various stages during the rest of the thesis. As far as the genetic influences (right hand side of diagram) are concerned, because there is nothing a child can do to select his or her parents, there is nothing that can be done about that aspect of the developmental process.

Referring to the middle section of the diagram, the pupils in this study could be considered to be part of a Western first-world culture with certain deficits such as a degree of isolation imposed by political factors and geographical distance, but with an advantage of having English as home language. The attitude of their particular sub-culture towards mathematics (and physical science) would be fairly specific aspects were discussed in each individual case and these depended on the earlier interviews conducted with their child. However, no discussion was pre-empted with any inkling of what their child had communicated in her own interviews and only rarely was any information in this regard offered by the interviewer. When this was in fact done, it was to facilitate further discussion which might otherwise not have transpired. Discussion was not confined to the daughter involved in the research, as the other siblings were involved as well. This proved to be particularly valuable in assessing individual differences, especially if there were sons in the family. The parents spoke freely and much valuable insight and information was gained. The impression was that they enjoyed the participation and felt they were making a contribution to the programme, but also that the activity was valuable to them as parents.

3.7 The Statistical Analysis

When rejecting a null hypothesis which is false, parametric tests are more powerful than their nonparametric counterparts, provided the tests are appropriate to the occasion in terms of the assumptions that need to be made. However, if these assumptions cannot be met confidently, the results would have little or no validity. In this study many different types of responses were elicited in the different questionnaires and in almost all of these the range of scores could not be considered to be producing true interval scales, and thus parametric tests were of doubtful use. According to Siegel (1956), "the power of any nonparametric test may be increased simply by increasing the size of N, and ... nonparametric tests deserve an increasingly prominent role in research in the behavioral sciences". The sample sizes in the present study were in fact large and with the overall sample size for the cross-sectional study in the order of three thousand five hundred pupils and with the smallest groups always greater than one hundred, the nonparametric chi-square test would appear to be entirely appropriate in investigating any differences that there might be between the frequencies of the discrete categories obtained from the numerous sub-groups represented in the sample. This meant, in addition, that the population distribution did not have to meet any specific conditions "as the accuracy of the probability statement does not depend on the shape of the population" (Siegel, 1956). The chi-square test was only used where the expected cell frequencies were large and any case the size of any sample was never less than forty which meant that there was really no need to consider the sizes of the cell frequencies for the 2 x 2 contingency tables. Where the number of degrees of freedom was greater than 1, the requirement of a maximum of 20% of the cells having frequencies of less than 5, was met. In fact it was not even necessary to combine any cell frequencies in order to meet this condition.

CHAPTER FOUR

THE MATHEMATICS ATTITUDE QUESTIONNAIRE

4.1 Some Earlier Research

As was mentioned before, this study emanated from a research programme of the Rhodes University Education Department and follows on from the work of Light (1984) and Oberholster (1985). Their research involved standards three, four and five (senior primary) for the former and standards six and seven (junior high) for the latter study (ages thus ranged from approximately ten years to fifteen years). It centred around a mathematics attitude questionnaire (Riedesel and Burns, 1977), but only the responses to the statements themselves were analysed and no second-order attitude scores were calculated by them from these responses. The present study commenced in fact, with an analysis of their data, but did not make use of their results as such. Second-order attitude factors were calculated from their data and these factors were then analysed. In accordance with the decision to use the chi-square statistic for the present study it was decided to use the same technique for these data in order to determine whether or not there were any statistical significant differences between various groupings from these samples. The results of these analyses are presented in the next two sections (4.1.1 and 4.1.2), but comment on them will be brief and reference will be made wherever necessary in later sections, in relation to the writer's own data and analyses. None of the results given in the following six tables were provided by the original researchers in their own theses, but were all calculated by the writer using their raw data.

4.1.1. The Primary School Study - Light

Data were gathered from six co-educational and three single-sex schools which provided a total sample of 963 boys and

1 006 girls. The majority of these schools are the main feeder schools for the four Port Elizabeth high schools used in the present study. The chi-square values and their significance and direction for various group comparisons, are given in the next three tables (Tables 4.1 to 4.3). The tables compare in turn, the following groups: the different sexes; types of schools (co-educational or single-sex); and standards.

4.1.1.1 Comparing the Sexes

TABLE 4.1

SEX DIFFERENCES IN MATHEMATICS ATTITUDES
(Chi-Square Values)

		Standard		
		3	4	5
Liking	A	78,06 *** B	71,99 *** B	50,06 *** B
	S	51,08 *** B	8,58 ** B	63,89 *** B
	C	42,85 *** B	75,77 *** B	8,21 ** B
Usefulness	A	17,54 *** B	0,04	9,85 ** B
	S	12,12 *** B	0,00	34,53 *** B
	C	9,93 ** B	0,15	0,20
Anxiety	A	61,30 *** G	32,82 *** G	52,73 *** G
	S	20,77 *** G	4,05 * G	51,23 *** G
	C	48,18 *** G	34,50 *** G	17,43 *** G
Interest	A	3,07	4,91 * B	40,59 *** B
	S	0,16	2,21	34,29 *** B
	C	4,14	3,34	13,94 *** B
Ability and Achievement	A	39,49 *** B	53,15 *** B	30,07 *** B
	S	33,23 *** B	0,55	30,73 *** B
	C	14,65 *** B	61,63 *** B	9,25 ** B
Understanding	A	17,37 *** B	10,24 ** B	0,92
	S	2,69	8,84 ** B	11,37 *** B
	C	17,02 *** B	3,26	0,39

df = 1

A = All - The whole group
S = Single-Sex schools
C = Co-Educational schools

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

B (boys) or G (girls) indicates which sex shows the greater level of that particular attitude.

There are several notable characteristics in Table 4.1 of which the first is the large number of highly significant differences between the sexes. When considering the results for the whole group (A), of the eighteen cells in the 3 x 6 matrix only three show no significance at all and these occur in each of the three standards and for three different attitudes so there is apparently no specific pattern of non-significance. The second aspect of note is that without exception, these differences all indicate more favourable attitudes by the boys. Note that the scores for *anxiety* show that girls are more anxious than boys, indicating a less favourable attitude by the girls. (Of the six attitudes generated by the questionnaire, only anxiety can be considered as a 'negative' attitude while the other five are all 'positive'.) A third characteristic is that there is little difference in the results for single-sex and co-educational schools (only five of the eighteen cells show differences), thus indicating that the sex differences are present in both types of schools. Of the six attitudes identified by the questionnaire, *interest in mathematics* shows the greatest equality, but a strong sex difference is evident at the standard five level. Three of the other attitudes show some hesitation in their predictions, but *liking* and *anxiety* show consistently strong differences in the feelings of both boys and girls.

4.1.1.2 Comparing Co-Educational and Single-Sex Schools

The information provided by the results in Table 4.2 is not nearly as decisive as the previous set which pointed to strong sex differences in the different standards. Remembering that Table 4.1 identified sex differences in both single-sex and co-educational schools, it is interesting to note here that out of the eighteen chi-square scores for the boys, twelve of them show significant differences between the two types of schools, while for the girls, eleven of them produced significant differences in attitude. Of the twelve differences for the boys, eleven of them show more positive attitudes for the all-boys' schools while only *ability and*

TABLE 4.2

DIFFERENCES IN MATHEMATICS ATTITUDES BETWEEN CO-EDUCATIONAL AND SINGLE-SEX SCHOOLS

(Chi-Square Values for Boys and Girls Separately)

		Standard		
		3	4	5
Boys	Liking	58,97 *** S	0,07	17,00 *** S
	Perceived Usefulness	26,20 *** S	10,20 ** S	17,72 *** S
	Anxiety	31,49 *** C	0,01	25,88 *** C
	Interest	1,46	1,08	9,19 ** S
	Ability and Achievement	16,97 *** S	38,27 *** C	2,22
	Understanding	4,33 * S	1,94	18,58 *** S
Girls	Liking	31,17 *** S	16,02 *** S	5,98 * C
	Perceived Usefulness	17,32 *** S	14,65 *** S	7,69 ** C
	Anxiety	43,94 *** C	7,41 ** C	0,60
	Interest	6,55 ** S	1,00	0,10
	Ability and Achievement	0,83	0,17	27,92 *** C
	Understanding	14,27 *** S	0,20	0,19

df = 1 *** significant at the 0,0001 level
** significant at the 0,01 level
* significant at the 0,05 level

S(single-sex) or C(co-educational) indicates which type of school shows the greater level of that particular attitude.

achievement for the standard four boys is contrary to this trend. Note that anxiety levels are higher for the boys from mixed schools (no significant difference for the standard fours though) which fits a general pattern of the boys from single-sex schools showing more positive attitudes towards mathematics in these top three standards of the primary school. There appears though, to be a discontinuity at the standard four level for the boys, as five of the six attitudes show significant differences for the standard three and standard five groups, but only one (excluding the non-conforming ability and achievement attitude) for the standard four group. While it is not the intention of this investigation to research the primary school standards, attitude patterns and changes at this stage of educational and general development will almost certainly affect later attitude formation and feelings towards subjects in the high school and it is necessary therefore to consider these fluctuations albeit briefly. Allied to this would be a consideration of Piaget's theory of cognitive development, where the change from the concrete operational to the formal operational stage is underway. The nature and content of mathematics syllabuses could thus have a major bearing on achievement and attitudes towards mathematics. With the imminent and actual onset of puberty combined with all of the above, a break in a pattern involving co-educational and single-sex schools is thus hardly surprising. In earlier investigations, Noble (1974) and Ilsley (1977) and then the comparison of these two (Noble and Ilsley, 1978), established relationships between certain personality factors and mathematical attainment (e.g. 'intelligence' and 'conscientiousness'), and that these relationships underwent sudden changes. These changes were in the form of breaks in the patterns of the correlation coefficients and occurred either during standard four or standard five. The reasons for these were not clear-cut, but some fifteen possible suggestions which included changes in teaching methods, teacher and parental expectations, pre-pubertal disruption and an increase in the order of mathematical difficulty, were made. Returning then to the disruption in the pattern for the boys, it is therefore not in the least surprising to have found this, in the light of this earlier research.

As far as the girls in the two types of schools are concerned there are also some confusing changes in attitude. As for the boys there is a strong indication of more positive attitudes in the single-sex schools for the standard three girls. Three of these attitudes (liking, usefulness and anxiety) still show highly significant differences, but for the others this is no longer evident. However, for the standard fives there is a further change in that there are now three chi-square scores at levels which indicate statistically significant differences between the types of schools, but it is now the girls from the mixed-schools who have the more positive attitudes. Whereas for the boys there was a change at standard four and then the attitudes reverted back to the standard three situation for the standard fives, the girls seem to show a gradual reversal of their feelings about mathematics. The girls from the co-educational schools become more positive in their attitudes towards mathematics at the expense of the girls from the all-girls' schools. This particular change should be easier to identify when analysing the differences between the standards for the various groups and will be looked at in the next section.

4.1.1.3 Comparing the Standards

The trend commented on in the previous section concerning the girls from the co-educational schools not showing a deterioration in attitude as the girls in the single-sex schools did, is borne out when Table 4.3 is consulted. Of the twelve cells in the table which deal with the girls from the mixed schools only one shows a negative change. This is *interest* for the girls in standards four and five and in fact is only significant at the 5% level. Three cells show positive changes in attitude and eight show no change at all. When these results are compared with the chi-square values for the all-girls' schools where eight of the twelve cells show negative changes in attitude, it can be seen that there is quite a large discrepancy between the girls in these two types of schools. The effect that these two sets of results have on the overall chi-square values is that mainly as a result of the girls from the single-sex schools, four of the six attitudes show strong differences in attitude, with the standard five girls having the less positive attitudes. The standard three and four girls with the exception of *usefulness* display no attitude differences at all.

As far as the boys are concerned, those in standard five in the co-educational schools have poorer attitudes towards mathematics than the boys in the lower standards. The boys from the single-sex schools show some differences between standards three and four and two positive differences for the standard fives over the standard four boys. Overall for the boys then there is not a great deal of change other than for

TABLE 4.3

DIFFERENCES IN THE MATHEMATICS ATTITUDES BETWEEN STANDARDS THREE, FOUR AND FIVE (Chi-Square Values for Boys and Girls Separately)

			Standards Compared					
			3 AND 4			4 AND 5		
Boys	Liking	A	3,93	*	3	19,17	***	4
		S	38,41	***	3	0,03		
		C	2,43			29,03	***	4
	Usefulness	A	0,67			4,82	*	5
		S	3,09			3,84	*	5
		C	0,02			1,85		
	Anxiety	A	11,91	***	4	0,32		
		S	30,46	***	4	8,39	**	4
		C	0,27			6,69	**	5
	Interest	A	0,03			0,19		
		S	0,05			2,24		
		C	0,00			0,23		
	Ability and Achievement	A	0,86			21,86	***	4
		S	41,77	***	3	0,00		
		C	11,37	***	4	32,01	***	4
	Understanding	A	0,52			2,57		
		S	0,85			1,77		
		C	0,08			6,11	*	4
Girls	Liking	A	1,69			11,27	***	4
		S	4,29	*	3	31,86	***	4
		C	0,22			0,14		
	Usefulness	A	13,57	***	4	1,48		
		S	3,47			19,05	***	4
		C	8,28	**	4	4,28	*	5
	Anxiety	A	1,23			5,91	*	5
		S	10,80	**	4	6,68	**	5
		C	0,48			0,99		
	Interest	A	0,33			15,56	***	4
		S	1,83			10,59	**	4
		C	0,03			5,80	*	4
	Ability and Achievement	A	2,39			16,81	***	4
		S	2,95			28,94	***	4
		C	0,37			0,74		
	Understanding	A	0,18			0,31		
		S	5,52	*	3	0,70		
		C	4,36	*	4	0,00		

df = 1

A = All - the whole group *** significant at the 0,001 level
S = Single-Sex schools ** significant at the 0,01 level
C = Co-Educational schools * significant at the 0,05 level
3 (Standard three) or 4 (Standard four) or 5 (Standard five) indicates which standard shows the greater level of that particular attitude.

liking for mathematics which falls away consistently from standard three through to standard five.

Considering the whole sample then, the changes from standard three through to standard five for the different groups are such that the sex differences reported in Table 4.1 are maintained consistently through the three standards and at consistently high levels of significance.

4.1.2 The Junior High School Study - Oberholster

Data were gathered from three co-educational and two single-sex schools which produced a total sample of 518 boys and 621 girls. With the exception of one of the co-educational schools, all the schools were also used in the present study. As for Light's primary school study the next three tables (Tables 4.4 to 4.6) will compare the sexes, different types of schools and the various standards.

4.1.2.1 Comparing the Sexes

When consulting Table 4.4 it is interesting to note that amongst the standard sixes there is total disagreement between the single-sex and co-educational schools as to any sex differences for the various attitudes towards mathematics. For the mixed schools it is the boys who show significantly more positive attitudes for five of the six groups (including anxiety), whereas it is the girls in the all-girls' school who have more positive feelings towards mathematics than do the boys from the all-boys' school. When all the standard six pupils are compared, the contrasting evidence of the two different types of schools resulted in there being only one attitude (perceived usefulness) which yielded a significant sex difference and a 'cancelling-out effect' occurred in the other five. (It should be noted that there were only two single-sex schools in the sample - one of each sex.)

TABLE 4.4

SEX DIFFERENES IN MATHEMATICS ATTITUDES
(Chi-Square Values)

		Standard					
		6			7		
Liking	A	0,00			67,95	***	B
	S	26,77	***	G	55,87	***	B
	C	18,10	***	B	20,13	***	B
Perceived Usefulness	A	9,83	**	B	67,75	***	B
	S	2,20			47,61	***	B
	C	6,32	*	B	24,27	***	B
Anxiety	A	3,52		G	87,02	***	G
	S	0,18			70,09	***	G
	C	6,38	*	G	26,28	***	G
Interest	A	0,00			21,51	***	B
	S	10,62	***	G	18,38	***	B
	C	7,67	**	B	5,95	*	B
Ability and Achievement	A	0,08			36,36	***	B
	S	14,93	***	G	49,77	***	B
	C	8,54	**	B	3,27		
Understanding	A	0,08			28,31	***	B
	S	1,71			18,03	***	B
	C	0,20			11,73	***	B

A = All - the whole group
S = Single-Sex schools
C = Co-Educational schools

df = 1
*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

B(boys) or G(girls) indicates which sex shows the greater level of that particular attitude.

These apparently divergent results will be dealt with in the next section when the two different types of schools will be compared directly. While the standard six evidence is contradictory, the standard sevens were definite, and at high levels of significance too, that the boys have much more positive attitudes than do the girls. Only one of the eighteen chi-square values is not significant and it would appear therefore that some dramatic differences existed between these two standards.

4.1.2.2 Comparing Co-Educational and Single-Sex Schools

TABLE 4.5

DIFFERENCES IN MATHEMATICS ATTITUDES BETWEEN CO-EDUCATIONAL AND SINGLE-SEX SCHOOLS

(Chi-Square Values for Boys and Girls Separately)

		Standard					
		6			7		
Boys	Liking	1,37			20,28	***	S
	Usefulness	7,71	**	S	20,59	***	S
	Anxiety	3,89	*	C	41,72	***	C
	Interest	0,02			5,73	*	S
	Ability & Achievement	0,34			36,73	***	S
	Understanding	1,89			8,84	**	S
Girls	Liking	70,86	***	S	0,16		
	Usefulness	15,73	***	S	2,37		
	Anxiety	26,07	***	C	4,58	*	C
	Interest	36,65	***	S	0,01		
	Ability & Achievement	58,24	***	S	0,02		
	Understanding	10,38	**	S	2,22		

df = 1 *** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

S(single-sex) or C(co-educational) indicates which type of school shows the greater level of that particular attitude.

In comparing the standard six boys from the co-educational schools with those from the all-boys' school (only one) and doing the same for the girls from these two types of schools, it can readily be seen that the boys have very similar attitudes towards mathematics in this standard whereas the girls from the all-girls' school (only one) have very much better attitudes towards the subject than do their co-educated counterparts. So great is the dichotomy in the girls' attitudes, that the somewhat unexpected results produced in Table 4.4 which showed sex-differences in opposite directions for the mixed and single-sex schools are possibly a little more understandable. The girls from the all-girls' schools had such strongly positive attitudes that they were greater than the boys from the all-boys' school, while the girls from the co-educational schools were very much less positive and thus relative to the boys from those schools displayed poorer attitudes.

The immediate reaction to this is probably that the single-sex schools involved are responsible for producing this somewhat unexpected result. Their teachers, the schools' attitude to the subject and the general educational ethos would all be factors, in fact all variables to do with the institutions themselves would be the explanatory factors. The obvious next step then is to look at the standard sevens. Table 4.5 indicates a complete turnabout, with the boys from the all-boys' school showing decidedly more positive attitudes than their co-educated counterparts and the girls from the two types of schools now not differing at all. From this, three conclusions can be drawn. Firstly it is possible that the samples are not adequately representative. Secondly, the influence of the schools is not as causative as was proposed, but even this is still possible if the third option, that a dramatic change in attitude has occurred between standard six and seven for the boys and girls from the single-sex schools, is considered. While the first two of these suggestions can only be speculated upon, the last can be looked at with more certainty as the data can be analysed accordingly.

4.1.2.3 Comparing the Standards

Analysis of the differences in attitude that exist between the standard six and seven pupils in fact is in accordance with the conclusion drawn at the end of the previous section.

The boys from the all-boys' school show a gain in their positive attitude towards mathematics while the boys from the mixed schools show a falling off (fairly weak though) in three of the attitude categories. Considering the whole sample, there is no difference in attitude between the boys in standard six and those in standard seven.

TABLE 4.6

DIFFERENCES IN MATHEMATICS ATTITUDES BETWEEN STANDARD SIX AND SEVEN (Chi-Square Values for Boys and Girls Separately)

		Boys			Girls		
Liking	A	0,03			74,97	***	6
	S	11,26	***	7	93,15	***	6
	C	5,91	*	6	7,77	**	6
Usefulness	A	4,58	*	6	63,88	***	6
	S	0,01			38,53	***	6
	C	4,46	*	6	23,26	***	6
Anxiety	A	0,01			67,35	***	7
	S	9,31	**	6	42,74	***	7
	C	3,32			21,93	***	7
Interest	A	0,06			21,44	***	6
	S	2,73			36,24	***	6
	C	0,88			0,32		
Ability & Achievement	A	0,15			50,94	***	6
	S	9,28	**	7	66,71	***	6
	C	7,14	**	6	3,01		
Understanding	A	2,59			18,90	***	6
	S	5,47	*		12,91	***	6
	C	0,40			5,88	*	6

df = 1

A = All - whole group
S = Single-Sex Schools
C = Co-Educational Schools

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

6(standard six) or 7(standard seven) indicates which standard shows the greater level of that particular attitude.

It is amongst the girls though where the drastic changes in attitude are to be found. Those from the all-girls' school produce extremely large significant differences in attitude showing a dramatic drop from standard six to standard seven while the girls from the co-educational schools showed a definite, but more moderate change.

Overall then there would appear to be a general falling off of attitudes from standard six to standard seven, but the boys and girls from the two single-sex schools are at the two extremes of this trend, with the girls showing a strong negative trend, while the boys in fact change very slightly in the positive direction.

4.1.3 From Standard Three to Standard Seven

While much statistical evidence has been presented in the previous sections, some of which would at face value seem contradictory, there is no doubt that there are certain strong indicators present. While the two studies discussed have disjoint samples in terms of towns, standards and pupils, they are drawn from essentially similar populations and there are nevertheless some conclusions that can be drawn from them. Strong sex differences in mathematics attitude are present and these point virtually entirely to boys having statistically significant better attitudes than girls at all stages. Also there would seem to be an indication that pupils in single-sex schools have more positive attitudes than do the pupils in co-educational schools. Finally it is apparent that in various standards, differences in attitude could well be present, but in general the strengths of positive attitudes probably decrease as the pupils get older and progress through the school system. Girls, however, appear to show a more definite downward trend in their attitudes towards mathematics than do the boys and in particular at the standard six and seven levels (ages ranging from thirteen to fifteen). All of this points to further investigation being necessary and in particular to a longitudinal study covering the junior high school standards.

4.2 The Present Study

On the basis of the evidence presented by the two studies discussed in section 4.1, the cross-sectional study by the writer was undertaken using a similar mathematics questionnaire (as described in section 3.5) and with the sample of 3 531 pupils (as described in section 3.3). The second-order attitudes generated by the pupil responses to the fifty two statements about mathematics, were then compared in no less than 636 different combinations. These different groups were obtained by sub-dividing the total sample in terms of the following variables: town in which school is situated; type of school (single-sex or co-educational); standard; sex of respondent; and whether or not they take mathematics (standard eights only). On the basis of previous research, differences in attitudes were investigated in the following areas: sex; type of school; and standard. In order to compare these frequencies to ascertain whether or not there were any that were statistically different, the chi-square test was used for the reasons given in section 3.7. These being 2 x 2 tables thus produced, the calculation of the chi-square value was a relatively simple task. The results of these comparisons are presented in the following five sections, but in order to improve the clarity and interpretation of the relevant tables, the chi-square values themselves have been omitted and only the levels of significance (where applicable) and the direction of the difference have been shown. The full tables with chi-square values are, however, given in Appendix F.

4.2.1 Comparing the Two Geographical Regions of the Sample

There were three reasons for drawing the sample from the two separate geographical regions. Firstly, the possibility of any local phenomena being responsible for any findings would be reduced. Secondly, the two studies mentioned in section 4.1 were drawn from these two towns and comparisons between the present study and those two would then be more meaningful. Thirdly, the number of similar single-sex schools is limited to one all-boys' school and one all-girls' school in each of the two towns and thus by using the two towns, the sample size involving single-sex schools was doubled making it more representative of single-sex schools.

Table 4.7 contains the statistically significant results of the comparisons between the two towns for all six attitudes and for the various groupings of single-sex and co-educational schools.

TABLE 4.7

A COMPARISON OF MATHEMATICS ATTITUDES BETWEEN THE TWO TOWNS (Statistical Significance and Directions of Differences)

			Attitude					
Sex	Groups	Std	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	All	6	* EL					
		7						
		8	*** EL			*** EL		
	S-S	6	*** EL		*** PE		*** EL	
		7		*** PE				
		8	*** EL			** EL		
	Co-Ed	6			*** EL		*** PE	
		7		*** EL				
		8	*** EL			*** EL		
Girls	All	6	*** EL		*** PE	*** EL	*** EL	
		7	*** EL					
		8					*** PE	
	S-S	6	*** EL		*** PE		** EL	*** EL
		7				** PE		
		8	*** PE		*** EL	** PE	*** PE	
	Co-Ed	6	*** EL		** PE	*** EL		
		7	*** EL			*** EL		
		8	*** EL					

S-S = Single-Sex Schools
Co-Ed = Co-Educational Schools

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

PE = Port Elizabeth (pupils have the higher level of that attitude)
EL = East London (pupils have the higher level of that attitude)

For the eighteen comparisons (six attitudes for three standards) involving all the boys, only three show a difference between the two towns. These three (one of them rejected only at the 5% level) all show better attitudes for East London boys, but it seems reasonable to assume that there is not a great deal of difference between the two samples over the entire range of attitudes and standards. On analysing the types of schools (single-sex or co-educational) separately though, a greater number of differences is evident. For the single-sex schools, five of the six comparisons show the East London school having better attitudes. In terms of the overall sample though it must be realized that this was a comparison between two schools only, and to find so few differences between the two is perhaps the more surprising result. With the boys from the four co-educational schools there are five differences, but three of them favour the East London boys and two the Port Elizabeth boys. It must be remembered that *anxiety* is a 'negative' attitude and in this instance the East London standard six boys show higher anxiety and thus the Port Elizabeth boys therefore have the more favourable attitude in this respect.

For the girls it is the co-educational schools which show a greater number of differences (mostly the categories of *liking* and *interest*) and once again the East London schools are more positive in their feelings. For the girls in the two all-girls' schools, there are nine differences, but these are split five-four in the towns that have the stronger attitudes, so there is no discernable trend at all. Overall there are six differences out of eighteen categories (five favouring the East London schools), so there seems to be slight trend which is indicated. The standard sixes are responsible for four of these so there does seem to be a difference as far as they are concerned, but not for the standard sevens and eights.

Considering the entire sample, the idea to include pupils from two separate towns would appear to have been a good one as in the vast majority of cases there have been no differences at all. However, where there have been some, due possibly to the small number of single-sex schools, the doubling of the number of schools (and hence pupils) has tended to balance out any local phenomena which may or may not be present. Consequently all analyses will, in terms of the hypotheses put forward, include the pupils from both towns as this will be more meaningful in terms of sample size (especially for the single-sex schools). However, separate statistics for the two towns will be given in Appendix F1 for all of the comparisons done. This will enable explanations of results to be undertaken (where necessary), but not specifically to compare the two towns. Hypotheses will therefore NOT be advanced for the different towns, but only for the sample as a whole.

4.2.2 Comparing the Sexes

In this section comparisons will be made between the sexes, but they will be done in standards and also for the two different types of school (single-sex and co-educational). The null hypothesis to be tested is:
there is no difference in attitudes towards mathematics between the sexes.

This hypothesis will be tested in the following groups:

in standards (a) standard six
(b) standard seven
(c) standard eight

and for each of these standards;

in type of school (i) all schools
(ii) single-sex schools
(iii) co-educational schools.

This means that nine hypotheses were tested, but each one for each of the six attitudes generated by the mathematics questionnaire. The nine hypotheses (all hypothesising NO differences between the sexes) are presented in the nine rows of Table 4.8 and are numbered as follows:

Hypothesis	Type of School	Standard
1	all schools	6
2	all schools	7
3	all schools	8
4	single-sex	6
5	single-sex	7
6	single-sex	8
7	co-educational	6
8	co-educational	7
9	co-educational	8

TABLE 4.8

SEX DIFFERENCES IN MATHEMATICS ATTITUDES
(Statistical Significance and Directions of Differences)

			Attitude					
Hypo-thesis	Groups	Std	Liking	Useful-ness	Anxiety	Interest	Ability & Ach.	Under-standing
1	All	6	*** B	*** B	*** G	*** B	*** B	*** B
2		7	*** B	*** B	*** G	** B	*** B	*** B
3		8	*** B	*** B	*** G	*** B	*** B	*** B
4	S-S	6	** B	*** B	*** G	** B	* B	
5		7	* B	* B	*** G			
6		8	*** B	*** B	*** G	** B	*** B	*** B
7	Co-Ed	6	*** B	*** B	*** G	*** B	*** B	*** B
8		7		*** B	*** G	** B	*** B	*** B
9		8	*** B	*** B	*** G	* B	*** B	** B

B = Boys have the higher level of that attitude
G = Girls have the higher level of that attitude
S-S = Single Sex Schools
Co-Ed = Co-Educational Schools

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

Considering the nine null hypotheses for each of the six attitudes, the following results are obtained from Table 4.8:

39 are rejected at the 0,1% level all in favour of the boys
6 are rejected at the 1% level all in favour of the boys
4 are rejected at the 5% level, 2 in favour of boys and
2 in favour of the girls
5 are accepted as showing no sex differences.

These statistics provide extremely strong evidence for sex differences in virtually all standards and for all attitudes. Perhaps the most remarkable aspect of Table 4.8 is the set of results where the boys and girls from the entire sample are compared (hypotheses 1, 2 and 3). Without exception, every single null hypothesis is rejected with strong confidence. Only one (standard eight interest in mathematics) is rejected at the 1% level and all seventeen others are rejected at the 0,1% level of confidence. In addition, all of them show that the boys have more favourable attitudes than do the girls, including *anxiety* which shows the girls as being more anxious than the boys. (Note that *anxiety* is considered to be a negative attitude.) This is a staggering result and it leaves no doubt that for the mathematics attitudes as measured by this questionnaire there are strong sex differences which require further investigation. On consulting the literature, these findings seem to be very much in line with previous research.

Maccoby and Jacklin (1975), Fennema and Sherman (1977), Betz (1978), Fox et al (1979), Fennema (1979, 1983), Visser (1985a) and Kelly and Tomhave (1985) all obtained evidence indicating that girls generally showed higher levels of anxiety than did boys.

Liking for mathematics did not really yield any sex differences, except for Preece (1979) who established that "liking cannot in general be predicted by success for the girls".

As far as interest was concerned, Hilton and Berglund (1974) established increasing sex differences as did the Assessment of Performance Unit (A.P.U. 1981b).

Sex differences in the perceived usefulness of mathematics were established in many studies such as Hilton and Berglund (1974), Fennema and Sherman (1977), Sherman (1979) and Sherman (1983). However, the A.P.U. (1981b), Pedro et al (1981) and Kempa and McGough (1977) reported specifically that no sex differences were evident in their investigations.

The other six hypotheses concern themselves with any possible sex differences within the single-sex and co-educational schools themselves. There is a measure of uncertainty amongst the standard seven boys and girls from the single-sex schools and only *anxiety* shows strong sex differences. The null hypotheses for *liking* and *perceived usefulness* are only rejected at the 5% level and the other three are not rejected at all. With the standard sixes being more demonstrative as far as sex differences are concerned and the standard eights being quite clear in all six attitudes, it would seem there is a possibility that from standard six to seven to eight some fluctuations in attitudes might be indicated for the single-sex schools. There is no point in speculating about this at this stage. Comment will be reserved until Section 4.2.4, and until the longitudinal study, where the pupils in the different standards will be compared with each other.

It would be noted that in terms of the overall study (including the longitudinal one) the first three attitudes in each table are considered to be the more important (liking, perceived usefulness and anxiety), while the other three are relevant, but of lesser importance. More importance can be attached to these three attitudes in view of the emphasis placed upon them in the literature reviewed. For these three attitudes there is very much less of a fluctuation between the standards, but nevertheless the standard seven sex differences are highlighted, but with less statistical confidence.

Moving on to the pupils in the co-educational schools there is only one cell which shows no significant difference between the sexes and one that rejects the null hypothesis at the 5% level. All the other sixteen are rejected with some considerable confidence and in all cases it is the boys who demonstrate the more favourable (positive) attitudes.

All the above evidence leaves no doubt that sex differences in mathematics attitudes exist in standards six, seven and eight and in single-sex and co-educational schools as well. These differences need to be explained, but to do so in isolation would be unwise as there are many other factors in the educational structure which might exhibit (or give rise to) differences as well. The variations in the results for the single-sex and co-educational schools shown in Table 4.8 and the chi-square values for these and all the inter-town sub-groups (given in Appendix F2) point to the need to look more closely at what effect 'type of school' has on attitudes towards mathematics and also whether or not there are differences in attitudes between the standards.

4.2.3 Comparing Co-Educational and Single-Sex Schools

In this section comparisons will be made between the different types of schools (single-sex and co-educational) and will be done in standards and separately for boys and girls as well.

The null hypothesis to be tested is:
there is no difference in attitudes towards mathematics between pupils in single-sex and co-educational schools.

This hypothesis will be tested in the following groups:

in standards (a) standard six
(b) standard seven
(c) standard eight
and for each of these standards;
for the different sexes (i) all pupils
(ii) boys only
(iii) girls only.

This means that nine hypotheses were tested, but each one for each of the six attitudes. The nine hypotheses (all hypothesising no differences between the two types of schools) are presented in the nine rows of Table 4.9 and are numbered as follows:

Hypothesis	Sex	Standard
10	all pupils	6
11	all pupils	7
12	all pupils	8
13	boys only	6
14	boys only	7
15	boys only	8
16	girls only	6
17	girls only	7
18	girls only	8

TABLE 4.9

DIFFERENCES IN MATHEMATICS ATTITUDES BETWEEN CO-EDUCATIONAL AND SINGLE-SEX SCHOOLS
(Statistical Significance and Directions of Differences)

			Attitude					
Hypothesis	Groups	Std	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
10	All	6	*** S	*** S	*** C	*** S	*** S	*** S
11		7	*** S	*** S	*** C	*** S	*** S	*** S
12		8	** S	*** S	*** C	** S	*** S	*** S
13	Boys	6	*** S	*** S	*** C	*** S	*** S	* S
14		7	** S	*** S	*** C		*** S	** S
15		8	*** S	*** S	*** C	** S	*** S	*** S
16	Girls	6	*** S	*** S	*** C	*** S	*** S	*** S
17		7	*** S	*** S	*** C	*** S	*** S	*** S
18		8		*** S			*** S	

S = Single-Sex Schools have the higher level of that attitude
C = Co-Educational Schools have the higher level of that attitude

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

Considering the nine null hypotheses for each of the six attitudes, the following results are obtained from Table 4.9:

43 are rejected at the 0,1% level in favour of single-sex schools
5 are rejected at the 1% level in favour of single-sex schools
1 is rejected at the 5% level in favour of single-sex schools
5 are accepted as showing no differences between the types of schools.

Once again extremely strong and clear-cut evidence is presented, but this time it is that the attitudes towards mathematics of pupils in single-sex schools differ markedly from those pupils in co-educational schools. When hypotheses 10, 11 and 12 in Table 4.9 are examined (these for all the pupils in all three standards and for all six attitudes), sixteen of the hypotheses are rejected at better than the 0,1% level of confidence and the other two at better than the 1% level. All of these show better attitudes by the single-sex school pupils as do all the comparisons for the boys and girls separately. When the boys are analysed separately only one cell (standard seven boys' interest in mathematics) shows no difference between the two types of schools while for the girls there are four cells of non-significant difference and all of these for the standard eights. While the boys therefore show remarkable consistency, the girls seem to undergo a change when in (or going into) standard eight. It cannot be determined from <u>these</u> results whether or not it is the single-sex or the co-educational pupils (or both types) who have changed their attitudes and this aspect can only be examined by comparing the standard seven and eight girls in the two types of schools separately. This will be done in the next section (Section 4.2.4).

In summary then, it is obvious that very strong significant differences in mathematics attitude (as measured by this questionnaire) exist between the pupils in single-sex and co-educational schools. The all-boys' and all-girls' schools produce more favourable attitudes than do the co-educational schools, with only the standard eight girls being an exception to this.

The literature reveals that in some studies, girls in mixed schools had poorer attitudes than did girls in single-sex schools (Dale 1974; Taylor,1979; Smithers and Collings, 1981 and 1982; Harvey,1984). Ormerod (1975 and 1981a) and Lee and Bryk (1986) established this as well, but they found that these differences exist not only for girls, but for boys too.

If the information from this section is combined with that from the previous section it produces the following:

1. There are differences in mathematics attitudes between pupils in single-sex and pupils in co-educational schools;

2. There are differences in mathematics attitudes between the sexes in all groupings of pupils.

The interesting conclusion to be drawn here is that even though girls from all-girls' schools have better attitudes towards mathematics than do the girls from mixed schools, they still have poorer attitudes than do their male counterparts in the all-boys' schools. Very broadly speaking then, boys and girls in 'similar' academic environments have different attitudes towards mathematics even though they might differ from their own sex in different types of schools.

4.2.4 Comparing the Standards

In this section comparisons will be made between the various standards. Standard six will be compared with standard seven, and standard seven with standard eight. The comparisons will be done separately for boys and girls and also for the two different types of schools. It seems to be a natural progression to look for any differences in this area, but in section 4.2.2 comment was made on the fluctuating sex differences between the three standards as there appeared to be a discontinuity in the trend of attitudes, particularly amongst the standard seven boys and girls from the single-sex schools.

The null hypothesis to be tested is:
there is no difference in attitudes towards mathematics between pupils in the three standards.

This hypothesis will be tested in the following groups:

in types of school (a) all schools
(b) single-sex schools
(c) co-educational schools
and for each of these groupings;
for the different sexes (i) boys only
(ii) girls only

and for the transition between;

(1) standards six and seven
(2) standards seven and eight.

This means that twelve hypotheses were tested, but each one for each of the six attitudes. The twelve hypotheses (all hypothesising no differences between the standards) are presented in the twelve rows of Table 4.10 (Parts A and B) and are numbered as follows:

Hypothesis	Transition	Sex	Type of School
19	6 to 7	boys only	all schools
20	6 to 7	boys only	single-sex
21	6 to 7	boys only	co-educational
22	6 to 7	girls only	all schools
23	6 to 7	girls only	single-sex
24	6 to 7	girls only	co-educational
25	7 to 8	boys only	all schools
26	7 to 8	boys only	single-sex
27	7 to 8	boys only	co-educational
28	7 to 8	girls only	all schools
29	7 to 8	girls only	single-sex
30	7 to 8	girls only	co-educational

Considering the six null hypotheses from Part A of Table 4.10 for each of the six attitudes, the following results are obtained:

9 are rejected at the 0,1% level in favour of standard six
2 are rejected at the 1% level in favour of standard seven
2 are rejected at the 1% level in favour of standard six
2 are rejected at the 5% level in favour of standard six
21 are accepted as showing no difference between standards six and seven.

Considering this breakdown and consulting the table (Table 4.10 Part A) it would appear that there is very limited support for any differences between these two standards. However, the *perceived usefulness* of mathematics is supported by the standard six pupils in all six of the groups. The implication of this is that the standard sevens as a whole, show a markedly poorer attitude towards the usefulness of the subject than do the standard sixes. The same cannot be said for the other attitudes, except for the boys, where *liking* and *interest* are also singled out as showing a negative change from standard six to standard seven. Because of the stronger feelings of the standard seven girls from the co-educational schools about their *ability and achievement* in mathematics the overall sample of girls shows a more positive attitude by the standard seven girls than the standard six girls. This particular result is contrary to the overall trend even though the overall trend is weak and (apart from the perceived usefulness of the subject) not supported generally. The null hypotheses for *perceived usefulness* are thus rejected with confidence while the others which show chi-square values indicative of differences are not very convincing in their indications.

Turning to Part B of Table 4.10 (standard seven compared with standard eight) the comments on the six null hypotheses for each of the six attitudes are as follows:

23 are rejected at the 0,1% level in favour of the standard sevens
4 are rejected at the 1% level in favour of the standard sevens
4 are rejected at the 5% level in favour of the standard sevens
5 are accepted as showing no differences between the standard sevens and eights.

A convincing difference in attitudes exists for these two standards and in favour of the standard sevens. Considering the entire group of boys and also all the girls, the results show, without exception, that the hypotheses can be rejected with considerable confidence. The exceptions to this strong trend are the all-boys' schools and the girls in the co-educational schools, where especially for the boys there is only one strong significant difference (liking) for the six attitudes. Overall, though, there can be no doubt in the trend of differences in attitude.

TABLE 4.10

DIFFERENCES IN MATHEMATICS ATTITUDES BETWEEN STANDARDS SIX, SEVEN AND EIGHT
(Statistical Significance and Directions of Differences)

Part A: Standard Six and Seven

			Attitude					
Sex	Hypothesis	Groups	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	19	All	** 6	*** 6		*** 6		
	20	S-S	*** 6	*** 6	* 7	*** 6		
	21	Co-Ed		*** 6				
Girls	22	All		*** 6			** 7	
	23	S-S	* 6	** 6	*** 7			
	24	Co-Ed		*** 6			** 7	

Part B: Standards Seven and Eight

			Attitude					
Sex	Hypothesis	Groups	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	25	All	*** 7	*** 7	*** 8	** 7	*** 7	*** 7
	26	S-S	*** 7		* 8		*	
	27	Co-Ed	*** 7	*** 7	*** 8	* 7	*** 7	** 7
Girls	28	All	*** 7	*** 7	*** 8	*** 7	*** 7	*** 7
	29	S-S	*** 7	*** 7	*** 8	*** 7	*** 7	*** 7
	30	Co-Ed		** 7		* 7	*** 7	** 7

S-S = Single-Sex Schools only
Co-Ed = Co-Educational schools only

6 = Standard sixes have the higher level of that attitude
7 = Standard sevens have the higher level of that attitude
8 = Standard eights have the higher level of that attitude

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

A comparison between these results and those of Oberholster (1985) is necessary at this stage. Oberholster only obtained data for standards six and seven and when these were analysed (in Section 4.1.2.3) for any differences between the two standards they revealed few differences for the boys, but clear-cut differences for the girls. For the boys these results coincide with those of the present study (including the fact that perceived usefulness was the only attitude which showed a change), but there is not the same agreement for the girls. In her study it was the all-girls' school which was largely responsible for the drastic differences, but nevertheless some speculation is necessary.

In the present study there is to a limited extent, a similar trend to that of Oberholster's study for the girls when the single-sex and co-educational schools are combined. These come about though through a dove-tailing of the results of these two different types of schools. (This can be seen in Appendix F4). The East London all-boys' school and the Port Elizabeth co-educational schools also display similar trends and the viewpoint that sample size in terms of the number of different schools (but not the number of pupils) is almost certainly producing this effect in the present study and was responsible for the effect in Oberholster's study, seems reasonable. The fact that in the present study, drastic differences were in evidence between standards seven and eight, simply points to the conclusion that between standards <u>six and eight</u> there are likely to be significant changes in the attitudes of both boys <u>and</u> girls towards mathematics. This in itself is sufficient speculation with the information that is available, and it should be the longitudinal study that should produce the finer details of this hypothesis, if indeed they are able to be 'teased out'.

The decline in the attitudes of boys and girls towards mathematics over the three-year span is thus strongly evident, but it must be borne in mind that this takes place while the differences between the sexes are still evident and with the single-sex and co-educational schools play their part as well.

The literature shows similar declines in various attitudes as follows:

Liking:	Hadden and Johnstone (1982. 1983a, 1983b).
Interest:	Hadden and Johnstone (1982, 1983a, 1983b) and Hilton and Berglund (1974).
Perceived Usefulness:	A.P.U. (1981b) and Sherman (1980).

It is noteworthy though that very few longitudinal studies seem to have been conducted and consequently the information on age trends is scarce.

4.2.5 Those That Take Mathematics and Those That Don't

4.2.5.1 Breakdown of the Standard Eight Sample

The distribution of the standard eight pupils either taking or not taking mathematics, is given in Table 4.11. This is not given in order to make any comparisons between the groups, but to support comparisons and conclusions that are made in the rest of this section.

TABLE 4.11

STANDARD EIGHT PUPILS IN THE SAMPLE WHO TAKE MATHEMATICS

Type of School	Sex	Number Taking Mathematics	Number NOT Taking Mathematics	Total in Standard 8
Co-Educational	Boys Girls	220 219	80 138	300 357
Single-Sex	Boys Girls	226 155	13 80	239 235
All	Boys Girls	446 374	93 218	539 592

4.2.5.2 Comparing Those Who Take and Those Who Don't Take Mathematics

In the previous section, reference was made to the fact that there were much bigger differences in attitudes towards mathematics, between the standard sevens and eights than there were between the standard sixes and sevens. The testing was done during the third quarter of the year before the standard sevens had made their subject choice for the senior secondary course and it could well be that their attitudes changed drastically over the last few months of the year once they had made their choices. These changes might well have been in accordance with their decision about taking or not taking mathematics, or if the changes had occurred before the choices had been made (during the final weeks of deliberation), they could have influenced their subject choices accordingly.

In order to gain further insight into the attitudes of the standard eights, it was decided to separate them into two groups viz. those who were taking mathematics and those who were not. Table 4.12 compares these two groups of boys and girls separately with the null hypothesis
there is no difference in attitudes towards mathematics between pupils in standard eight who take mathematics and those who don't take mathematics.
This means that two hypotheses were tested, but each one for each of the six attitudes. These are presented in Table 4.12 and are numbered as follows:

Hypothesis	Sex
31	Boys
32	Girls

As is to be expected for these two groups, the null hypothesis is rejected at better than the 0,1% level of confidence for both the boys and the girls for all six attitudes. All the differences are in favour of those who are continuing with mathematics and suggest therefore that choosing to continue with the subject in standard eight must be strongly related to the feelings a pupil has towards mathematics. The six attitudes represent very varied aspects of a pupil's make-up, but it is nevertheless not surprising that those who have 'dropped-out', like the subject a lot less, see it as being less useful, find it less interesting and don't think that they have the same ability or understanding as those who continue with mathematics. The one attitude worth singling out though is that of *anxiety*.

TABLE 4.12

DIFFERENCES IN MATHEMATICS ATTITUDES BETWEEN THOSE STANDARD EIGHTS WHO TAKE MATHEMATICS AND THOSE WHO DON'T

(Statistical Significance and Directions of Differences)

		Attitude					
Hypothesis		Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
31	Boys	*** T	*** T	*** D	*** T	*** T	*** T
32	Girls	*** T	*** T	*** D	*** T	*** T	*** T

T = Those pupils who take mathematics who have the higher level of that attitude

D = Those pupils who don't take mathematics who have the higher level of that attitude.

*** significant at the 0,001 level

That those continuing with mathematics show lower anxiety than the others, is a very strong indicator that anxiety is an important factor affecting subject choice. Three of the other attitudes (liking, perceived usefulness and interest) could all be affected after mathematics has been dropped, but anxieties towards the subject would not form after the decision has been made and must therefore have existed before. Anxiety towards mathematics can thus be regarded as an important determinant affecting mathematics subject choice.

4.2.5.3 Comparing Various Groups of Those Who Don't Take Mathematics

Those pupils in standard eight who have elected to drop mathematics, formed part of the sample upon which all the comment on the previous sections is based. It is important therefore to investigate their feelings to see whether or not they form a homogeneous group or whether they show the same differences in their various sub-groups, viz. sex and type of school.

Table 4.13 compares these various groups with the null hypothesis being
there is no difference in attitudes towards mathematics amongst pupils in standard eight who do not take mathematics.

This hypothesis will be tested in the following groups:

A. Between the sexes for (a) all schools
(b) single-sex schools
(c) co-educational schools.
B. Between the two different types of schools for
(a) all schools
(b) boys only
(c) girls only.

This means that six hypotheses were tested, but each one for each of the six attitudes. The six hypotheses (all hypothesising no differences between the groups) are presented in Table 4.13 and are numbered as follows:

A. Testing between the sexes

Hypothesis	Type of School
33	all schools
34	single-sex
35	co-educational

B. Testing between the types of schools

Hypothesis	Sex
36	all pupils
37	boys only
38	girls only

TABLE 4.13

DIFFERENCES IN MATHEMATICS ATTITUDES AMONGST PUPILS IN STANDARD EIGHT WHO DON'T TAKE MATHEMATICS

(Statistical Significance and Directions of Differences)

Part A: Comparing the Sexes

		Attitude					
Hypothesis	Type of school	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
33	all schools	*** B	* B	*** G	* B	* B	
34	S-S						X
35	Co-Ed	*** B	*** B	** G	* B		

Part B: Comparing the Types of Schools

		Attitude					
Hypothesis	Sex	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
36	all pupils	*** C		* S			
37	boys	X					X
38	girls	*** C	** S				

B = Boys have the higher level of that attitude
G = Girls have the higher level of that attitude
S = Pupils in Single-Sex schools have the higher level of that attitude
C = Pupils in Co-Educational schools have the higher level of that attitude

X denotes a statistical difference which has not been quoted, because the expected cell frequencies are too low.

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

It is interesting to note that hypothesis 33 has been rejected for five of the six attitudes all in favour of the boys, but three of the five are only rejected at the 5% level. A problem with this sub-sample (those who don't take mathematics) is that in one of the two all-boys' schools, mathematics is all but compulsory and this means that care has to be exercised in assessing the results. Effectively then, hypotheses 34 and 37 do not produce any reliable comparisons, although it is interesting to note that in nine of the twelve comparisons no differences were found. Hypothesis 35, involving the comparisons of the boys and girls from the co-educational schools, produces similar results to those for the whole sample (of those who don't take mathematics) as they dominate this group numerically (see section 5.2.5.1). It is interesting to note though, that boys still show better attitudes in four of the six categories, three of which were referred to earlier as being the more important attitudes measured (liking, perceived usefulness and anxiety). From this it can either be concluded: of those who drop mathematics, most of the girls have negative attitudes towards the subject while some of the boys still have positive feelings; or simply (and more generally); of those that drop mathematics, more boys than girls have positive attitudes towards the subject.

Hypotheses 36, 37 and 38 involving the comparison of types of school (with the limitation on hypothesis 37 as mentioned above) yield no differences of any consequence in that, for the girls, the two differences that are indicated are contradictory.

In summary then, there seem to be no real differences amongst the pupils who drop mathematics in standard eight in terms of the different types of schools (single-sex or co-educational), but it would appear that in the co-educational schools the boys who drop the subject have better attitudes towards the subject than do the girls.

4.2.5.4 Comparing Various Groups of Those Who Take Mathematics

In the light of the finding in the previous section which ascertained that amongst those who drop mathematics there are still more boys than girls with more positive attitudes towards the subject, it is logical therefore to examine those that are taking the subject to see if any differences exist amongst various sub-groups, viz. sex and type of school.

Table 4.14 compares these various groups with the null hypothesis being
there is no difference in attitudes towards mathematics amongst pupils in standard eight who take mathematics.

This hypothesis will be tested with the following groups:

A. Between the sexes for
- (a) all schools
- (b) single-sex schools
- (c) co-educational schools.

B. Between the two different types of schools for
- (a) all pupils
- (b) boys only
- (c) girls only.

This means that six hypotheses were tested, but each one for each of the six attitudes. The six hypotheses (all hypothesising no difference between the groups) are presented in Table 4.14 and are numbered as follows:

A. Testing between the sexes

Hypothesis	Type of School
39	all schools
40	single-sex
41	co-educational

B. Testing between the types of schools

Hypothesis	Sex
42	all pupils
43	boys only
44	girls only

TABLE 4.14

DIFFERENCES IN MATHEMATICS ATTITUDES AMONGST PUPILS IN STANDARD EIGHT WHO TAKE MATHEMATICS
(Statistical Significance and Directions of Differences)

Part A: Comparing the Sexes

		Attitude					
Hypo-thesis	Type of school	Liking	Useful-ness	Anxiety	Interest	Ability & Ach.	Under-standing
39	all schools	*** G			* G		
40	S-S	*** G			* G		
41	Co-Ed	*** G					

Part B: Comparing the Types of Schools

		Attitude					
Hypo-thesis	Type of school	Liking	Useful-ness	Anxiety	Interest	Ability & Ach.	Under-standing
42	all pupils	*** C	*** C				
43	boys	** C	*** C			*** S	
44	girls	* C	*** C			*** S	

G = Girls have the higher level of that attitude
S = Pupils in Single-Sex schools have the higher level of that attitude
C = Pupils in Co-Educational schools have the higher level of that attitude

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

In studying the results of hypotheses 39, 40 and 41 it can be seen that only *liking* for mathematics shows any significant sex differences, but it is important to note that this, as well as the limited rejection of no differences in *interest* for the single-sex schools is in favour of the girls. What is just as important is that the remaining twelve chi-square calculations revealed NO difference between the sexes, while for the WHOLE sample of standard eights there were considerable differences between the sexes (see Table 4.8). (Significant differences were obtained for EVERY attitude for the whole sample, and also for the single-sex and co-educational schools separately.) All of this backs up the suggestion made earlier (and in the previous section too) that the girls who have negative attitudes towards mathematics elect to drop the subject, whereas some boys who drop it still have positive attitudes. In addition to this though, there are obviously a number of boys who continue with the subject DESPITE HAVING NEGATIVE ATTITUDES TOWARDS MATHEMATICS whereas this does not seem to be the case for girls.

This particular viewpoint obviously requires some consideration and speculation, but before doing this it might well be better to investigate any differences that there might be between the standard sevens and those standard eights who take mathematics. In other words the analysis of section 4.2.4 will be repeated, but leaving out those who have dropped mathematics in standard eight.

4.2.5.5 Comparing the Standard Sevens with Those Standard Eights Who Take Mathematics

For the reasons given in the preceding section, it is necessary to compare those in standard eight who have continued with mathematics with all the pupils in standard seven. This will be done for the boys and girls separately and the null hypothesis is *there is no difference in attitudes towards mathematics between the pupils in standard seven and those in standard eight who have chosen to continue with mathematics*.

This hypothesis will be tested for all six attitudes. The two hypotheses (hypothesising no differences between the two standards) are presented in Table 4.15 and are numbered as follows:

Hypothesis	Sex
45	boys only
46	girls only

TABLE 4.15

DIFFERENCE IN MATHEMATICS ATTITUDES BETWEEN PUPILS IN STANDARD EIGHT WHO TAKE MATHEMATICS AND ALL PUPILS IN STANDARD SEVEN
(Statistical Significance and Directions of Differences)

		Attitude					
Hypothesis	Sex	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
45	Boys						* 8
46	Girls	*** 8	*** 8	*** 7	*** 8	*** 8	*** 8

7 = Pupils in Standard 7 have the higher level of that attitude
8 = Pupils in Standard 8 have the higher level of that attitude

*** significant at the 0,001 level
* significant at the 0,05 level

The analysis of hypotheses 45 and 46 yields extremely interesting results. For the boys, only one of the six attitudes points to a difference between the standards and that only weakly so. It is quite reasonable to conclude therefore, that there is no difference between the attitudes of the boys in standard seven and those in standard eight who take mathematics. This means that amongst the standard eight group there is what one could call a 'normal' standard seven distribution, which would contain a reasonable number of boys with negative attitudes towards mathematics. Turning to the results of the girls, all six chi-square values are such that the hypothesis is rejected for all of them at better than the 0,1% level of confidence. Furthermore, all of the differences favour the standard eight girls and this dramatic difference between the boys and the girls (as observed in the previous two sections as well) needs some explaining. The evidence does in fact support the theory put forward in the previous section, that all (or most of) the girls who have negative feelings about mathematics, drop the subject. This leaves all those taking it as having very positive attitudes and those not taking it, as having very negative attitudes. For the boys though, many of those with negative attitudes drop the subject, but a significant number still carry on with it.

The above can be simplified as follows:

1. Girls are strongly guided by their attitudes towards mathematics as to whether or not they will take the subject;
2. Boys are affected by their attitudes towards mathematics in electing to take (or not take) mathematics, but they might still take the subject even if they have negative feelings about it.

This particular relationship between attitudes and course selection was not reported in any of the research literature that was reviewed.

CHAPTER FIVE

THE PHYSICAL SCIENCE ATTITUDE QUESTIONNAIRE

The questionnaire and the sample were described in Sections 3.5 and 3.3 respectively and the analysis and comments which follow are along similar lines to the discussion of the mathematics questionnaire which was undertaken in Section 4.2 of the previous chapter. The fifty two statements in the questionnaire yielded six second-order attitudes towards physical science (referred to in this chapter as science) and various groups were compared in 636 combinations. These different groups were obtained by sub-dividing the total sample in terms of the following variables: town in which school is situated; type of school (single-sex or co-educational); standard; sex of respondent; and whether or not they take science (standard eights only). Differences in attitudes were investigated in the areas: sex; type of school; and standard. In order to compare these frequencies to ascertain whether or not there were any that were statistically different, the chi-square test was used for the reasons given in Section 3.7. The tables thus produced were 2 x 2 tables, and the results of these comparisons are presented in the following five sections. As for the analysis of the mathematics questionnaire, and for the same reasons, the chi-square values themselves have been omitted from these tables and only the levels of significance (where applicable) and the direction of the difference, have been shown. The full tables with chi-square values are, however, given in Appendix G.

5.1 Comparing the Two Geographical Regions of the Sample

The reasons for including schools from two separate geographical regions were given in Section 4.2.1, but unfortunately there are no earlier studies from this country which can be used by way of comparison, as was the case for the mathematics questionnaire. Two factors should be borne in mind throughout the discussion of these results. Firstly, there was only one all-boys' and one all-girls' school in each of the two towns. Secondly, of the six second-order attitude factors generated by the responses to the questionnaire, only *anxiety* is a 'negative' attitude, while the other five can all be considered to be positive. Thus a higher level of anxiety is an unfavourable result, as opposed to higher levels of the other five attitudes which would all indicate more favourable attitudes.

Table 5.1 contains the statistically significant results of the comparisons between the two towns for all six attitudes and for the various groupings of single-sex and co-educational schools.

In the comparisons involving the boys for the mathematics questionnaire there were virtually no differences between the towns, but a large number of differences are evident for the science questionnaire. Making the comparisons by standards, the standard six boys overall show two differences in favour of the Port Elizabeth schools, but it is interesting to note that there are two opposite trends in the single-sex and co-educational schools. The single-sex schools (only one in each town) favour the East London boys, while the co-educational schools favour the Port Elizabeth boys in all six of the attitudes. These opposing views thus cancel out and yield a quite acceptable result that there is little difference between the towns for the standard six boys. The standard six girls show a similar dichotomy, but reversed for the two types of schools in terms of direction. The combined effect of these two opposing trends is that for the entire sample of standard six girls there are no differences at all in any of the six attitudes between the two towns.

The standard seven girls show a very slight trend favouring the Port Elizabeth schools, but for the boys in this standard there is a very strong indication that the East London boys show much more positive attitudes than their Port Elizabeth counterparts.

TABLE 5.1

COMPARISON OF PHYSICAL SCIENCE ATTITUDES BETWEEN THE TWO TOWNS
(Statistical Significance of Direction and Differences)

			Attitude					
Sex	Groups	Std	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	All	6		*** PE		*** PE		
		7	*** EL	* EL	*** PE	*** EL	*** EL	*** EL
		8	* PE	*** PE	** EL		*** PE	
	S-S	6	* EL	*** PE	*** PE		*** EL	** EL
		7	*** EL	** PE	*** PE	* EL	*** EL	*** EL
		8		*** PE			*** PE	
	Co-Ed	6	*** PE	* PE	*** EL	*** PE	*** PE	*** PE
		7	*** EL	*** EL	** PE	*** EL	** EL	
		8			** EL			
Girls	All	6						
		7			*** EL		*** PE	
		8			* EL			
	S-S	6	*** PE	*** PE	*** EL	*** PE	*** PE	** PE
		7			*** EL			
		8	*** PE	** PE	*** EL	*** PE	*** PE	** PE
	Co-Ed	6	*** EL	** EL		** EL	* EL	
		7			*** EL		*** PE	
		8	*** EL					

S-S = Single-Sex Schools
Co-Ed = Co-Educational Schools

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

PE = Port Elizabeth (pupils have the higher level of that attitude)
EL = East London (pupils have the higher level of that attitude)

For the standard eights there is a slight trend favouring the Port Elizabeth boys over the East London boys. While it is not as strong as that for the standard seven boys, it is in the opposite direction, and this in itself seems to point merely to differences in various groups and not to any real difference of any note between the towns. Amongst the standard eight girls, the two all-girls schools differ considerably in their opinions about science, but overall there is no difference of any significance between the two towns.

Generally speaking then the situation seems to be much the same as that summarised in Section 4.2.1 for the mathematics questionnaire. Including pupils from both regions was beneficial to the study in that it provided a larger and more representative sample and would have assisted greatly in balancing out local phenomena and trends that might be present. As for the mathematics analysis, no further discussions on the differences involving the two towns separately, will be undertaken, but all chi-square values for the various sub-groups involving the towns are given in Appendix G1. Hypotheses advanced in the sections which follow will not include any which deal with the two towns separately, but only for the sample as a whole.

5.2 Comparing the Sexes

In this section, comparisons will be made between the sexes, but they will be done in standards and also for the two difference types of school (single-sex and co-educational). The null hypothesis to be tested is; *there is no difference in attitudes towards physical science between the sexes.*

This hypothesis will be tested in the following groups:

in standards (a) standard six
(b) standard seven
(c) standard eight
and for each of these standards, in type
of school (i) all schools
(ii) single-sex schools
(iii) co-educational schools.

This means that nine hypotheses were tested, but each one for each of the six attitude hypotheses (all hypothesising NO differences between the sexes). They presented in the nine rows of Table 5.2 and are numbered as follows:

Hypothesis	Type of School	Standard
47	all schools	6
48	all schools	7
49	all schools	8
50	single-sex	6
51	single-sex	7
52	single-sex	8
53	co-educational	6
54	co-educational	7
55	co-educational	8

TABLE 5.2

SEX DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES
(Statistical Significance and Directions of Differences)

			Attitude											
Hypothesis	Groups	Std	Liking		Usefulness		Anxiety		Interest		Ability & Ach.		Understanding	
47	All	6	***	B	***	B	***	G	***	B	***	B	***	B
48		7	***	B	***	B	***	G	***	B	***	B	***	B
49		8	***	B	***	B	***	G	***	B	***	B	***	B
50	S-S	6	***	B	***	B	***	G	***	B	***	B	***	B
51		7	***	B	***	B			***	B			*	G
52		8	***	B	***	B			***	B	***	B		
53	Co-Ed	6	***	B	***	B	***	B	***	B	***	B	***	B
54		7	***	B	***	B	***	B	***	B	***	B	***	B
55		8	***	B	***	B	***	B	***	B	***	B	***	B

B = Boys have the higher level of that attitude
G = Girls have the higher level of that attitude
S-S = Single Sex Schools
Co-Ed = Co-Educational Schools

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

Considering the nine null hypotheses for each of the six attitudes, the following results are obtained from Table 5.2:

49 are rejected at the 0,1% level all in favour of the boys
1 is rejected at the 5% level in favour of the girls
4 are accepted as showing no sex differences.

These statistics provide extremely strong evidence for sex differences in all standards and for all attitudes. What is remarkable about Table 5.2 is the set of results where the boys and girls from the entire sample are compared (hypotheses 47, 48 and 49). Without exception, every single null hypothesis is rejected with strong confidence at the 0,1% level. These sex differences are similar to those obtained from the mathematics questionnaire and as for that subject, all differences favour the boys as having more favourable attitudes than the girls. The literature also points to strong sex differences in some of the attitudes that pupils have towards physical science.

As far as anxiety towards the subject is concerned there is virtually no evidence of sex differences at all, and only Levin and Fowler (1984) appear to have established slight differences and these favoured the males.

Duckworth and Entwhistle (1975), Robinson (1980), Warburton et al (1983) and Kelly (1981e, 1986), all established strong sex differences in the pupils' liking for physical science, while as far as the perceived usefulness of the subject was concerned, investigations seem to be non-existent which is somewhat surprising.

Equally interesting is that for the co-educational schools (hypotheses 53, 54 and 55) the same outright result in favour of the boys is observed. As far as the single-sex schools are concerned the indications are also strong, but the standard seven and eight pupils show no sex differences for *anxiety* nor do the standard sevens as far as their perception of their *ability* in the subject is. *Understanding* of science for the standard eights also shows no sex differences and for the standard sevens it is the only attitude which shows up in favour of the girls, but weakly so (only at the 5% level). The single-sex schools are thus quite clear in their feelings about *liking, perceived usefulness* and *interest* as far as science is concerned.

All the above evidence leaves no doubt that sex differences in science attitudes exist in standards six, seven and eight and in single-sex and co-educational schools as well. It would be more meaningful to consider these results (including the variations - although slight - presented by some of the single-sex groups) by looking first at the comparisons of the different types of school (single-sex and co-educational) and then also at any differences that there might be between the standards.

5.3 Comparing Co-Educational and Single-Sex Schools

In this section comparisons will be made between the different types of schools and will be done in standards and separately for boys and girls as well.

The null hypothesis to be tested is: *there is no difference in attitudes towards physical science between pupils in single-sex and co-educational schools.*

This hypothesis will be tested in the following groups:

in standards (a) standard six
(b) standard seven
(c) standard eight
and for each of these standards; for the
different sexes (i) all pupils
(ii) boys only
(iii) girls only

This means that nine hypotheses were tested, but each one for each of the six attitudes. The nine hypotheses (all hypothesising no differences between the two types of schools) are presented in the nine rows of Table 5.3 and are numbered as follows:

Hypothesis	Sex	Standard
56	all pupils	6
57	all pupils	7
58	all pupils	8
59	boys only	6
60	boys only	7
61	boys only	8
62	girls only	6
63	girls only	7
64	girls only	8

TABLE 5.3

DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES BETWEEN CO-EDUCATIONAL AND SINGLE-SEX SCHOOLS
(Statistical Significance and Directions of Differences)

			Attitude					
Hypothesis	Groups	Std	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
56	All	6	*** S	*** S	*** C	** S	*** S	*** S
57		7		*** S			* S	
58		8		*** S				
59	Boys	6		*** S	*** C		* S	
60		7	*** C	** S	*** S	*** C	*** C	*** C
61		8	*** C		*** S	** C	*** C	** C
62	Girls	6		*** S	** C		*** S	* S
63		7	*** S	*** S	*** C	*** S	*** S	*** S
64		8	*** S	*** S	*** C	*** S	** S	*** S

S = Single-Sex Schools have the higher level of that attitude
C = Co-Educational Schools have the higher level of that attitude

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

Considering the nine null hypotheses for each of the six attitudes, the following results are obtained from Table 5.3:

- 22 are rejected at the 0,1% level in favour of single-sex schools
- 8 are rejected at the 0,1% level in favour of co-educational schools
- 4 are rejected at the 1% level in favour of single-sex schools
- 2 are rejected at the 1% level in favour of co-educational schools
- 15 are accepted as showing no differences between the types of schools.

It is obvious that while there does seem to be a tendency favouring the pupils from the single-sex schools there is nowhere near the strong indication that there was in the corresponding analysis of the mathematics questionnaire in Section 4.2.3.

Looking at the results a standard at a time, the standard sixes show strongly that the single-sex school pupils have much more favourable attitudes towards science than do their counterparts in the co-educational schools. All six attitude hypotheses are strongly rejected, but when the boys and girls results are analysed separately, the same consistency is not obtained. The two sexes do not produce contradictory results, but when added together, the numerical increase in the sample size makes the tests more sensitive to any variation. It can be stated therefore, that better attitudes towards science are evident in standard six pupils from single-sex schools.

For standards seven and eight there is a certain similarity in the differences between the two types of schools. As far as the overall samples are concerned, *perceived usefulness* is the only attitude to show significant differences throughout. This applies in fact to all three standards, and all favour the pupils from the single-sex schools. For the separate analyses of the boys and girls there are a number of differences evident for the majority of the attitudes for these two standards. However, in almost every case they are contradictory results between the sexes. If the *perceived usefulness* category is not considered, then ten of the chi-square values favour the co-educated boys and two the all-boys' schools. Amongst the girls, thirteen chi-square values favour the girls from the all-girls' schools and none of the other girls. When these results are combined, they tend to cancel the two opposite trends and produce the overall result described above with only one attitude showing any significant differences between the two types of schools.

Overall then, the results can be generalised to there being a strong difference in science attitudes between standard six pupils in single-sex and co-educational schools (favouring the former), but no real differences in standards seven and eight. Greater clarity could be obtained on this when comparisons are made between the different standards for the different sexes and for the two types of schools.

Reviewing the literature relevant to this one finds that Harding (1979, 1981), Ormerod (1981) and Lee and Bryk (1986) established that girls in the mixed schools had less positive attitudes than did girls in single-sex schools. The GEMSTAT project, using anecdotal evidence, (Nottinghamshire LEA, 1985) found similar differences. Only Harvey (1985a) has presented contrary evidence, but rather surprisingly no reports involving any differences (or lack of them) for boys could be obtained.

5.4 Comparing the Standards

In this section, the standard sixes will be compared with the standard sevens, and the standard sevens with the standard eights. The comparisons will be done separately for boys and girls and also for the two different types of schools.

The null hypothesis to be tested is:
there is no difference in attitudes towards physical science between pupils in the three standards.

This hypothesis will be tested in the following groups:

in types of school (a) all schools
(b) single-sex schools
(c) co-educational schools
and for each of these groupings: for the different sexes (i) boys only
(ii) girls only
and for the transition between;
(1) standards six and seven
(2) standards seven and eight.

This means that twelve hypotheses were tested, but each one for each of the six attitudes. The twelve hypotheses (all hypothesising no differences between the standards) are presented in the twelve rows of Table 5.4 (Parts A and B) and are numbered as follows:

Hypothesis	Transition	Sex	Type of School
65	6 to 7	boys only	all schools
66	6 to 7	boys only	single-sex
67	6 to 7	boys only	co-educational
68	6 to 7	girls only	all schools
69	6 to 7	girls only	single-sex
70	6 to 7	girls only	co-educational
71	7 to 8	boys only	all schools
72	7 to 8	boys only	single-sex
73	7 to 8	boys only	co-educational
74	7 to 8	girls only	all schools
75	7 to 8	girls only	single-sex
76	7 to 8	girls only	co-educational

TABLE 5.4

DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES BETWEEN STANDARDS SIX, SEVEN AND EIGHT

(Statistical Significance and Directions of Differences)

Part A: Standards Six and Seven

			Attitude					
Sex	Hypothesis	Groups	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	65	All	*** 6	*** 6	*** 7	*** 6	*** 6	*** 6
	66	S-S	*** 6	*** 6	*** 7	*** 6	*** 6	*** 6
	67	Co-Ed	*** 6	*** 6	*** 7	*** 6	*** 6	** 6
Girls	68	All	*** 6	*** 6	*** 7	*** 6	*** 6	*** 6
	69	S-S	*** 6	*** 6	*** 7	*** 6	*** 6	** 6
	70	Co-Ed	*** 6	*** 6	*** 7	*** 6	*** 6	*** 6

Part B: Standards Seven and Eight

			Attitude					
Sex	Hypothesis	Groups	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	71	All	*** 7		*** 8	** 7	*** 7	*** 7
	72	S-S	*** 7	* 7	*** 8	* 7	*** 7	** 7
	73	Co-Ed	*** 7		*** 8	* 7	*** 7	*** 7
Girls	74	All	*** 7		*** 8	*** 7	*** 7	*** 7
	75	S-S	*** 7	** 7	*** 8	* 7	*** 7	*** 7
	76	Co-Ed	*** 7		*** 8	** 7	*** 7	*** 7

S-S = Single-Sex Schools only
Co-Ed = Co-Educational schools only

6 = Standard sixes have the higher level of that attitude
7 = Standard sevens have the higher level of that attitude
8 = Standard eights have the higher level of that attitude

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

Considering the six null hypotheses from Part A of Table 5.4 for each of the six attitudes, the following results are obtained:

34 are rejected at the 0,1% level in favour of standard six
2 are rejected at the 1% level in favour of standard six.

Unlike the corresponding analysis for the mathematics questionnaire where there was very limited support for the existence of any differences between standards six and seven, here the differences are strong and uniform for all groups. When these results are read along with those for Section 5.2 where the sexes were compared and where strong differences for all standards were indicated, it can be concluded that both the boys and the girls show significant deteriorations in attitudes towards science and in doing so, maintain the strong sex differences reported in Table 5.2.

Turning to Part B of Table 5.4 where the standard sevens and eights were compared, the comments on the six null hypotheses for each of the six hypotheses are as follows:

24 are rejected at the 0,1% level in favour of standard seven
4 are rejected at the 1% level in favour of standard seven
4 are rejected at the 5% level in favour of standard seven
4 are accepted as showed no differences between the standard sevens and eights.

At first glance these appear to show reasonably strong differences, but if Table 5.4 (Part B) is consulted it will be seen that the attitude of *perceived usefulness* shows no real differences between the standards. The other five, with the exception possibly of *interest* in science, all demonstrate extremely strong differences between the two standards. The immediate reaction to this is to suggest that the drop in attitude from standards six to seven for the perceived usefulness of the subject was so great that it could not drop any further between standards seven and eight. However, on consulting the chi-square values for these comparisons (Appendix G4) quite the opposite is indicated.

Although there is a large significant difference between standards six and seven, that particular chi-square value is LOWER than the other highly significant chi-square values. This suggests therefore, that the *perceived usefulness* of science was already lower (relative to the other attitudes) than the others and that it did not drop any further between standards seven and eight. It could well be that physical science is seen by the pupils as a subject to be taken in standards eight, nine and ten only it is leads somewhere, in other words if it is useful career-wise. If this is the case (the interviews conducted in the longitudinal study could well be of benefit in establishing this), then despite all the other attitudes being favourable, if the perceived usefulness of the subject is low at standard six already and continuing to drop, there will be large numbers of drop-outs in science. The sex differences as discussed in Section 5.2 are clearly visible, and the prediction that more girls than boys will drop physical science at the end of standard seven is subsequently borne out by the statistics produced in chapter one (nationally and internationally) and later in Section 5.5.1 (for the schools in this study).

The decline in the attitudes of boys and girls towards physical science is thus strongly evident, but it must be borne in mind that this takes place while the differences between the sexes are still evident and with the single-sex and co-educational schools playing their part as well.

Declining attitudes over a period of several years were also revealed by a few investigators. These were as follows:

Liking:	Hadden and Johnstone (1982, 1983a, 1983b) and Kelly (1986).
Interest:	Hadden and Johnstone (1982, 1983a, 1983b) and Hilton and Berglund (1974).

There appeared to be no results as far as the perceived usefulness of physical science over a period of years was concerned, but this seemed to be in keeping with the dearth of research evidence in the physical science attitudes area.

5.5 Those That Take Physical Science and Those That Don't

In Section 4.2.5, where an analysis and discussion on those taking and not taking mathematics in standard was presented, some interesting aspects of the attitudes of the boys and girls were revealed. Accordingly it is appropriate that similar analyses are done for physical science attitudes in order that any similar trends might be uncovered if they exist.

5.5.1 Breakdown of the Standard Eight Sample

The distribution of the standard eight pupils either taking or not taking physical science, is given in Table 5.5. This is not given in order to make any comparisons between the groups, but to support comparisons and conclusions that are made in the rest of this section.

TABLE 5.5

STANDARD EIGHT PUPILS IN THE SAMPLE WHO TAKE PHYSICAL SCIENCE

Type of School	Sex	Number Taking Physical Science	Number NOT Taking Physical Science	Total in Standard 8
Co-Educational	Boys	168	132	300
	Girls	115	242	357
Single-Sex	Boys	183	56	239
	Girls	90	145	235
All	Boys	351	188	539
	Girls	205	387	592

5.5.2 Comparing Those Who Take and Those Who Don't Take Physical Science

The attitudes of the pupils who either take or don't take physical science were analysed separately and using the chi-square test, these two groups of pupils were compared. Results are presented in Table 5.6 and it will be noticed that the boys and girls were analysed separately. The null hypothesis which was tested is;
there is no difference in attitudes towards physical science between pupils in standard eight who take physical science and those who don't take physical science.

This means that two hypotheses were tested, but each one for each of the six attitudes. These are presented in Table 5.6 and are numbered as follows:

Hypothesis	Sex
77	Boys
78	Girls

TABLE 5.6

DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES BETWEEN THOSE STANDARD EIGHTS WHO TAKE PHYSICAL SCIENCE AND THOSE WHO DON'T (Statistical Significance and Directions of Differences)

		Attitude											
Hypothesis		Liking		Usefulness		Anxiety		Interest		Ability & Ach.		Understanding	
77	Boys	***	T	***	T	***	D	***	T	***	T	***	T
78	Girls	***	T	***	T	***	D	***	T	***	T	***	T

T = Those pupils who take Physical Science who have the higher level of that attitude

D = Those pupils who don't take Physical Science who have the higher level of that attitude.

*** significant at the 0,001 level

As is to be expected, and as was the case for the mathematics attitudes, the null hypothesis is rejected at better than the 0,1% level of confidence for both the boys and the girls for all six attitudes. All the differences are in favour of those who are continuing with science and suggest therefore that the six attitudes measured are strongly related to a pupil's decision to carry on with the subject or not.

5.5.3 Comparing Various Groups of Those Who Don't Take Physical Science

By looking more closely at the pupils who comprise this group it might be possible to identify attitude factors which could have affected their decision to discontinue with physical science. Table 5.7 compares them in terms of sex and type of school with the null hypothesis being
there is no difference in attitudes towards physical science amongst pupils in standard eight who do not take physical science.

This hypothesis will be tested in the following groups:

A. Between the sexes for
  (a) all schools
  (b) single-sex schools
  (c) co-educational schools

B. Between the two different types of schools for
  (a) all schools
  (b) boys only
  (c) girls only

This means that six hypotheses were tested, but each one for each of the six attitudes. The six hypotheses (all hypothesising no differences between the groups) are presented in Table 5.7 and are numbered as follows:

A. Testing between the sexes

Hypothesis	Type of School
79	all schools
80	single-sex
81	co-educational

B. Testing between the types of schools

Hypothesis	Sex
82	all pupils
83	boys only
84	girls only

In comparing the sexes, hypothesis 79 involving all the pupils is strongly rejected for five of the six attitudes. Only *understanding* shows no sex difference, as was the case for the mathematics questionnaire. When looking at hypotheses 80 and 81 for the single-sex and co-educational schools it can be seen that it is the co-educational schools whose pupils are responsible for the five sex differences for the overall sample. They consistently favour the boys, which contrasts with the single-sex schools where the girls show better attitudes as far as *liking*, *anxiety* and *understanding* of science are concerned. It appears therefore that, of those that decide not to continue with physical science, the girls have poorer attitudes towards the subjects than do the boys. An examination of those that DO TAKE physical science might well reveal that girls with negative attitudes all drop the subject while those with positive attitudes all continue with it. As far as the boys are concerned, it would appear that their decision is less affected by their attitudes than is the case for the girls. The analysis in the next section (5.5.4) might throw some light upon this.

TABLE 5.7

DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES AMONGST PUPILS IN STANDARD EIGHT WHO DON'T TAKE PHYSICAL SCIENCE

(Statistical Significance and Directions of Differences)

Part A: Comparing the Sexes

		Attitude					
Hypothesis	Type of school	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
79	all schools	*** B	*** B	** G	*** B	*** B	
80	S-S	*** G		*** B			** G
81	Co-Ed	*** B	*** B	*** G	*** B	*** B	* B

Part B: Comparing the Types of Schools

		Attitude					
Hypothesis	Sex	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
82	all pupils	** C					
83	boys	*** C	*** C	*** S	*** C	*** C	* C
84	girls	** S		*** C			** S

B = Boys have the higher level of that attitude
G = Girls have the higher level of that attitude
S = Pupils in Single-Sex schools have the higher level of that attitude
C = Pupils in Co-Educational schools have the higher level of that attitude

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

As far as hypotheses 82, 83 and 84 are concerned, the separate analyses for the boys and girls are contradictory, although the boys are more definite, but the combination of these produces no differences in the types of schools other than a slight difference in *liking* favouring the co-educational schools. It does seem though (hypothesis 83) that there are many boys from the mixed schools who are dropping science despite feeling relatively positive about the subject. In other words, there must be reasons other than their attitudes guiding their choice.

5.5.4 Comparing Various Groups of Those Who Take Physical Science

In the light of the finding in the previous section which ascertained that amongst those who drop science there are still more boys than girls with more positive attitudes towards the subject, it is logical to examine those that are taking the subject to see it any differences exist amongst various sub-groups, viz. sex and type of school.

Table 5.8 compares these various groups with the null hypothesis being
there is no difference in attitudes towards physical science amongst pupils in standard eight who take physical science.

This hypothesis will be tested with the following groups:

A. Between the sexes for
  (a) all schools
  (b) single-sex schools
  (c) co-educational schools

B. Between the two different types of schools for
  (a) all pupils
  (b) boys only
  (c) girls only.

This means that six hypotheses were tested, but each one for each of the attitudes. The six hypotheses (all hypothesising no difference between the groups) are presented in Table 5.8 and are numbered as follows:

A. Testing between the sexes

Hypothesis	Type of School
85	all schools
86	single-sex
87	co-educational

B. Testing between the types of schools

Hypothesis	Sex
88	all pupils
89	boys only
90	girls only

TABLE 5.8

DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES AMONGST PUPILS IN STANDARD EIGHT WHO TAKE PHYSICAL SCIENCE

(Statistical Significance and Directions of Differences)

Part A: Comparing the Sexes

		Attitude					
Hypothesis	Type of school	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
85	all schools	*** G	*** B	*** B			
86	S-S	*** G		*** B	** G	** G	** G
87	Co-Ed	** B	*** B		*** B		** B

Part B: Comparing the Types of Schools

		Attitude					
Hypothesis	Sex	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
88	all pupils	*** C	*** S	*** S	*** C	*** C	*** C
89	boys	*** C		*** S	*** C	*** C	*** C
90	girls		*** S		* S		

B = Boys have the higher level of that attitude
G = Girls have the higher level of that attitude
S = Pupils in Single-Sex schools have the higher level of that attitude
C = Pupils in Co-Educational schools have the higher level of that attitude

*** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

there is no difference in attitudes towards physical science between the pupils in standard seven and those in standard eight who have chosen to continue with physical science.

This hypothesis will be tested for all six attitudes and the two hypotheses (hypothesising no difference between the two standards) are presented in Table 5.9 and are numbered as follows:

Hypothesis	Sex
91	boys only
92	girls only

TABLE 5.9

DIFFERENCE IN PHYSICAL SCIENCE ATTITUDES BETWEEN PUPILS IN STANDARD EIGHT WHO TAKE PHYSICAL SCIENCE AND ALL PUPILS IN STANDARD SEVEN
(Statistical Significance and Directions of Differences)

		Attitude					
Hypothesis	**Sex**	**Liking**	**Usefulness**	**Anxiety**	**Interest**	**Ability & Ach.**	**Understanding**
91	Boys	*** 8	*** 8		*** 8	* 8	
92	Girls	*** 8	*** 8	*** 7	*** 8	*** 8	*** 8

7 = Pupils in Standard 7 have the higher level of that attitude
8 = Pupils in Standard 8 have the higher level of that attitude

*** significant at the 0,001 level
* significant at the 0,05 level

For the girls the hypothesis (92) is rejected at better than the 0,1% level for all six attitudes. All of these differences are in favour of the standard eight pupils and this confirms the speculation that very few (if any) of the girls who have negative attitudes towards science, continue with the subject. This conclusion is made using the above information, combined with that from Table 5.8 (hypothesis 85) and Table 5.7 (hypothesis 79). From hypothesis 85 it was established that for those who do take science in standard eight, the boys and girls do not differ greatly in their attitudes (see Section 5.5.4) and from hypothesis 79 it was established that for those who do not take science in standard eight, the boys have better attitudes than the girls. The implication is thus that the girls with positive attitudes take science and those with negative attitudes drop it, while for the boys there are still some (more than the girls) with positive attitudes NOT taking the subject and some (more than the girls) with negative attitudes still taking science. This conclusion is the same as that made regarding the choice of mathematics, but the information is perhaps not as conclusive as it was for that subject.

This view is reinforced when looking at the results of hypothesis 91 (Table 5.9) in that only three of the attitudes show strong differences between the two standards. This implies that there are still a number of boys taking science who have negative attitudes (as there are in standard seven). The chi-square values in Appendix G8 show very large values for the differences for the girls in the two standards and much smaller values for the boys and this also serves to strengthen the theory that has been put forward.

A comment was made at the end of Chapter 4 concerning this theory in relation to mathematics attitudes. It holds true for physical science as well, in that it has not appeared in any of the literature that was reviewed.

CHAPTER SIX

THE LONGITUDINAL STUDY - STANDARD SIX

6.1 Introduction

The previous two chapters described how, by means of a large cross-sectional study, certain differences in attitudes towards mathematics and physical science (as measured by the two questionnaires which were administered) have been identified. This is a major portion of the overall study and it served to establish certain facts regarding attitudes, as well as to indicate the initial directions that needed to be taken in the longitudinal study. The reasons for the longitudinal study, the progressively-focused sample chosen and the general approach are described in Section 3.6. As was explained in that section, the longitudinal study commenced in standard six in 1985 with a questionnaire which was designed to form a broad base which would provide all the necessary information for the two subsequent years of the on-going research. The standard seven and eight years were investigated using interviews, but interviews were not used in standard six. Consequently a large sample (358 boys and girls) was then possible. Further reasons are given in Section 3.6.1, but essentially it was because that by the time the group had got to standard eight it would have separated into five different groups, viz. taking mathematics, taking physical science, taking mathematics and physical science, not taking either and those who had left the sample schools. This made it essential to have a large number of standard sixes participating, to ensure reasonable survival in each of the categories. The questionnaire was therefore thought to be the best method of achieving this end.

The questionnaire as such is basically only the starting point for the longitudinal study and simply serves to determine what the attitudes (general) and opinions of the standard sixes from the three schools were at this stage.

The responses do, however, yield information which can be interpreted, either generally or statistically and this will be done in the next two sections. The main aim, however, is simply to establish the situation as it existed at the beginning of the investigation and in many instances reference will only be made by way of comparison, when discussing the information gathered in the later standards.

6.2 Differences Evident from the Questionnaire

The cross-sectional study described in the previous two chapters, identified three main groups which produced differences between their sub-sets. The two sexes showed dramatic differences for both physical science and mathematics, as did the pupils from the single-sex and co-educational schools. These two groups will be looked at in terms of their responses to certain of the questions. The other set of differences obtained in the cross-sectional study was between the various standards and this can obviously not be dealt with in this section as it only deals with one standard.

The questionnaire which was administered had forty three questions, most of which had separate questions relating to mathematics, physical science and biology. Not all the questions are relevant to this part of the discussion and some have therefore been excluded from this analysis (e.g. Are your teachers for mathematics and physical science male or are they female?). This question is only of value in terms of the later interviews and not for any comparisons of groups and therefore is not discussed here. There does not appear to be any value in considering mathematics and physical science separately so these two subjects will be dealt with together. Similarly the two different comparisons will also be dealt with in parallel.

The questions will be dealt with in the order in which they appear in Table 6.1

TABLE 6.1

COMPARISONS OF RESPONSES TO CERTAIN OF THE QUESTIONS FROM THE STANDARD SIX QUESTIONNAIRE
(Chi-Square Values and Significance of Differences)

		Groups being compared	
No.	Question	Co-Ed Girls vs Co-Ed Boys	Co-Ed Girls vs S-S Girls
1	What percentage do you usually get for mathematics?	11,29 (6)	27,62 (6) ***
2	What percentage do you usually get for physical science?	5,33 (6)	13,73 (6) *
3	Do you like mathematics?	6,75 (2) *	12,75 (2) **
4	Do you like physical science?	32,35 (2) ***	5,08 (2)
5	Rank all your subjects in order of liking. (Mathematics ranking comparison.)	12,87 (9)	33,31 (9) ***
6	Rank all your subjects in order of liking. (Physical Science ranking comparison.)	32,59 (9) ***	15,57 (9)
7	Rank all your subjects in order of difficulty. (Mathematics ranking comparison.)	19,69 (9) *	16,32 99)
8	Rank all your subjects in order of difficulty. (Physical Science ranking comparison.)	30,06 (9) ***	10,66 (9)
9	What percentage do you think you will get for mathematics at the end of the year?	9,28 (6)	21,83 (6) **
10	What percentage do you think you will get for physical science at the end of the year?	7,55 (6)	15,94 (6) *
11	Do you think you are suited to taking mathematics in standards 8, 9 and 10?	22,54 (2) ***	15,03 (2) ***
12	Do you think you are suited to taking physical science in standards 8, 9 and 10?	22,37 (2) ***	14,77 (2) ***
13	Do you think mathematics and physical science are similar subjects?	3,08 (2)	0,23 (2)
14	Do you think that if you can do the one subject you can do the other?	3,42 (2)	5,08 (2)
15	Would you prefer a male teacher or a female teacher for mathematics?	0,94 (1)	0,79 (1)

16	Would you prefer a male teacher or a female teacher for physical science?	0,07	(1)	18,46 ***	(1)
17	Does your mathematics teacher address questions mainly to the boys or mainly to the girls?	5,29	(3)	not applicable	
18	Does you physical science teacher address questions mainly to the boys or mainly to the girls?	2,93	(4)	not applicable	
19	Who is better at mathematics? Boys or girls?	16,97 ***	(3)	14,23 **	(3)
20	Who is better at physical science? Boys or girls?	2,02	(3)	19,72 ***	(3)
21	Who works harder at mathematics? Boys or girls?	6,58	(3)	0,35	(3)
22	Who works harder at physical science? Boys or girls?	5,04	(3)	0,48	(3)
23	Have you thought much about your subject choice for standard 8 yet?	3,61	(1)	1,62	(1)
24	Do you think you will carry on with mathematics?	17,72 ***	(2)	9,83 **	(2)
25	Do you think you will carry on with physical science?	38,31 ***	(2)	11,06 **	(2)
26	Is your subject choice in any way linked to a career?	8,75 *	(2)	0,91	(2)
27	Do you have a career in mind that you would really like to do?	15,63 ***	(2)	3,91	(2)
28	Name or describe the career you have in mind.	20,86 ***	(5)	5,35	(5)
29	If you were a member of the opposite sex, would you choose to do the same subjects in standard 8 as you will choose for yourself?	1,72	(2)	3,52	(2)
30	Are any members of your family either studying subjects or working in occupations which have anything to do with mathematics?	1,73	(2)	3,48	(2)
31	Are any members of your family either studying subjects or working in occupations which have anything to do with physical science?	6,20 *	(2)	13,73 ***	(2)
32	When you are a parent one day, would you advise your daughter to take mathematics?	6,77 *	(2)	10,73 ***	(2)
33	When you are a parent one day, would you advise your son to take mathematics?	0,87	(2)	1,60	(2)

34	When you are a parent one day, would you advise your daughter to take physical science?	22,67 (2) ***	17,26 (2) ***
35	When you are a parent one day, would you advise your son to take physical science?	1,26 (2)	6,09 (2) *

The Comparison Columns contain the following information:
Chi-Square value with degrees of freedom in brackets.
Significance of any differences *** significant at the 0,001 level
** significant at the 0,01 level
* significant at the 0,05 level

Co-Ed = Co-Educational
S-S = Single-Sex

Question 1

This simply provided information as to their mathematics *examination and test results* throughout the preceding year, which it is acknowledged are only roughly comparable. In the co-educational schools there was no significant difference between the sexes in their achievement, but the girls from the all-girls' school had achieved significantly better results than their co-educated counterparts.

Question 2

As far as physical science was concerned, there was (as for the mathematics), no difference between the sexes, as far as *results* were concerned, but there was a slight difference between the two types of schools. This small difference favoured the all-girls' schools slightly and differed a lot from the strong difference which was evident for mathematics.

Question 3

There was a slight difference favouring the boys as far as *liking for mathematics* was concerned, but a stronger difference between the girls in the single-sex and co-educational schools. There was possibly some tie-up between *liking* and *percentage* (their mathematics mark), but it was not possible to justify this statistically.

Question 4

Here the boys showed a very much stronger *liking for physical science* than did the girls. This is definitely not linked in any way to their relative performances in tests and examinations because question 2 revealed no sex differences at all. Although mathematics showed strong 'type of school' differences (co-educational and single-sex), there was no difference for physical science.

Question 5

The pupils were asked to *rank* all of their standard six subjects in order of *liking* and a comparison of the mathematics rankings has shown no significant differences between the two sexes from the co-educational schools. However, in comparing the girls from the all-girls'and mixed schools there were strong differences which indicated that the former had ranked their liking of the subject much higher than their co-educated counterparts.

Question 6

For physical science the reverse was true, with strong sex differences evident between the sexes and no difference between the single-sex and co-educational schools. All of these observations for both mathematics and *physical science rankings* were in line with those for the pupils' *liking* of the two subjects.

Question 7

All three groups *ranked the difficulty of mathematics* at much the same level and it is interesting to note that for the boys and girls from the co-educational schools this was in line with their ranked liking of the subject, but for the co-educational/single-sex comparison this was not the case. This seemed to imply that the girls from the single-sex and co-educational schools found mathematics equally difficult, but the former liked the subject more and did better at it. Degree of difficulty as such, was thus apparently not a deciding factor in terms of their ranked liking of the subject, whereas it was for the boys and girls from the co-educational schools.

Question 8

For *ranked difficulty of physical science* the difference between the sexes was negatively related to the ranked liking. Thus, strong liking was linked to low difficulty. The two different types of school showed no difference in their ranking of the difficulty of the subject which agreed with their view on their liking for it.

Questions 9 & 10

As far as the boys and girls from the co-educational schools were concerned, they did not demonstrate any sex differences when it came to what they thought they would score for the *end-of-year examinations* for both mathematics and physical science. This is in agreement with no differences for their marks obtained during the year, as was the case for the girls' co-educational/single-sex comparison where the single-sex girls felt they would do better at the end-of-the-year examination than the other girls felt they would do.

Questions 11 & 12

In these two questions the pupils were responding to whether or not they felt they were *suited to taking mathematics* *and/or physical science* in Standards 8, 9 and 10. For both of these subjects there were strong sex differences in the co-educational schools in favour of the boys and strong differences between the girls from the two types of schools. These results are perhaps some of the most illuminating of all of those obtained, as in none of the other combinations of responses were there such strong differences between all the groups and for both subjects. In other words, the girls from the single-sex school and the boys from the co-educational schools felt that they were better suited to taking the two subjects in the senior secondary standards than the girls from the co-educational schools, but this feeling was not as clearly conveyed by any of the other sets of responses other than for questions 24 and 25 (discussed later).

Question 13

There were no differences between any of the groups at all as to whether mathematics and physical science are *similar subjects* or not. Between forty and fifty percent thought that they were similar, with the rest spread between the 'uncertain' and 'no' options,

Question 14

Similarly, there were no differences in opinion as to whether or not if you could *do the one you could do the other*. However, while there was agreement about this, only approximately thirteen percent thought that this was so and about sixty percent felt that this was not the case.

Question 15

In response to being asked whether they would prefer a *male or a female mathematics teacher*, all groups tended similar responses. However, what is perhaps unexpected is that sixty six percent of the boys (similar percentages for the girls in both types of schools) would have preferred a female teacher. Could it be that they had had better experiences with female teachers (and worse with male teachers) during their standard six year or perhaps at primary school? In fact fifty six percent of the boys already had a female mathematics teacher and were obviously happy with that situation and a further ten percent (or perhaps more) of the boys would have preferred a female teacher. Perhaps female teachers in standard six offer an easier and more sympathetic introduction to high school as far as mathematics is concerned and possibly they demonstrated much higher levels of empathy.

Question 16

Responding to the same question as above, but for physical science, the boys and girls still agreed on what teachers they would prefer, but the proportions had now swung the other way. Sixty six percent of both the boys and the girls would have preferred male science teachers. It is possible that both boys and girls see this subject as having a more 'male character' than mathematics. As far as science teachers were concerned, the girls from the all-girls' school still felt (as for mathematics) that a female teacher would be preferable, so a difference in opinion existed between them and the girls from the mixed schools.

Questions 17 & 18

When questioned as to whether their mathematics and science teachers devoted more *questioning time* to the boys or to the girls, there was no significant difference in the divisions of their responses. More than fifty percent thought that the teachers' time was equally spread, and over thirty percent hadn't noticed any difference. Therefore in the pupils' opinion there was no sex bias in terms of questioning and attention. It is possible that differential 'wait time' might have operated in the mixed classrooms, but it is unlikely that the pupils would have noticed the subtlety of this classroom interaction. (These questions were obviously not applicable to the all-girls' school.)

Question 19

In the co-educational schools, the girls thought that the girls were *better at mathematics* and the boys thought the boys were better. This would appear to indicate no real difference (which ties up with question 1) and their opinions are simply biased towards their own sex. An interesting result though is that the girls from the single-sex schools have a lower opinion of their mathematical ability compared to their perceived ability of the boys, but the co-educated girls do not agree. This difference could well be attributed to the fact that the girls in the co-educational schools have the opportunity to compare their performances with those of the boys, whereas the other girls have what can only be described as a socially imposed myth in terms of the relative abilities of the sexes as their source of information. Thus despite having been shown by the mathematics attitude questionnaire that they have better attitudes than the co-educated girls, the girls from the all-girls' schools have lower opinions of themselves in relation to boys than do the other girls.

Question 20

In this response, the boys and girls from the co-educational schools all agreed that the boys were *better at physical science* than were the girls. However, the girls from the single-sex school were even more certain that boys were better at science than girls were. Once again this opinion was held despite the fact that their attitudes towards physical science as measured by the attitude questionnaire, were significantly better than those of the girls from the co-educational schools.

Questions 21 & 22

When questioned as to which of the sexes *works the hardest at mathematics and/or physical science*, all three groups of pupils showed no difference in their opinions for both of these subjects. Interestingly though, the consensus was that girls work harder at both mathematics and science than do the boys, but this probably stems from a fairly commonly held belief that girls generally work harder than boys in most subjects.

Question 23

Approximately seventy percent of all three of the groups had *thought about their standard 8 subject choice* at this stage.

Question 24

Already at this stage the decision about whether or not to *continue with mathematics* was showing significant differences between the sexes and between the girls in the two types of schools. Seventy five percent of the boys thought that they would carry on with the subject, while for the girls from the single-sex and co-educational schools, the percentages were sixty eight and fifty three respectively. This question and the next, link up very strongly with the responses to questions 11 and 12. (Are you suited to taking mathematics/physical science?)

Question 25

Similar findings for physical science were produced in terms of the differences between the groups, but the percentages for the various pupils deciding to *continue with physical science* were all much lower. These were forty eight, thirty and sixteen respectively for the three groups mentioned above. The stage was apparently already set for the drop-out dilemma.

Question 26

Slightly more boys than girls in the co-educational schools thought that their subject choice was linked to a career, but the same percentages of girls in the two different types of schools (approximately forty percent) thought that this was the case. The next two questions can possibly provide some further information in this area.

Questions 27 & 28

The girls from the all-girls' and mixed schools showed no differences as to whether or not they had a *career in mind* and of those that had, the careers were spread similarly over the ***mathematics-related, science-related and other fields.*** For the boys and girls in the co-educational schools, the chi-square value shows a significant difference in how many pupils had careers in mind. However, from the chi-square values in the appropriate cells, the difference was in fact only in the proportions of those who were 'uncertain' and those who thought 'no', so the difference is therefore not really relevant. About sixty percent of all three groups did actually have careers in mind at that stage. Their ideas would almost certainly change over the years, but the important point is that their attitudes and feelings about mathematics and physical science could well have been linked to these careers. A big difference was evident between the boys and girls as far as the mathematics- and science-relatedness of their career choices were concerned. The boys showed a much stronger leaning in these directions and the girls favoured the non-scientific regions. (Biology-related careers were equally supported.) Thus as far as the responses to question 26 in connection with subject choice being linked to a career were concerned, although the responses showed no differences, differences did in fact exist in the careers (and hence the subjects chosen) which were being favoured by either of the two sexes.

Question 29

As far as choosing *different subjects* if the respondents were members of the *opposite sex*, there were no differences between the groups. What is interesting though, is that in each case at least half of the pupils thought that they would choose the same subjects and only twenty percent thought they would choose differently. This would seem to imply that the majority of the standard sixes were not sexist in their subject-choices, but it possibly did not reflect what they thought deep-down, if their responses to questions 26, 27 and 28 are considered.

Questions 30 & 31

These questions had to do with members of the respondent's *family who were involved with mathematical or scientific careers*. As far as mathematics was concerned, there was equal representation amongst all groups, but for physical science there was a difference at the 5% level between the girls and boys from the co-educational schools. While more boys than girls indicated that members of their family had post-school mathematical involvements, the main difference was in the 'uncertain' response. This would seem to indicate that this group of girls was possibly uninformed about mathematical careers or about what their family's involvement was. Both of these are significant in terms of the consequences of career information and guidance. The girls from the all-girls school showed no difference from the other girls in terms of mathematics careers, but for physical science there was a significant difference. This, however, seemed to make no difference as far as any of the other questions regarding careers and physical science were concerned.

Questions 32 & 33

These questions required responses as to whether or not they *would advise their 'daughters' and 'sons' to take mathematics* in standards 8, 9 and 10. As far as mathematics for 'daughters' was concerned, there were slight differences between the sexes with the boys thinking it more important than the girls did and a large difference between the girls, with the girls from the single-sex school thinking it about as important as the boys did. For the 'sons' there was no difference between the sexes, nor between the girls in the two types of schools. However, the most important aspect of the responses to these questions was that the percentages favouring their 'off-spring' taking mathematics was very high (between seventy and eighty nine percent), but in all three groups it was thought that it was more important for boys to do mathematics than it was for the girls. The percentages indicating the perceived importance of mathematics for their 'sons' and 'daughters', are given in Table 6.2.

TABLE 6.2

IMPORTANCE ATTACHED TO THEIR UNBORN PROGENY TAKING MATHEMATICS (PERCENTAGES)

	Their 'Children'		
	Daughters	Sons	Difference
All-Girls' School	81,7	89,0	6,3
Co-Educational Girls	70,3	86,7	16,4
Co-Educational Boys	84,4	88,1	3,7

There was amazing agreement as far as their 'sons' were concerned, with the greater variation occurring for 'daughters', but nevertheless at high percentages.

As far as physical science was concerned the pattern is much the same, but more pronounced. Table 6.3 shows the perceived importance of physical science for their 'sons' and 'daughters' and as can be seen, physical science is not considered anywhere near as important as mathematics. It is extremely interesting that the boys are strongly less sexist in their sex-stereotyping of the importance of the two subjects. Once again the girls from the co-educational schools have shown the greatest variation in their opinions and this seems to suggest that co-educational schools reinforce and/or develop ideas that mathematics (and more so physical science) are regarded as more important subjects for boys than for girls.

TABLE 6.3

IMPORTANCE ATTACHED TO THEIR UNBORN PROGENY TAKING PHYSICAL SCIENCE (PERCENTAGES)

	Their 'Children'		
	Daughters	Sons	Difference
All-Girls' School	28,3	58,5	30,2
Co-Educational Girls	21,1	68,0	46,9
Co-Educational Boys	50,5	62,0	11,5

6.3 Summary

Much information has been provided in the previous section, but it should be borne in mind that all of this, plus the responses to all the questions not quoted, forms the platform for the longitudinal study. However, certain aspects of what has been commented on are deserving of further attention.

What comes through clearly is the strong prevalence of sex-role stereotypes. One area where it was evident was that boys showed a marked leaning towards scientific-based careers, whereas the girls did not. Society's expectations in terms of sex-typed careers obviously has its effect on both boys and girls. Yet when asked about the need to have a different choice of subjects if one was a member of the opposite sex, only twenty percent thought that different subjects would be more appropriate. It could be of course that this group might be responsible for tipping the scales in sex-related choices, but this can only be suggested as pure speculation. A second sex stereotype that is firmly established in these standard sixes, is that as far as both mathematics and physical science are concerned, the boys and both groups of girls think that the boys are more suited to taking these subjects in the higher standards. This outlook ties up very firmly with the one concerning science-related careers, and in the case of the girls from the single-sex school, extends to them thinking that boys were actually better than girls at mathematics and physical science. The girls from the co-educational schools only thought this so of physical science, but having the opportunity to demonstrate that their results were as good as the boys' were, they didn't think boys were better at mathematics even though they thought the boys were more suited to it. They performed as well as the boys did in physical science, but society's influence was too great for them to be aware of that and they rated boys as better in physical science as well as being more suited to it.

From their responses in terms of teachers that they would prefer, it is possible that physical science is considered to be even more 'male' than mathematics and therefore requiring male teachers, but the fact that the majority would have preferred female mathematics teachers (even the boys), probably indicates that the different approach that female teachers might well have, is more acceptable to them at the standard six level. This does also suggest that a different approach in handling the pupils might well have a positive effect on their attitudes towards the subject.

Their view that mathematics (and more so physical science) was more important for their 'sons' than their daughters fits in with all the above and has given a good indication as to how 'well' they have been indoctrinated by society in their upbringing.

6.4 Reasons for Liking and Taking Mathematics

In the questionnaire, the standard sixes were asked whether or not they liked mathematics (physical science) and then to furnish some reasons for their response. The same was asked of them as far as whether or not they thought they would continue with these subjects in standards eight, nine and ten. The breakdown of the frequencies of the various groups was discussed in Section 6.1 and discussion here will be confined to the reasons given by the pupils for their choices, with the specific aim of being able to identify any changes in the sample population as they progress through the three-year span covered by the longitudinal study.

The reasons given for *liking mathematics* did not differ substantially for any of the three groups described in the previous sections (girls from the single-sex school and boys and girls from the co-educational schools). The reasons most commonly quoted were similar to the following:

> "It's challenging and I like puzzling things out."
> "I like doing calculations and working with figures."
> "It's an interesting subject and I enjoy it."

These were the main reasons put forward, but while the girls from the co-educational schools confined their responses almost exclusively to these areas, the boys from these schools and the girls from the all-girls' school also presented other reasons, but with no consistency apparent. One of these was that they thought that

> "mathematics helps me to develop logic" or that
> "I get good marks" and that
> "it is not always the same".

There will always be many different reasons, but the most commonly quoted reasons given above, were presented with remarkable agreement.

For those who fell into the category of being *uncertain* about their *liking of mathematics* there were really only two reasons presented by the girls. The first of these

> "mathematics is sometimes interesting (nice) and sometimes not" including
> "it depends on the section of work"

was the only one really supported by the boys, while the other comment which came from the girls most often was strongly linked to the first one, viz.

"I understand most (some) of the time".

It is linked in the sense that if a pupil does not understand a section of the work, he or she is highly unlikely to find it interesting. The girls are possibly being more open (honest) about their feelings, or possibly simply more aware of them and this might account for the narrow band of responses from the boys.

As far as those claiming *not to like mathematics* is concerned there is no pattern to their reasons at all, but all were negative reasons and ranged around the following:

"I don't understand mathematics."
"It's too difficult (complicated)."
"I'm not doing well."
"I don't like the way my teacher teaches."
"I don't like my teacher."
"I don't enjoy mathematics."

All of these imply the same thing, namely that the pupil is not coping with the subject. They are reasons for not liking the subject, but of course they are not reasons why this group of pupils is failing to come to grips with mathematics. For many of them it could of course be related to an inability to cope, but for many the reasons must lie in experiences they have had and attitudes they have developed. This group is probably already firmly established as the non-takers of the future, but they will be joined by a significant number of boys and girls (but mostly girls) during the standard seven year.

Turning then to the reasons advanced by the various groups who thought they may or may not take mathematics, or were uncertain about it, those who fell into the category of pupils that would *take mathematics* advanced three main reasons for their choice. Two of these dealt with what they would do after they had left school, either from a studying or an employment point of view and the third was simple enjoyment.

"I enjoy mathematics."
"It will help with my future (career)."
"It's very important for after school."

Other suggestions (not very frequent) were that "I do well at mathematics" or that "it gets more interesting the further you get", but there is no doubt that the 'usefulness' and 'need' for mathematics were more often than not the most important reasons given. This is further backed up when considering the numbers of pupils that fell into the two categories of 'liking' and 'taking' mathematics. Tables 6.4 and 6.5 respectively, give the percentages of the responses to the questions: Do you like mathematics? and; Do you intend taking mathematics in standards eight, nine and ten?

TABLE 6.4

LIKING OF MATHEMATICS
(Percentages of the Responses)

Yes	Uncertain	No
51,8	29,4	18,8

TABLE 6.5

INTENDING TO TAKE MATHEMATICS
(Percentages of the Responses)

Yes	Uncertain	No
65,0	20,2	14,8

As can be seen from these two tables, over thirteen percent of the pupils intended continuing with mathematics even though they weren't sure if they liked the subject or not. This would seem to confirm that the reasons given as to the 'usefulness' and 'need' of the subject outweigh other considerations for many of the pupils and would indicate an area which could relatively easily be given some attention.

The debate would revolve around whether or not the subject is useful to the extent which it is perceived as such by the layman, and also whether this really should be the most important reason for boys and girls taking the subject in the senior high school phase. It would seem that both of these considerations need looking at. Firstly, if the perceived usefulness of mathematics is viewed as being so vitally important then this should in fact be scientifically established and the 'users' of these so-called mathematicians (the employers) should be educated in its truth. Secondly and possibly more important, the reasons for pupils taking mathematics should surely go beyond the bounds of its usefulness and some of its other merits should be advanced and considered.

For those who fell into the *uncertain* category as far as *taking mathematics* was concerned there were two main areas of response. Most commonly "I don't know what career I'm going to enter" was their reply and this backs up the arguments of the previous paragraph in that once a pupil had decided on his/her career, the decision regarding mathematics would then follow, and this for some twenty percent of the sample. "It depends on my marks" was the next most common response. This implied that the need for taking mathematics was firmly established and the intention to take already existed, but with somewhat doubtful prospects for those pupils.

What then would cause a pupil to decide *not to take mathematics* if the 'need' for it was so firmly entrenched? For the sample at this stage (standard six) there were relatively few of them (fifteen percent) so they understandably almost all fall into the category of "not enjoying it" because "it's too difficult" and "I'm doing badly". In other words their marks were low and they are the same group that didn't like the subject for the same reasons. This group is probably not all that important to the present study, but those who would join them during the year that followed certainly would be. The reasons for this latter group dropping mathematics would hopefully be revealed by the standard seven stage of the investigation.

6.5 Reasons for Liking and Taking Physical Science

The reason given for *liking physical science* were as for the reasons for liking mathematics, representative of all three groups (girls from the single-sex school and boys and girls from the co-educational schools). There were two more commonly quoted reasons for liking the subject:

"It's an interesting subject."

"I enjoy the experiments and knowing about the things around us."

There were very few other suggestions, but one which is of interest in that it should apply to all subjects was, "I like physical science because it's not only the teacher working". Certainly a very sound reason for liking a subject, but rather a condemnation of those which don't allow the same to happen. Physical science obviously lends itself to a presentation of this nature and unfortunately too much hope is placed on this happening automatically in science classes and all too often this is not the case. It is obviously an aspect of science teaching that could make the subject much more acceptable to a larger number of pupils.

As far as those who were *uncertain about their liking of physical science*, they mostly found the subject "sometimes boring and sometimes interesting". These pupils formed nearly forty percent of the sample (Table 6.6) and attention to the curriculum and to methods of presentation would obviously be aspects of the subject which could improve this situation drastically.

Those that felt that they *didn't like physical science* did not differ greatly from those that didn't like mathematics and similarly they were characterised by an outlook of "not understanding physical science" and finding it "too complicated and confusing". In addition they found it "boring and too much work". As for mathematics then, they were obviously not coping with the subject at all and to 'rescue' them would be (if possible) an extremely difficult task. Of greater concern, would be those that did have good attitudes towards physical science and those that were uncertain.

Turning to those who at this stage of their educational process thought that they would be *taking physical science* in standards eight, nine and ten, there were two main reasons advanced which were the same as those given for liking mathematics. The one was that they "enjoy (like) physical science" and the other aimed at their possible careers in that it would "help them in their career" in other words "they need the subject" or "might need it".

TABLE 6.6

LIKING OF PHYSICAL SCIENCE
(Percentages of the Responses)

Yes	Uncertain	No
40,9	37,5	21,6

TABLE 6.7

INTENDING TO TAKE PHYSICAL SCIENCE
(Percentages of the Responses)

Yes	Uncertain	No
30,0	39,8	30,2

Looking at the various percentages of the various categories of the responses as to whether they 'liked' or were considering 'taking' physical science as given in Tables 6.6 and 6.7 respectively, there is (as for mathematics) a significant difference between the number opting to take the subject and those who had expressed a liking for it. Contrary to the situation for mathematics though, there were approximately ten percent of the pupils who liked physical science who at this stage already were not intending to take it. As was reported in Section 6.2, more boys than girls intended continuing with physical science and also career considerations were similarly sex-biased. The conclusion that can be drawn here then (as it was for mathematics in Section 6.3) is that physical science is considered almost exclusively in terms of its career importance and that large numbers of pupils (the majority of whom would be girls) would consequently not consider taking the subject.

Those pupils falling into the group who were *uncertain about taking physical science* were varied in their reasons, but these centred around "I don't get such good marks" or that "it might help with my career" or it may get harder". There was no definite trend visible, but forty percent of them fall into this category and many of them could obviously be favourably influenced in their attitudes during the standard seven year, but even more easily, they could fall by the wayside if neglected.

For the pupils who indicated that they would *not take physical science* in the higher standards, there were two distinct groupings of responses:

"I don't like physical science" and
"I don't need it (for my career)".

These are probably not unrelated, in that by deciding that they didn't like the subject, any thoughts of careers in that direction would long since have been discarded, or other careers would have displaced science-based careers from an early age. Although, as for mathematics, some thirty percent of the group fall into this category, it is unlikely that any remedial action would change their attitudes at this stage and it is the other seventy percent who during the standard seven year are going to decide one way or the other, who need the greater attention at this stage. It will be <u>their</u> decisions which will be examined by means of the interviews and subsequent questionnaire which were undertaken during *the year of decision*, i.e. standard seven.

CHAPTER SEVEN

THE LONGITUDINAL STUDY - STANDARD SEVEN

7.1 Introduction

This was the second phase of the longitudinal study and here the sample was narrowed down to fifty girls and twenty eight boys, drawn from two co-educational schools and one all-girls' school. The reasons for the size of the sample and the breakdown of the sample are described in Section 3.6.2 as are the methods of information gathering which were used. The original plan allowed for personal interviews to be conducted with boys and girls, but with greater emphasis being placed on the girls, because reasons for the girls dropping out were being sought and the boys were there as a type of 'control group'. The sample catered for all three subject selection-groups, viz. those who chose mathematics only, those who chose mathematics and physical science, and those who were taking neither of the two subjects. More information in connection with the sample and the format of the interviews is given in Section 3.6.2 and the questions which were posed are listed in Appendix D1.

After the interviews had been concluded and the relevant sections had been transcribed, it became obvious that some of the questions were eliciting some very similar groups of responses. Consequently it was decided to administer what has been named the 'post-interview questionnaire' to ALL the standard sevens in these three schools, some four hundred and twenty eight pupils (see Section 3.6.2). The information obtained from the interviews and the questionnaire which followed them, will be (where relevant) discussed together for both mathematics and physical science. There were in fact, more questions pertaining to physical science than there were to mathematics.

7.2 Mathematics

7.2.1 The Mathematics Decision

When the interviews commenced, the pupils had just completed making their subject choices for standard eight. This time was chosen because their deliberations would have been recent and the arguments for and against, fresh in their minds. When they had filled in the standard six questionnaire approximately one year earlier, they had been asked whether or not they liked mathematics and whether or not they thought they would continue with it in standard eight. The interviewees were reminded how they had responded the previous year and with this as background, the reasons for their decision as to whether or not they were going to continue with mathematics were then sought. Table 7.1 compares their intentions in standard six with their actual choice made at the end of standard seven.

TABLE 7.1

RELATIONSHIP BETWEEN INTENTIONS IN STANDARD SIX AND FINAL SUBJECT CHOICE INVOLVING MATHEMATICS

Part A: Those Taking Mathematics in Standard Eight

	Intention When in Standard Six			
	Will Take	Uncertain	Won't Take	Total
Girls Boys	21 16	5 6	2 0	27 22
Total	37	11	2	50

Part B: Those NOT Taking Mathematics in Standard Eight

	Intention When in Standard Six			
	Will Take	Uncertain	Won't Take	Total
Girls Boys	10 6	9 0	3 0	22 6
Total	16	9	3	28

It can be seen from Table 7.1 that there were twenty (fourteen girls and six boys) of the total interview-sample of seventy eight who were uncertain of their choice when they were in standard six. Of these twenty, eleven decided to take mathematics and nine to drop it. Probably the most significant statistic of this groups is that all six of the boys who were uncertain decided to take mathematics, whereas only five of the fourteen girls felt sufficiently confident to continue with the subject. There were two girls who changed their mind and decided to take mathematics having thought that they would not, but ten girls and six boys who originally thought they would take mathematics, opted out. This meant that nineteen girls (38% of the girls) six boys (21% of the boys) who were originally either uncertain about their mathematics choice or who thought that they were going to take it, decided to drop out of mathematics. It is these pupils plus the three girls who started with the feeling that they would be dropping mathematics who will receive the most attention in what follows.

7.2.1.1 Reasons for Dropping Mathematics

Twenty eight of the fifty eight pupils made the decision to discontinue with mathematics (see Table 7.1). Every one of them advanced a reason which had to do with marks that were not good enough. For most of them this was the only reason why they had given up, but for some there were additional reasons, but all were related to their problem of low marks. Typical comments from those who found their performance in mathematics inadequate, were:

"I like it, but I'm not taking it because it's very difficult."
"Maths has got harder."
"It's become more difficult since standard six."
"You have to work too hard and I don't understand most of it."
"I did O.K. in primary school."
"I'm doing badly so there's no question."

> "I'm not taking it because of marks."
> "I'm not doing well - I get poor marks."

All of the above comments were from pupils who were getting marks below fifty percent (most of them below forty) and for them the decision had been straightforward and uncomplicated. A few of them had still seen the possible usefulness of mathematics and would have liked to continue, but their low marks did not permit this.

> "I hoped to do it, if my marks could be improved."
> "I would've taken it if my marks were better."

This latter comment (and variations of it) came up no less than fifteen times, indicating willingness to take mathematics, but that possible `failure' was too strong to be ignored.

There were of course those whose marks were still good, but in their mind not good enough. These pupils all had viable alternatives, always in the arts field, to which they were more than happy to retreat. One girl (A) stated "I thought maths was really necessary and I was going to stick it out." She had dropped to about fifty percent and said that "if I was doing well I would've taken it even though I don't enjoy it - it's necessary". She is a pupil who is doing well academically with the exception of mathematics, and her case will be discussed in greater detail in the next chapter as she is one of the ten girls who was followed through into standard eight. At the standard six stage, she showed a strong graphic arts leaning and her forceful nature enabled her to drop mathematics even though she saw its usefulness.

Another girl (B) was scoring in the sixty percents for mathematics, but this was not good enough for her. "My marks have gone down and I'm not interested in it" was her response and she justified her stand (not very convincingly) by saying "I don't need any more maths - what I've learnt up to standard seven is adequate". She had usually scored about seventy percent and when in standard six she thought she would do mathematics, but wasn't sure whether or not she liked it. Not being all that sure that mathematics was necessary for girls though and because her mother (no father) didn't mind her dropping it, she opted for a much less onerous subject and justified this on the grounds of getting low mathematics marks. She was an example of a girl opting out of mathematics as a result of her horizons only being outside the school gates, and with no encouragement coming her way from the home (nor probably from the school) she had no reason to aim any higher.

A similar situation was presented by a girl (C) from a different school who was also getting in the sixty percents for mathematics. Her reason for choosing to drop mathematics was "I don't need maths because I'm not going to university". A year earlier she intended taking the subject "because I like it", but when in standard seven she no longer deemed it necessary, she didn't think she liked it any more and so dropped it even though she wasn't sure what she was going to do on leaving school. She was adamant about not wanting to go to university and thus thought she did not need mathematics. This attitude and those of the previous two pupils mentioned, seem to fit what has been said in the previous chapters, i.e that mathematics is a 'useful' subject and you take it if you can do it, but if you don't need it, then there is no real reason to continue with it. This is to a certain extent backed up by another comment by the same girl, "I wouldn't take it even if I could do it, because I don't need maths". As in every other situation though, the reasons always revolved around marks, but cause and effect are impossible to establish.

Also linked to marks, but a different reason for worry, were the comments similar to "my sister dropped a lot (marks)". This girl was then very wary of going any further even though her marks were reasonable. Other reasons given along this line were:

> "I'm worried that it's going to get harder." (This from a girls getting sixty percent for mathematics.)

> "My sister is doing maths and she's not doing very well at it and she is better than me .... so I'm scared of taking it."
>
> "I'm worried that it might get too complicated by the time get to matric (standard ten)."
>
> "I feel I won't cope by the time I get to standard ten."

These last five quotes all indicated an undoubted wariness and apprehensiveness of what the future held, something not evident for any of the boys. They (the boys) were all far more confident about the future and their thoughts did not entertain the possibility of failure if they thought that they would choose to continue with mathematics, which does not seem to be the case with the girls. The following quote from one of the girls cited above, bears out the possible 'anxieties' that according to the results quoted in chapter four exist to a much greater extent for girls than for boys:

> "I get my homework right, but as soon as I have the tests in front of me I go a total blank and I don't know where to start."

This comment echoes the uncertainties exhibited by many girls, and reinforces the feelings of the girls quoted earlier who were unsure as to how much more difficult mathematics might become in the future and whether or not they would be able to cope with it.

The recurring theme presented by the interviewees who were dropping mathematics, was one of 'poor marks'. As mentioned earlier, because in this area of the interview there seemed to be so many similar responses, it was decided to ask the same question of more pupils in case the sample was producing a distorted view. Accordingly a 'post-interview questionnaire' which posed this question as well as others which seemed appropriate, was constructed and then completed by all the standard seven pupils of the three schools involved in the longitudinal study (see Appendix D2). The first section of the questionnaire asked the pupils to select from the list, those statements (more than one could be chosen) which reflected their reasons for either taking, or not taking mathematics in standard eight. Table 7.2 contains the percentages of the number of boys and girls who selected the various statements.

TABLE 7.2

THE POST-INTERVIEW QUESTIONNAIRE
REASONS FOR CHOOSING OR NOT CHOOSING MATHEMATICS (Percentages)

Part A: Reasons for Choosing Mathematics

	Statements	Boys	Girls
1.	I do well at it	15,6	12,4
2.	I find it easy	20,8	10,1
3.	It's interesting	50,0	46,6
4	It's useful	50,0	74,1
5.	I need it for my career	69,8	51,7
6.	It's necessary in order to get a job	38,5	39,3
	Number of Pupils Choosing Mathematics	96	178

Part B: Reasons for NOT Choosing Mathematics

1.	I don't do well at it	77,5	68,4
2.	I find it difficult	77,5	71,9
3.	It's boring	57,5	57,9
4.	It's not useful	7,5	18,4
5.	I don't need it for my career	27,5	42,1
6.	It's not a necessary subject for a job	17,5	12,3
	Number of Pupils NOT Choosing Mathematics	40	114

Turning first to Part B of Table 7.2 it can be seen that the first two reasons, viz. that they don't do well at the subject and they find it difficult, are by far the most common reasons given for not taking mathematics in standard eight. Not surprisingly then, the majority find it boring and these three (or combinations of them) are very strongly indicative of both the girls' and boys' reasons for opting out of mathematics. The reasons given by the interview sample are then obviously representative of all the standard sevens of the three schools and deciding whether or not to continue with mathematics becomes a much easier task if it is simply based on their marks. Is it as simple as this though?

Certainly it can't be disputed that the pupils made the decision on the basis of marks, but does this tell the whole tale? If the boys and girls (to an equivalent degree) use marks as a yardstick, then it would be expected that the mean scores for mathematics for those who drop it would be similar for the boys and the girls.

When the standard sevens completed the post-interview questionnaire, they were also asked to give their mathematics mark. This was obviously a rough figure as to how they had performed during the year, but it can be regarded as very representative of the mark that they used as a yardstick in making their decision about taking mathematics or not and is very useful as such. When the average percentages of the girl and boy non-takers were calculated, they came out as 41,7% and 31,4% respectively. In this sample of all the standard sevens from the three schools, there were approximately twice as many girls as boys, and nearly three times as many girls NOT taking mathematics as there were boys not taking the subject (see Table 7.3).

TABLE 7.3

MATHEMATICS CHOICES OF ALL THE STANDARD SEVENS IN THE THREE SCHOOLS (Percentages)

	Taking Mathematics	Not Taking Mathematics	Total Number
Girls	61,0	39,0	292
Boys	70,6	29,4	136
Total	274	154	428

As mentioned above, the mean percentages for the boys and girls who drop mathematics would be expected to be similar, but the fact that the girls were ten percent higher, confirms the thought that girls need higher marks than boys before deciding to go ahead with choosing mathematics. It would be expected then that the mean percentage for the 'takers' would be higher for the girls than the boys, because a number of girls with reasonable (but lower) mathematics scores would have dropped out. This is confirmed, in that the girls in this group averaged some eight percent higher than the boys, thus lending weight to the theory that despite having similar mathematical abilities, the girls place more stringent mark requirements on their decision than do the boys.

Referring back to Table 7.2 and the fact that 'not doing well at mathematics' was seen by the non-takers (boys and girls) as being so vitally important to their decision, the next question to be posed would be, 'why do girls seem to have these higher standards than the boys?' This is where the question of *attitudes* would come in. The statistics presented in chapter four were quite definite in identifying the girls as having poorer attitudes towards mathematics. The girls and boys who fall into the 'band of decision' in terms of their previous marks for mathematics, are going to be guided by their feelings towards the subject.

The girls have poorer attitudes than the boys and the scales will therefore probably tip towards the drop-out side for these girls. The boys, however, because they have more favourable attitudes such as *liking mathematics*, *perceived usefulness* of the subject and low *anxiety* towards it, will probably decide to take it even if they have not being doing all that well at it during the standard seven year, because their feelings towards the subject are more positive. This further endorses the theory put forward in Section 4.2.5 where the attitudes of the standard eights who were taking or not taking mathematics were investigated. More specifically in Section 4.2.5.5 it was found that for those who were doing mathematics in standard eight, the girls had better attitudes than the boys. This pointed to more boys with negative attitudes than girls with negative attitudes continuing with the subject and probably that all girls with negative attitudes towards mathematics would not continue with it. This ties in with the finding in this section that there will be a significantly greater number of girls in the non-taking group doing better at the subject than there are boys.

Another area covered by the interview was as to whether or not mathematics was considered to be a subject more suited to boys or to girls. This was included because the literature researched in Section 2.3.2.3 indicated that the stereotyping of mathematics as a male domain was a major factor in explaining why more boys than girls chose mathematics in high school and also because when questioned in standard six, the girls thought that boys were more suited to mathematics than girls were. In the interviews, the majority of the pupils felt that mathematics was not biased towards either of the sexes, so a direct question was included in the 'post-interview questionnaire' which asked *do you think mathematics is a subject for boys and not really for girls?* The responses to this question for all the standard sevens are recorded in Table 7.4. Those of the girls are given separately for the single-sex and co-educational schools.

TABLE 7.4

IS MATHEMATICS A SUBJECT MAINLY FOR BOYS?

		Those Taking Mathematics		Those NOT Taking Mathematics	
	School	Yes	No	Yes	No
Girls	Single-Sex Co-Educational	0 0	87 91	0 15	23 76
Boys	Co-Educational	13	83	0	40

As can be seen from Table 7.4 only twenty eight out of the total sample of four hundred and twenty eight pupils thought that mathematics was more of a boys subject and the rest thought that it had no sex connotation at all. This small fraction obviously means that the speculation can be dismissed as far as this sample is concerned, but nevertheless it is worthwhile examining the breakdown of the totals. Of those taking mathematics, none of the girls thought it a 'male' subject, but thirteen of the boys did. Of those NOT taking it, none of the girls from the all-girls' school thought it a 'male' subject, but fifteen of the girls from the co-educational school did, and none of the boys thought it `male'. These data are interesting in that while there is no conclusive evidence, they do point out that the girls from the single-sex school do not see it as a boys subject and that from the co-educational schools, some of the boys that take it regard it as a boys subject as do some of the girl non-takers. This would seem to clash with their response mentioned earlier and discussed in Section 6.2, that the girls from the single-sex school and the boys from the co-educational schools all thought that boys were more suited to mathematics than the girls from the co-educational schools did, but it probably serves to illustrate how the pupils give totally different interpretations to what adults might consider similar questions.

In addition the results presented in this chapter might be similar to what Fennema and Sherman (1977) encountered concerning a similar response to a similar question when they concluded that while the girls had overtly agreed that mathematics was just as appropriate for women as for men, when it came to electing mathematics courses, they behaved in a more stereotyped way. It also tends to explain why the literature related to this aspect of mathematics is to a certain extent contradictory in its findings in that answers to a straight-forward question might show one thing, but questions involving sex-stereotyping in careers another. Another example of this is the response to the standard six questionnaire when asked about whether they thought they would encourage their own children to take mathematics. Here (also Section 6.2) the boys and the girls agreed that it was more important for their `sons' to take mathematics than it was for their `daughters', but when asked a similar question about themselves they answered differently. Possibly it hinges around whether they see the question as directly affecting them as individuals (in which case they are strongly egalitarian as far as the sexes are concerned), or indirectly (as for boys/girls, sons/daughters, males/females, etc). This could well explain the differences and the apparent contradictions. It could be that the stereotypes develop because of the societal influences, but as individuals, when being asked about these stereotypes, the girls don't think that they apply to them as individuals and yet they are subtly influenced by them in terms of their decisions and career considerations. Counselling and guidance in the area of sex roles and career stereotyping could well remedy this situation, but what should not be lost sight of, is that other factors are probably affecting the attitudes of the girls who fall into this group and who could go either way as far as their decision about further mathematics courses are concerned.

7.2.1.2 Reasons for Taking Mathematics

It can be seen from Part A of Table 7.1 that from the total group of seventy eight standard sevens who were involved in the interviews, thirty seven of them who thought in standard six that they might choose to take mathematics through to standard ten, correctly forecast their final decision. Of the twenty who were uncertain about their choice, eleven elected to take mathematics and a further two decided to take it despite not thinking they would when they were in standard six. It will be particularly important to try to establish what decided the pupils from the latter two groups to go ahead with mathematics, and to see whether or not it ties up with the suggestions made in the previous section in connection with those girls (there were no boys) who were uncertain in standard six, but elected later not to continue with mathematics.

Turning first to those boys and girls whose final decision was in line with what they thought they would do when they were still in standard six, it is interesting to note that their reasons given when in standard seven were much the same as those given the previous year and they revolved around enjoying the subject, feeling that it would be useful and important as far as careers were concerned. Some comments which illustrate this are:

> "It's a good subject to take .... If you've got maths you can do more things (careers), but I'm taking it because I like it."
> "I'll probably need it - it's a good subject to have .... I've always enjoyed maths."
> "I need maths for getting into Pre-Primary School education."
> "It's a pretty good subject to have. It'll help me and one can do things with it - not only from a career point of view."
> "I don't get on with my teacher, but it's essential for university."
> "I don't know what I'm going to do, so I'd better take it."
> "I need maths - it's probably a good idea for my career." (A girl wanting to become a veterinary nurse - "mostly men become vets".)
> "There is no proper career if you don't take maths."
> "It's interesting and will help me."

Unquestionably the common theme is the usefulness and need for the subject in terms of careers or in many cases as an 'insurance policy' because they weren't sure what they would do when they left school, but because mathematics was in their minds essential in so many areas, it was necessary to take it through to standard ten.

There were other areas, but these were far less common. One of these is in some way linked to needing the subject as mentioned in many of the quotes above and that was that they were taking mathematics because they wanted to do physical science (a prerequisite in most schools).

> "I don't really need it, but I want to do science."
> "I want to do science and therefore I have to do maths ..... it's probably a good idea for many careers."

This need arises from the integrated nature of most of the scientific careers and is often a reason for a pupil opting for mathematics in terms of "I need it for my career". Another interesting effect of the 'need' to have mathematics is illustrated by the following comments from girls:

> "I have improved in maths because I need it."
> "I find maths more interesting than before because now I'm certain that I need it."

These show a positive spin-off in that they aren't taking the subject "simply because they need it", but their heightened career awareness has in fact resulted in an improved outlook on the subject which has consequently had a positive effect on their performance. For example, a girl who was unsure about taking mathematics when she was in standard six claimed that "my new teacher has helped and my marks have improved." She was one of only seven girls who were either uncertain or weren't taking mathematics, but who eventually decided to choose it for the senior high school course (see Table 7.1). Two of them originally thought they definitely wouldn't take mathematics because "I don't enjoy it and I don't think it will help me in the future" and "because I always do so badly in maths".

The first of these two was turned around for a combination of reasons. Her mother thought it would be useful and was "talking to me the whole year" (about taking mathematics). This dawning awareness led to her falling into the category mentioned above, of improving in mathematics because of the realisation that she would need it. Once again it all comes back to the 'need' for mathematics being something of which they are made aware, but must, however, genuinely apply to them.

The second of the two girls took it because she deemed it "essential for university". She was someone who was getting at least sixty percent for mathematics, but her parents thought it a good idea and their influence fortunately prevailed and although she had no idea of what career she would follow she continued with it "just in case". The five girls who were 'uncertain' in standard six, but who decided to carry on with mathematics, fell into two categories. There were those who were uncertain because of their 'low' marks and it will be remembered that this was the reason given almost exclusively by those who had decided to drop mathematics, but the others were uncertain because they weren't sure whether or not they would need mathematics when they left school. When it came to making their final decisions though, it was the need for the subject which was suggested as the reason for taking it. Either because they wanted to take physical science or because they were considering careers which might make the subject either preferable or essential.

For the reasons mentioned in the previous section the post-interview questionnaire was used in order to gather additional information, because of the apparent consistency of the interview responses. Part A of Table 7.2 (in the previous section) gives the percentages of the pupils who responded to the various statements which were presented as possible reasons for those pupils electing to take mathematics. While those who had decided NOT to take mathematics gave `poor performance' and `degree of difficulty' as their main reasons, `doing well' and `finding it easy' featured as being by far the least important reasons for taking mathematics. As has been evident from the discussion above, `I need it for my career' featured strongly as a reason. For the boys this was the main reason (seventy percent) and while it was important for fifty percent of the girls, their main reason was the `usefulness' of the subject (seventy four percent). These two responses are of course very similar and could quite easily have been seen as such by the pupils. However, from the interviews it would seem possible that the former is envisaged by them as being of direct use in studying for career and the latter (usefulness) as being only an allied factor or possibly as being a non-academic (i.e. general intelligence) qualification. This would be in keeping with the statistics presented in Table 6.1 and the discussion of questions 27 and 28 which follow it, where the boys had shown greater interest in maths- and science-related careers than had the girls and would therefore explain why these two major reasons are placed in different priority order by the two sexes.

What must be realised is that the majority of boys and girls that decide to take mathematics have positive attitudes towards the subject and therefore for them to be convinced that they might `need the subject' or `perceive it as useful' would not be a difficult task. In view of the importance attached by this group of pupils to these two reasons for taking mathematics and linking this to a recommendation made at the end of the previous section (7.2.1.1) regarding the role that guidance and counselling could play (in preventing pupils who might well cope with mathematics courses from dropping it) it would seem that this type of positive action if employed at the appropriate stages, could play a major role in successfully countering the high drop-out rate, particularly amongst girls.

7.3 Physical Science

7.3.1 The Physical Science Decision

Although physical science is heavily dependent on mathematics and has a large component of mathematics in it, it is nevertheless a different type of subject in which (particularly in the lower standards) there are many sections of the work which can be managed by pupils with non-mathematical inclinations. However, it is a complex subject, essentially about everyday life (which should make it relevant and interesting), but the various theories, principles, concepts, etc. and the interrelationships between these, as well as the different ways of finding out about them, are puzzling to many pupils and probably even to some who carry on with the subjects (physics and chemistry) at university level. What this implies is that there is going to be a diversity of opinion whether physical science is worthwhile taking or not. This is unlike mathematics, which, as described in the previous sections, showed considerable uniformity in the reasons given either way as far as pupils either taking or not taking it was concerned. The opinions expressed by the interviewees as far as their reasons for their particular choice is concerned, were in fact much more varied than they were for mathematics, but there are nevertheless certain areas of comment which stand out significantly more than others.

7.3.1.1 Reasons for Dropping Physical Science

TABLE 7.5

RELATIONSHIP BETWEEN INTENTIONS IN STANDARD SIX
AND FINAL SUBJECT CHOICE INVOLVING PHYSICAL SCIENCE

Part A: Those Taking Physical Science in Standard Eight

	Intention When in Standard Six			
	Will Take	Uncertain	Won't Take	Total
Girls	6	6	4	16
Boys	9	2	3	14
Total	15	8	7	30

Part B: Those NOT Taking Physical Science in Standard Eight

	Intention When in Standard Six			
	Will Take	Uncertain	Won't Take	Total
Girls	14	14	6	34
Boys	2	3	9	14
Total	16	17	15	48

It is reasonable to accept that mathematics as a subject extends into far more other subjects, careers and everyday living than does physical science. Physical science can therefore be considered to be more specific in its applications and will as a subject choice have a lesser appeal than mathematics has. It is also more career-based than mathematics is and for younger pupils (standard six), career uncertainties will be therefore linked to subject choice uncertainties. Table 7.5 shows that about one-third of the interview sample were uncertain about whether or not they would take physical science in standard eight and a further seven pupils who initially thought they wouldn't, changed their mind at the end of standard seven. As was the case for mathematics, the girls dominated this 'uncertain' group (twenty out of the twenty five) and once again most of them (fourteen) decided against taking the subject. A feature of the table is firstly there was a smaller percentage opting for physical science than there was for mathematics and secondly that there was much greater uncertainty about what they might decide at the end of standard seven.

The reasons advanced for not taking physical science were similar for the boys and the girls and as mentioned earlier there were a number of different areas into which these reasons fell. There were, however, some that were more frequent than others, but what was interesting was that more often than not, far more reasons were offered by individuals than was the case for mathematics, where there usually tended to be only one or two main reasons per pupil. It will be seen in the following quotes from some of the girls that in fact their reasons were much more varied.

> "I found it easy in standard six, but difficult in standard seven .... It's boring .... and the chemical names and reactions are difficult .... I won't need it for anything I'm going to do."
>
> "It's confusing and not logical .... My maths is not good and this affects my work .... It's not as interesting as biology and I battle with formulas .... Electricity is confusing and .... chemistry is not interesting at all."
>
> "I get confused with different calculations and formulas .... I get bored learning science .... I'm not going into anything that needs science."
>
> "I don't like it, it's pointless and boring .... I don't see the relevance of it .... I don't need to know most of the things in the syllabus."
>
> "I do O.K. in non-calculations."
>
> "I would like to do it, but can't because I'm not doing maths."

> "It's difficult and not interesting at all."
>
> "I would do it if I didn't have to do maths."
>
> "I don't like science because it's not interesting .... and I battle with the maths aspects. I don't like electricity, it's not interesting and (is) too difficult."
>
> "I wouldn't do it even if I didn't have to do maths."
>
> "I'm not interested in finding out why or how things work .... science has been out since standard two. The content of the syllabus is very boring and of no interest to me - it's not the teacher or the school."
>
> "It doesn't interest me and it's not my line. It involves unnecessary information and is not going to help me in everyday life."

No two sets of reasons given by the girls in the quotes above is the same and yet the same <u>separate</u> reasons are present in many of them. Thus while there is apparently great diversity, there is actually a lot of common ground. The common reasons are covered by the following summary:

Physical science: is boring
is difficult
is confusing
is not necessary for a career
is not useful
is not relevant
can only be taken with mathematics.

As far as the boys are concerned, their reasons are along exactly the same lines as the girls and subsequently the post-interview questionnaire was used in order to ascertain which of the reasons was cited most often, and also if any sex differences were evident for the reasons given for not electing to take physical science. Table 7.6 (Part B) lists the six statements which were suggested to all the standard sevens from the three schools and gives the percentages of boys and girls selecting the various responses. There is still a clear indication given by these data, but as predicted it is nowhere near as definite as the responses concerning mathematics selection. Nevertheless, sixty percent of the girls find the boring nature of science the main reason for them not wanting to take the subject. This also features strongly in the boys' list, but for them the decision is far more related to not seeing a need for physical science because of not pursuing a career in that direction. Not needing it for a career was the second most important reason for the girls not choosing the subject, but finding it difficult was also an important reason given by both sexes.

TABLE 7.6

THE POST-INTERVIEW QUESTIONNAIRE
REASONS FOR CHOOSING OR NOT CHOOSING PHYSICAL SCIENCE (Percentages)

Part A: Reasons for Choosing Physical Science

	Statements	Boys	Girls
1.	I do well at it	37,7	15,3
2.	I find it easy	40,3	13,3
3.	It's interesting	75,3	66,3
4	It's useful	62,3	54,1
5.	I need it for my career	50,1	45,9
6.	It's necessary in order to get a job	20,8	4,1
	Number of Pupils Choosing Physical Science	77	98

Part B: Reasons for NOT Choosing Physical Science

1.	I don't do well at it	37,3	32,5
2.	I find it difficult	44,1	41,2
3.	It's boring	47,5	60,8
4.	It's not useful	27,1	22,2
5.	I don't need it for my career	57,6	50,0
6.	It's not a necessary subject for a job	44,1	20,1
	Number of Pupils NOT Choosing Physical Science	59	194

The other reasons also feature to varied extents, but it is the spread of opinion which is the significant aspect of the data. One of them does deserve special comment though and that is whether or not performance (don't do well at it) is an important reason or not. For those 'not taking mathematics' it was the most important factor (approximately seventy five percent), but for those not taking physical science, only about one-third of the boys and girls rated it as important. The significance of this is that most pupils would take mathematics if they felt they could cope with it because of their perceived 'need' and 'usefulness' of the subject. Physical science, however, has a much more limited 'need' appeal and having to do well at it is therefore not as necessary. A further interesting aspect is that the boy and girl non-takers attach an equal importance to performance, but the imbalance between the sexes has been brought about at this stage already by other factors. It is these that need to be speculated upon in terms of the suggestions made above about career considerations determining their attitudes towards physical science.

One of the questions asked at the interviews and then also in the post-interview questionnaire was as to whether they thought physical science was a subject which was more for boys than for girls. It would appear that the interview (as can be expected) was far more revealing with regard to this issue. The questionnaire was far too specific in its demand for a yes/no response with no opportunity for a pupil to explain the feelings he or she had. Nevertheless, the results from the questionnaire do reveal a trend as to what the various groups (takers/non-takers, boys/girls) think about the 'maleness' of physical science. Table 7.8 reveals that the girls from the single-sex school do not agree with the suggestion that 'science is a boys subject', but the interviews suggested that it was not as simple and clear-cut as this. One girl for instance thought that it wasn't a boys subject, but that "boys find it more relevant .... and girls do not enjoy it as much because they don't get a chance to put it into practice". This statement seems to be a contradiction of her answer, but this outlook was common amongst the girls and revealed a great difference between a straightforward questionnaire response and the more meaningful opinions expressed in an interview. There were a number of girls who thought that it was probably more of a boys subject than a girls subject, but when it came to the questionnaire they thought that it was not a boys subject.

In other words the divide between the yes/no of the questionnaire was too great for them to side with science being a boys subject and the data from the questionnaire must consequently be treated with great care. Nevertheless, the statistics from Table 7.8 do give an indication of a trend. This trend was that amongst those *taking* science it was not really considered as a boys subject, but amongst the *non-takers* there was a feeling that it might be. However, this feeling was very strong amongst the girls from the co-educational schools and to a lesser extent amongst the boys. The interviews were more informative as the following quotes from girls reveal.

> "Boys are more interested in electricity .... what does a girl need electricity for?"
> "Possibly the topics are more appealing to boys."
> "It (physical science) appeals more to boys than to girls."
> "Boys enjoy doing science, they are more familiar with it."
> "Yes (it is a boys subject), especially electricity."
> "Boys like the technical side of things - they understand it better."
> "They (boys) understand circuits."
> "The syllabus is more geared towards boys."
> "Girls think they can't do the experiments."

These quotes from girls from both single-sex and co-educational schools, present a strong case for physical science being seen as a boys subject by those girls who have decided not to continue with it in standard eight. The implication inherent in them is probably that the subject matter (e.g. electricity) is biased towards boys' interests and even though they don't rate physical science as a boys subject, it possibly provides them with a sufficiently strong background against which to decide to drop the subject, especially in view of their probable outlook in terms of stereotypes associated with careers. Also there is the indication that boys have either been born with an ability or have some type of informal training, in being more suited to what are regarded as scientific pursuits and thus are able to cope better with the subject.

The interviewees were asked to categorise occupations that they could think of that could be considered as careers for males or careers for females. Virtually all of them were of the opinion that males and females could compete equally for positions, but teaching, secretarial work and nursing came up over and over again as being suggested as careers suited to females, while males were better off being engineers, electricians or doctors as far as many of them were concerned. These three careers, suggested most often as typifying 'male careers', are all science-related whereas those suggested for the girls are not. It is probably this view of boys being associated with careers that are science-related, that gives rise to the previously mentioned comments relating to their feeling that the science syllabus was not relevant to those girls who were dropping physical science. This is well summarised by a quote from one of the girls "The way I was brought up was that there are certain things that boys do and some that girls do". It would appear that sex stereotypes propagated by society and reinforced in many ways as a result of attitudes and viewpoints accepted through tradition rather than through logic and commonsense, effectively (but possibly unintentionally) divert more girls than boys from continuing with physical science. The point was made earlier that finding the subject boring and not related to career ambitions were the main reasons for not taking the subject. As has been suggested, these factors will be promoted by socially imposed sex stereotypes of careers and syllabuses which appeal less to the girls who have had their thinking directed away from science-related vocations.

All the above has been confined to the <u>girls</u> who have decided not to continue with physical science, but what then of the boys in this category? The main argument expressed for the girls dropping out is that they have felt that they as females have been excluded from the subject because of the image it has in terms of syllabus content, but this obviously cannot be the argument put forward for the boys. What should be realised though, is that from all the standard sevens in the three schools, twenty three percent fewer girls than boys opted for physical science in standard eight (see Table 7.7). (This figure is in line with the overall approximate percentage difference between the sexes of twenty percent, for the cross-sectional study which involved the eight schools from the two cities.) It is this twenty three percent difference which possibly results from the sex stereotyping mentioned above and the remaining approximately forty percent could well have similar reasons for dropping the subject as the boys have. There were only fourteen boys interviewed who were in this category and the reasons that they advanced were varied, as were those given by the larger sample used for the post-interview questionnaire. These reasons centred around low marks, topics (in syllabus) not relevant, the subject not being career-related and some pupils who wanted to take the subject, but who were not allowed to do so because they were not continuing with mathematics.

TABLE 7.7

PHYSICAL SCIENCE CHOICES OF ALL THE STANDARD SEVENS IN THE THREE SCHOOLS
(Percentages)

	Taking Physical Science	Not Taking Physical Science	Total Number
Girls	33,6	66,4	292
Boys	56,6	43,4	136
Total	175	253	428

7.3.1.2 Reasons for Taking Physical Science

One of the most important reasons advanced by the girls and boys for <u>not</u> taking physical science was that they didn't need it for a career. Table 7.6 (Part A) indicates that for those who elected to continue with physical science, *needing it for a career* featured high on the list for both boys and girls as being an important factor. Two other reasons, *it's interesting* and *it's useful*, were also seen as being very important by a large percentage of the pupils, with 'interest' being the highest for both boys <u>and</u> girls. The quotes which follow illustrate this outlook.

> "I'm not sure if I enjoy it, but I made up my mind very recently, entirely because of career choice." (something in the medical or paramedical fields) .... "The syllabus is more interesting."
>
> "I enjoy learning it and might want to follow a career which needs science."
>
> "It's interesting .... and also interesting career-wise."
>
> "I want to go to 'varsity' and need to keep my options open ... but I'm not only doing it because of 'varsity' options.
> It's related to everyday life .... and I'm enjoying it more than in standard six."
>
> "It's interesting and I need it for university study .... I like the problems we have to solve .... and find the content more interesting at high school than primary school."

The interest and career usefulness are strongly underscored by the above and as far as the boys are concerned the reasons are the same.

> "I like it and I need it (for a career - engineering)."
>
> "I enjoy it because it has fascinating facts .... and I find it relevant and useful."
>
> "I enjoy the subject .... science is a relevant subject. I will follow a career in science (chemistry-related)."
>
> "It's interesting and I enjoyed it even before school .... I've always wanted to know why things work."

Because there does not seem to be a great deal of difference between the sexes in terms of why they were taking physical science, it is necessary to see if this extends into the area of whether or not the girls see physical science as belonging to the 'male domain' as was the case for the non-takers.

TABLE 7.8

IS PHYSICAL SCIENCE A SUBJECT MAINLY FOR BOYS?

		Those Taking Physical Science		Those NOT Taking Physical Science	
	School	Yes	No	Yes	No
Girls	Single-Sex	1	55	4	50
	Co-Educational	5	37	47	93
Boys	Co-Educational	16	60	15	44

As for the previous section (those not taking physical science) there was a considerable discrepancy between the question asked in the post-interview questionnaire (do you think physical science is a subject more for boys than for girls? - see Table 7.8.) and a similar question asked in the interview itself. For the straightforward (yes/no) questionnaire response, there was a slight indication that the boys (approximately twenty percent) thought that it was a subject more suited to boys, but the girls didn't think so at all. As far as the boys were concerned this was not really in line with what they had expressed in the interviews as the following extracts will show:

> "Boys go for it .... it's more practical .... and girls don't find electricity as interesting and easy."
>
> "When I think of scientists I think of males. Men are more capable of using what they learn." (He was referring to opportunities afforded to males.)
>
> "When we do experiments girls are scared and hang back."
>
> "It's mostly for boys .... You don't get women electricians."
>
> "Girls aren't as involved as boys, they simply learn it."

There were of course a number of boys (about forty percent) who thought that it was a subject equally for girls as for boys, but the quotes above do tell a tale. Their impressions are of course gained by personal observation, but also from stereotypes propagated and perpetuated by 'society'. What then were the feelings expressed by the girls in the interviews? As for the boys, the girls' comments were not in agreement with the yes/no questionnaire response which obviously needed greater flexibility in order to be worthwhile.

> "Boys are brought up in a more scientific way and the subject is more geared towards boys."
>
> "It's for boys more than girls because of the syllabus content."
>
> "It's more a boys subject .... boys enjoy it more."
>
> "Boys are more advanced (in science)."
>
> "It's a boys subject .... (they are) more practical about the subject. Electricity makes science a boys subject .... A shift in emphasis towards chemistry would make it a subject for boys <u>and</u> girls."

There is a much higher percentage of girls (than boys) that think it is <u>not</u> a subject which is more suitable for boys (approximately sixty percent), but the feelings quoted above, of some of the girls who opted to take science, demonstrate quite clearly that there is a strong feeling that it is more geared towards the boys. This observation does not put these girls off though, because they still have strong positive attitudes towards the subject, especially in terms of liking it and its perceived usefulness. Was there an indication from the interviews as to what it was that made the girls feel that science was more suitable for boys? Two comments from the boys and one from the girls which were given above give some clue that there might well be. These are the comments which relate to electricity and in fact there are several references to it both by those taking and those not taking physical science.

7.3.1.3 Electricity as a 'Boys Topic'

In the vast majority of interviews where girls felt that physical science was more geared to boys' interests, it was electricity that was suggested as one of the main reasons (if not <u>the</u> main reason) why this was so. This feeling was not confined only to those girls who were dropping physical science, and some the 'takers' felt the same way. Some quotes from those taking physical science were:

> "Physics is more for boys, but girls can still do it though, for example, electricity."
> "Electricity is O.K., but I'm not mad about it."
> "Boys find it (electricity) more interesting and cope better."

and from the non-takers:

> "Boys are more interested in electricity."
> "Electricity is for boys only."
> "Boys prefer working with electrical experiments and will probably become scientists."
> "What does a girl need electricity for?"

These were some of the reasons given why physical science was considered to be a 'boys subject', but the following comments were offered when the girls were asked to give reasons why they either were or weren't taking physical science the next year. From two girls taking science:

> "My marks are good and I enjoy science, but I've never liked electricity .... I find it difficult to understand .... I can connect up circuits, but I don't enjoy it."
> "It's interesting and I like the problems we have to solve .... Electricity is a bit confusing - I'm not interested in it and I'm a bit scared."

From four girls who had decided to drop physical science:

> "Electricity is confusing, girls seem to find it confusing."
> "I don't like electricity very much so I lack confidence."
> "I don't like electricity - I don't have to use it, it's not relevant .... It's confusing setting up circuits."
> "I don't like electricity - it's not interesting and is too difficult."

It should be noted that any comments specific to electricity were not solicited in any way and thus the number that came up was somewhat surprising and unexpected. Consequently, five questions specific to electricity were asked in the post-interview questionnaire (see Appendix D2) in order to gain further clarity on what seemed to be a major stumbling block as far as many girls and physical science were concerned. Table 7.9 gives the percentages of the numbers of either 'takers' or 'non-takers' who responded 'yes', 'uncertain' or 'no' to the five questions.

TABLE 7.9

ASPECTS OF ELECTRICITY IN THE STANDARD SEVEN CURRICULUM
(Percentage Responses)

		Taking Science		NOT Taking Science	
		Girls	Boys	Girls	Boys
1. Do you ENJOY electricity?	Yes	33,7	63,2	20,6	50,8
	Uncertain	34,7	23,7	58,8	28,8
	No	31,6	13,1	20,6	20,3
2. Do you find electricity BORING?	Yes	41,8	18,4	59,8	33,9
	Uncertain	32,7	67,1	21,6	54,2
	No	25,5	14,5	18,6	11,9
3. Do you UNDERSTAND electricity?	Yes	73,5	85,5	45,9	62,7
	Uncertain	3,0	3,9	23,2	16,9
	No	23,5	10,6	30,9	20,4
4. Is electricity RELEVANT?	Yes	72,4	78,9	62,9	56,0
	Uncertain	10,2	13,2	21,6	22,0
	No	17,4	7,9	15,5	22,0
5. Do you like CONNECTING up electrical CIRCUITS?	Yes	57,2	78,9	36,6	66,1
	Uncertain	26,5	13,2	53,1	25,4
	No	16,3	7,9	10,3	8,5

The first questions related to whether or not they *enjoyed* electricity. Simply comparing the 'yes' responses, it can be seen that the boys in both groups (those taking physical science and those not taking it) indicate quite clearly that they find electricity far more enjoyable than do the girls

(63,2% compared to 33,7% for those taking and 50,8% compared to 20,6% for those not taking science).

Asked whether or not they find electricity *boring*, a similar difference is quite understandably obtained. The boys taking science find electricity very much <u>less</u> boring than do the girls (18,4% compared to 41,8%), while amongst the non-takers the percentages are 33,9% and 59,8% for the boys and girls respectively.

As to whether or not they felt they *understood* electricity there was still an indication that the boys felt they understood it better than did the girls, but it is a noticeably smaller difference (only 12,0% and 16,8% in the takers and non-takers groups respectively). Another observation worth mentioning is that there is a considerably larger difference between the boys in the takers and the non-takers groups (22,8%) and an even bigger difference (27,6%) between the girls in these two groups.

Both the boys and the girls who were taking physical science thought that learning about electricity was *relevant*, with only a small (6,5%) difference in the number of boys and girls who responded 'yes'. Rather surprisingly a large percentage of the boy and girl non-takers' thought that electricity was relevant even though they had admitted to not enjoying it.

When it came to whether or not they liked *connecting up circuits*, there was a considerable difference between the boys and girls in both groups. For those taking physical science, the boys showed a 21,7% greater liking for this activity and an even bigger difference of 29,5% was evident for the non-takers.

The responses to the five questions supported very strongly the apprehensiveness of the girls towards electricity which was obvious from the interviews. The boys and girls basically understood the electricity components of the syllabus equally, and saw its relevance to everyday life.

They did, however, show considerable differences in their levels of enjoyment of the topic as a whole and also in connecting up circuits, and the girls found this section of the work more boring.

In summary then, it would seem feasible to assume that electricity topics in the physical science syllabus play a major role in affecting the attitudes of girls towards the subject and consequently have a major impact on each pupil's decision as to whether or not he or she should elect to take the subject in the senior secondary phase of high school.

CHAPTER EIGHT

THE LONGITUDINAL STUDY - STANDARD EIGHT

8.1 Introduction

This was the third phase of the longitudinal study and continuing with the progressive-focusing of the investigation, the sample was narrowed down to ten girls drawn from the two co-educational schools and one all-girls' school, and all were from the standard seven group of fifty girls who had been interviewed the previous year. The breakdown of the sample is described in Section 3.6.3.1 as is the format of the interviews which were conducted with these ten girls. As was explained in the previous chapter, the emphasis in this part of the investigation was on the girls. This was because reasons why more girls than boys were dropping out of mathematics and physical science, were being sought. Three of the girls interviewed were taking both mathematics and physical science, four were doing neither and the remaining three were taking mathematics, but not physical science. They were chosen in order to meet the requirement of the three subject-choice groups, but also because in their standard seven interviews they had made comments which justified further investigation and which might have yielded information which would be valuable to the longitudinal study. Thus these girls were not representative of any general body of opinion.

In the previous four chapters many theories and ideas were put forward in order to explain either data, or observations from pupil responses to questionnaires and interview questions. Comments made by the girls in their standard eight interviews will be used in this chapter to speculate further on some of the earlier suppositions, in an attempt to get further clarity on some of the issues. Various areas of interest have been highlighted and the responses of the interviewees will be dealt with under several headings which are related to these. Many of these are of course interwoven in the complex web of factors of affective and educational variables which affect the subject choices of the pupils at the end of standard seven. However, at the risk of inevitable repetition, the discussion will nevertheless be dealt with in sections. As far as mathematics and physical science are concerned, they will be dealt with either separately or together in each of the sections, depending on the information provided by the interviewees.

As was reported in Section 3.6.3.2, the parents of these ten girls were interviewed after the pupil interviews had been concluded. These interviews with the parents will be discussed in a later section, but certain of their comments which are relevant to the present discussion will be commented on in the other sections, whenever necessary.

8.2 Teacher Effect

Of the four girls (A, B, C and D) who dropped both mathematics and physical science, only three of them reported any problems with teachers as far as these two subjects were concerned. The fourth (girl D) thought if she had had a particular female teacher at her school for mathematics in standards six and seven she would have done better at it, but still doubted whether she would have taken mathematics. She felt that "it was my fault for not asking questions" and "I didn't want to act stupid in front of anybody". The 'anybody' was not anyone in particular and had no sex connotation. This was a surprising comment from a normally very confident girl and indicates the difficulty an average pupil might have in getting help. She did not express any strong feelings about the specific teacher, but other girls in the standard seven interviews had found him difficult to approach at times and although this particular girl claimed not to be intimidated by him, she was probably affected by his manner.

Returning to the other three girls, one in particular (girl B), suffered badly from experiences with teachers. She was doing well in standard three, but in standard four found that she was failing. She attributed this to the teacher, who was the physical education teacher, who in the girl's opinion "wasn't maths orientated .... and read out of the book. I kept getting left behind .... I was angry with her .... She never wrote on the board" and apparently used a calculator to work out the problems (standard three!). Her dramatic plunge in achievement was (and probably quite rightly so) blamed on the teacher and although in standard five "I came up a bit, but I was still failing", the die had been cast. This girl by her own admission found it difficult to get on with many teachers and the standard three mathematics teacher was one of these.

Her parents corroborated this and explained that her relationship with her teacher was vital to her performance in that subject. Standard six mathematics showed how true this was and "I had a proper teacher .... she explained and I could go to her for extra lessons and .... she would explain things over and over again if you couldn't understand. She was very comfortable". She improved to the extent that she was getting eighty percent in standard six and her comment in the standard six questionnaire was "I am able to do it, without much effort". This was a dramatic turnaround for her and she now liked mathematics and was sure she would take it in standard eight. This could well have been the consequence of understanding and empathy shown to pupils new in high school, which was mentioned in the previous chapter.
However, at the end of standard six she dropped "because the work got harder and in standard seven I went right down again". Once again she had encountered a teacher problem and this one she did not like "because she wouldn't explain .... she got all impatient and .... she wanted as few people as possible in maths" (in standard eight). "She told us once, 'I'm not going to waste time on you that's got (sic) no ability'. She had told me a few days before that I wasn't mathematically orientated, so I felt that she had been talking to me". Now in total contrast to her standard six comments she said, "I didn't like maths, I wanted to drop it, she (the teacher) was very discouraging".

None of this had anything to do with stereotypes or differential treatment of girls, but stems from a probably unqualified and unsuitable teacher in the primary school combining with a discouraging and negative teacher in standard seven and this resulting in a mathematics drop-out. This, despite the good work done by the standard six teacher. She was probably described by some of these teachers as a 'difficult' pupil, but possibly not by the standard six teacher. This is in contrast to what Aiken (1976) found, in that he could establish no statistically significant results showing that teachers' attitudes affected pupils' attitudes, but agrees with Phillips (1973) who did in fact establish a relationship, but who pointed out that one had to look further back than the most recent teacher in order to establish this. Armstrong and Price (1982) note that "students who perceived their teachers as encouraging also tended to take more mathematics" and this ties up with the positive experience in standard six, but which was unfortunately not sustained through to standard seven, the year which is of course the most important in that it is 'the year of decision'.

The other two girls who fell into this subject-choice category of not taking mathematics or science, had experiences which could be regarded as similar and which resulted not from lack of encouragement or interest, but rather from teaching approaches which caused problems for these girls (and almost certainly many others) in subsequent years. This particular problem occurs when during all the primary school years (or sometimes only up to standard four) greater emphasis is laid on neatness and layout than on the mathematics (arithmetic) itself. Girls usually respond far better to these requirements than do boys and feel very comfortable when working in this safe environment where there are no uncertainties as to what is expected of them.

This situation was commented on by Tobin and Garnett (1987) who reported on studies that noted that boys were spoken to more frequently and received praise for <u>quality</u> or work while girls were praised for form and neatness. The problem arises then with either the transition to high school or sometimes with a male standard five mathematics teacher who is 'preparing them for high school'. Suddenly there is less rigidity, particularly in the high school and the teacher experiences great irritation in the continual demands as to where to rule off, where to put the date or the numbers or the answer and so on. High school teachers (particularly males) are often insensitive to the reasons for this clamouring for 'help' and the pupil who had now emerged from his or her 'educational cocoon' is puzzled and uncertain (insecure possibly) about many things (mathematics included). What they regarded as mathematics in earlier standards, has suddenly changed into a new subject, but one which they don't understand because its 'simplicity' and 'straightforwardness' have disappeared.

One of the two girls to whom the above applied (girl C) experienced her uncertainty in standard five and although she had had a male mathematics teacher in standard four, of him and her standard three teacher she said "my standard three and four teachers explained very well .... our standard five teacher expected us to know things .... he didn't spend time trying to explain". She had done well in the previous standards, but in standard five she found the 'word problems' (mathematics 'C') difficult because "there were so many steps .... I couldn't figure it out. You just sat there and saw all these words and didn't know where to start .... because it didn't tell you what to do". This hadn't worried her before, but she was uncertain and "I started to worry more about maths and I didn't want to get my exam paper back". She was having to think for herself for the first time and because it was happening in mathematics, it was mathematics that was responsible rather than the system or method in which this 'new' process was being presented. Mathematics in other words, was getting blamed for inadequacies in other areas of the educational process.

The other girl mentioned (girl D), had a standard five mathematics teacher (male) who was very precise and demanded high standards of neatness. "I liked that .... I followed the rules" sums up what mathematics meant to her. She said that the teacher did not like pupils who did not get the work right. When she moved through to standard six though, things started to go wrong, because she had been placed in the top set (because of her standard five results) and couldn't keep up. She was possibly in the wrong ability group and remembered very clearly "What do you mean you don't understand it, I explained it to you yesterday". The teacher (female) explained again, but she dreaded being called upon to write on the board or answer a question when she did not understand because "it started getting too fast for me". For her, "primary school was easy, I knew exactly what to do". This was probably a situation where her 'true' mathematical ability was masked in primary school and when reality stared her in the face in standard six her attitudes towards the subject changed so drastically that she was on the path to dropping out of mathematics completely, instead of being better catered for (which was not the case in standard six either) over the years preceding her decision regarding continuing with or dropping mathematics. There were of course other contributory factors for all of the girls mentioned above and in the case of the last one, her mother had a strong influence on her as far as her decision to drop mathematics was concerned.

Amongst the girls who had opted to carry on with mathematics, there were two who continued despite having negative experiences with teachers in their standard five year. Fortunately for them they were high achievers who 'recovered' in standard six, partly because of the mathematics teachers they had, but their primary school experiences were still strong in their minds. One of the two (girl E) was scared by her standard five mathematics teacher (male) because "he shouted .... and it took me until near the end of the year to get used to him". Mathematics was easy for her to understand though and her father was a strong positive influence as far as the subject was concerned and consequently the transition to high school removed the difficulty she was experiencing. This particular father was aware of the problem his daughter had encountered with her standard five mathematics teacher and because of his position in educational circles knew the teacher well. He felt "the girls were more affected by the teacher than the boys .... the girls being more sensitive and going through that stage of development". This is a very pertinent comment and one that ties up well with a viewpoint expressed in chapter six where the sex of the standard six mathematics teacher (and possibly the attitude and approach of that teacher) was important to a large percentage of the boys and girls.

The second of these two girls (girl F) had her confidence shattered by her standard five mathematics teacher (female) who raised strong doubts as to her ability, but these were countered in standard six by a sympathetic teacher. Although she has continued with mathematics and is doing well, she still lacks confidence in her ability and tends towards nervousness and uncertainty when tests and examinations are imminent. She remembers her final year primary school teacher saying to her when she got something wrong, "you can do better" when she felt she <u>was</u> trying her best (and doing well) and to others who got it right "you're a good child, you can do maths". Probably a well meaning teacher who thought she was giving encouragement, but she did not realise what long-term effect she was having on her pupil.

As far as physical science was concerned, there were not many feelings expressed as far as their teachers were concerned and many of them had the same teacher for the two subjects. Comments were, however, always made in respect of mathematics and it is in this subject where they were <u>aware</u> of their teachers, while not realising that their physical science teachers were affecting their attitudes as well. Mathematics is quite simply the subject on which far more stress is laid by the school, the home and society and so it is not surprising that these girls have such strong memories of their mathematics lessons and not of their physical science classes. The only area of comment which is significant was that their primary school science teachers (biology and physical science are taught together as general science) spent far more time and were more interested in biology and thus physical science attitudes were probably affected more by what was <u>not</u> done rather than by what <u>was</u> done.

A good example of this was given by girl G, who stated during both her standard seven and standard eight interviews that "science (physical science) has been out since standard two". She said that she had never liked science, but didn't know why and found the "content of the syllabus very boring". She thought that it wasn't the teacher or the school, but the interview with her parents revealed an interesting comment from her mother (who was teaching at that school at the time) about her daughter's standard two teacher. "They (girl and teacher) didn't get on very well. The teacher's a friend of mine and she doesn't like (physical) science". The mother (a primary school teacher) maintained "I definitely think teachers influence children .... that (standard two) teacher was very keen on history and to this day J... (name) is very keen on history". Many history and science teachers were encountered by her (girl G) between standards two and seven, but the seeds could well have been sown as early as standard two and depending on the other teachers, these attitudes could have been strengthened and entrenched over the five years. What struck the writer about this girl during the interviews, was that she felt very strongly about standard two and the other standards were not nearly as significant in her memory.

Teacher *wait time* is according to many researchers (Swift and Gooding, 1983; Gore and Roumagoux, 1983; Riley 1986; Tobin, 1987) an important condition for higher cognitive level achievement in both mathematics and physical science achievement, but if different wait times were accorded the different sexes in the co-educational schools, the pupils were not aware of it. It is of course a subtle factor of which no-one in the classroom is aware, but if it exists its influence is thought to be marked.

Teachers undoubtedly exert considerable influence in the classroom and the way in which they teach, the 'requirements' that they have of their pupils and their own character and personality are all decisive factors in determining the attitudes their pupils develop. The effect that teachers have is a major socialization factor and even a relatively short interaction between teacher and pupil can be an important influence in determining that child's educational future, but specifically as far as mathematics and physical science are concerned. This is only one part of the social learning process, but it is a vital one as this section has shown.

8.3 Anxiety and Confidence

Reference was made in the previous section to some of the girls experiencing a lack of confidence in their ability and also nervousness about approaching mathematics examinations. It was suggested in Section 2.3.1.2 that anxiety and confidence lay on opposite ends of a continuum and these two attitudes will accordingly be dealt with together in this section.

Lorenz (1982) reported that teachers' low opinions of their pupils' abilities could result in an unwillingness on the part of the teacher to assist these pupils. This would very much be a self-fulfilling prophecy as far as the teacher and child were concerned and would almost certainly produce the very result on which the teacher's original assessment was based. Tobias and Weissbrod (1980) and Tobias (1982) used anecdotal evidence to show that more women that men admit to mathematics making them nervous and worried. Teachers (as was reported) can contribute to bringing this about, but it would also depend on the light in which the relevant subjects, as well as general academic success, are held in that particular family.

Three of the girls who developed signs of anxiety towards mathematics were mentioned earlier because it was the teacher who had precipitated their worries about mathematics. One (girl D) dreaded being called upon to write on the board or having to answer a question out aloud when she didn't understand what they were doing. This tended to cause her to panic she said and then she wasn't able to think. This was when she was in standard six and she began to worry about mathematics. This practice of getting pupils to write on the board seems to be a strange one and is hardly likely to achieve its purpose of 'pupil participation'. The more likely result would be to produce certain levels of anxiety in the pupils, which is exactly the result obtained in this instance. In standard seven she was dropped to the second set and found that she didn't panic as much, but strangely enough she would have preferred to stay in the top set because she thought her marks would be better because of the competition. The second girl (C) was battling with word problems in standard five mathematics and started to "worry about maths .... and became a bit nervous". The third girl (F) stated that it had never occurred to her that she may be having a problem (if indeed she was) until she was told "you can do better" and to those getting it right "you're a good child, you can do maths". It was at this stage that she began to doubt her ability and her confidence sagged. She felt about mathematics and science that if she knew both equally well, "I'll still feel nervous about as maths exam, but not about science." An interesting comment from a girl who decided not to take physical science, but continued (very successfully) with mathematics. She also felt that her loss of confidence in herself as far as mathematics was concerned might not have happened if she hadn't had that particular standard five teacher.

A fourth girl (A) who dropped out of both mathematics and science found mathematics very easy and pleasant all the way through to high school. However, in standard six she found it a drastic change from primary school and cited her introduction to algebra as making her aware of the difference. These were some of the comments she made about how she felt about mathematics when she was in standard six. "I was a nervous wreck before a maths exam, but not in primary school .... I had sleepless nights and didn't eat breakfast and I felt ill and had stomach cramps .... I never had worries about failing .... and this didn't happen for other subjects - except Accounting". Her parents corroborated these fears that she had and noted that she hated mathematics and "she used to carry on and get herself so worked up - I think she used to work herself up before she went in (to the examination)". These were the feelings of an intelligent girl whose attitudes towards mathematics changed drastically during standard six. She found geometry no problem at all, but algebra was her downfall where she said that in the beginning she didn't know what the letters stood for.

Olivier (1987) in commenting on a book by Karl Menger (1957) provides the reason why so many of the interviewees were finding algebra difficult to cope with. Menger writes as follows:

> *Algebra, analytic geometry, and large parts of the calculus, as taught today, are products of the 17th century. The fundamental ideas of those branches of mathematics are among the great legacies of that period and have ever since belonged to the most precious heritage of mankind. But with those ideas; the 20th century has also inherited the form in which they were presented by their discoverers. .... It has further inherited the indiscriminate use of the letter* x *in more than ten altogether discrepant types of procedure .... Because all those terms and the symbol* x *have not been, and are not being, used consistently, their vocabulary and grammar have never been written. This is why .... in the process of learning mathematics, important meanings and rules must be surmised. The deepest difficulties of mathematical education therefore are not due to shortcomings in education. They are due to procedures in mathematics.*

Olivier gives some of Menger's examples which explain some of the uses of x:

> *Have I not heard that* $x = 2$ *is the solution of the equation* $x + 1 = 3$, *whereas now I am told that* $x = 2$ *is an equation - the equation of a straight line?*
>
> *How can it be that* $x = 2$ *and* $y = 2$ *are totally different straight lines, whereas* $x + 1 = 3$ *and* $y + 1 = 3$ *are essentially the same equation?*

Small wonder that so many pupils find algebra confusing, and particularly when they meet it for the first time. It must surely give rise to many worries and anxieties and is indicative of the extra care that needs to be exercised when introducing pupils to it, especially if it is in standard six, their first year in high school.

A major difference between primary and high school was that "there were lots of steps (in solving problems) whereas in primary school there was only one step". It was suggested in the previous section that there was possibly some teacher problem because she said, "I asked questions and still didn't understand and didn't want to act stupid". However, the pupil didn't think that there was a real problem and the only possibly speculation as to the reason why this sudden drop in performance and appearance of anxiety manifested themselves is that the subject had been taught and presented in such a way in the primary school that her ability to absorb and remember facts and simple procedures (one step instead of many) enabled her to cope more than adequately. This idea is perhaps backed up by her comment that "I do better in learning subjects". Her academic success when there were facts to be learnt or where problems had one step only was thus assured, until she came up against mathematics that made different demands on her. She had not been adequately weaned into the new demands and the cognitive developmental stage which she had reached was possibly inadequate to enable her to cope. The transition between the two school systems was therefore possibly too great, and her subsequent drop in marks could well have raised her anxiety levels significantly. What is certain though, is that since this had occurred, no normal classroom situation would have been adequate to rescue her even though she and her parents were still convinced that it would be in her own interests to continue with mathematics through to standard ten.

This girl's anxiety is probably in line with what Sepie and Keeling (1978) established, that "under-achievers in mathematics are more clearly differentiated from their achieving and over-achieving peers in mathematics-specific anxiety than in either general or test anxiety". It would appear that she also fell into the category of pupils about whom Richardson and Suinn (1972) note that "mathematics anxiety exists among many individuals who do not ordinarily suffer from any other tensions".

A mother of one of the girls made an interesting comment about how the children get pressure put on them by their parents when they reach a situation where they are not understanding some of the work, "I'll say .... you better learn to know what's going on there .... because mommy can't help you and if you don't understand what's going on you're going to suffer for the rest of high school, because you must understand your maths" .... and then to the interviewer, "I'm saying what all the parents are saying, because we can't help the children .... and are putting pressure on them". This is a good example of one way in which a child can be pressurised, but it also demonstrates how the 'helplessness' of the parents contributes to the creation of increase of anxiety towards mathematics. Mathematics marks are seen by the parents as a very important (if not the most important) subject and a comment from a parent such as "you've got to get your maths marks up", typifies this.

The husband of the mother who made the previous comments about the pressures the children were subjected to, felt that "emotionally I don't feel they're equipped to handle it". This sums up very neatly that the pressures are enormous and that (some) children are not going to cope with the pressure - this is mathematics anxiety.

Although girl B (the fourth of the group who were dropping mathematics) did not show any outward anxiety symptoms, if what Tobias (1978) felt about mathematics avoidance being a classic symptom of mathematics anxiety was correct, then she could well have fallen into that category. She was possibly masking the symptom with her sometimes aggressive reactions to situations where she felt helpless. The other three though were very definitely anxious about their performance in mathematics and by stating as early as the end of standard six, their intention to drop out a year later, they certainly fitted the Tobias 'math avoidance' mould. When discussing in standard eight (after they had in fact dropped out) how they felt about their decision, all four professed great relief at their decision and their parents all backed this up in that they said they had noticed a big difference in their children's general attitudes. This is indicative of the general stress that the mathematics anxiety had produced, but while it was probably the mathematics anxiety that had caused them to drop the subject, the reasons for the appearance of the anxiety could be many and varied.

Visser (1985a) maintained that anxiety towards mathematics can begin at any age during a child's schooling and the comment during standard eight by one of the girls (E) who had opted to take mathematics, bears this out. She said, "this year I've started to get a little anxious about tests - I wasn't before". She was scoring about seventy percent, but felt she needed extra help with geometry. "Geometry is a problem .... I find it difficult. When I get faced with a geometry problem, I say 'I can't do it' - that's my first reaction". Here was a girl who had always done well at mathematics and was still doing well (perhaps not by her standards though), yet she was starting to have doubts about her ability and was beginning to worry. So much so, that she was contemplating dropping from higher grade to standard grade and her parents also noted that "she is beginning to doubt her own confidence .... this has arisen recently (in standard eight)". Her 'anxiety' was not the cause of her slight drop in marks, but rather it was the result of an entirely reasonable decrease in view of the higher level of the work in standard eight. The fact that the averages do drop slightly (or even stay the same) from standard seven to standard eight is perhaps surprising when one considers that the weaker pupils have dropped out of the subject. However, it does happen, but it doesn't appear that any reasonable explanations are given to the pupils and any doubts which arise can hardly be regarded as surprising.

It was suggested in the previous pages that girl A who had coped very well with mathematics in the primary school, had suffered a severe setback when in standard six she encountered algebra for the first time. She became a classic example of a mathematically anxious pupil and never recovered from this. Despite believing that mathematics was an important subject to take up to standard ten, and also getting encouragement from her parents to do so, she nevertheless dropped out of both mathematics and science at the end of standard seven.

From her comment "I didn't know what the letters stood for .... and they introduced the concept of x and y (sic) and the laws for adding and multiplying", it would seem as though one of her difficulties (possibly the major one) was related to what Macnab and Cummine (1986) refer to as *the formal notation of mathematics* (see Section 2.3.1.4). This refers to the visible part of mathematics and being able to separate it from its underlying meaning. The example quoted earlier was $3x - x$ giving an answer of 3, because removing x from $3x$, leaves 3.

Another possibility was the *variable* in mathematics, which of course for the standard six and seven years is no more than a fixed unknown or an unknown in an expression with several fixed values being substituted into it. These are usually taught as being variables and so when 'true' variables are encountered, the pupil can experience considerable difficulty in moving away from the idea that algebraic symbols always have fixed values. The symbols can be a source of great puzzlement to the pupils and something like $-x$ they find very difficult to comprehend as possibly representing a positive quantity.

The writer's experience has been that this example (as simple as it might seem to a mathematician), typifies one of the major areas of misunderstanding and worry amongst pupils new to algebra.

A second girl (B) of the group of four not taking mathematics or science, also experienced a major difficulty when encountering algebra for the first time, but her problems started even before she got to high school. "I was actually very worried to go into it (algebra) at first, because I had two brothers and they were always moaning how bad it is.... When I first heard that we were going to do it, then immediately I tensed up. This girl is close to her brothers and sets a great deal of store by what they say. She was prepared for the worst and having experienced a severe loss of confidence in standards four and five (see earlier discussion), she was set for a major setback. Her standard six teacher, however, succeeded in making her more positive about mathematics and up to June (half-year) she made good progress and she said "in standard six when I did well I was very happy, I thought I had a new brain"., However, she faltered a little and stated that she "coped at first, but then it got difficult". For her to recover was too much, but at the end of the year she was still anticipating opting to carry on with mathematics in standard eight. As mentioned previously though, in standard seven she didn't get on with the teacher at all, and her attitudes towards the subject took a sharp nose-dive again.

The other two girls (C and D) who dropped mathematics, did not express any major reservations about algebra. Girl C found algebra "quite interesting, but different .... then things changed". In standard seven she found geometry easier than algebra, but this was because "I learned the theorems" and she managed to get what she thought were reasonable marks.

According to the literature (Sherman, 1980; Badger, 1981 and Fennema, 1983) girls have a poorer spatial ability than boys and this affects their performance in mathematics, but particularly in geometry. It is interesting to note that very few of the girls found geometry a problem in standard six and seven and that it was algebra that provided the setbacks that they remembered.

It is only in standard eight and more so in standard nine that geometry really begins to present a real problem in our system of education. In standards six and seven, it mostly consists of learning theorems and axioms and only limited applications and logical deductions are required. From standard eight onwards, more steps are involved, the sketches which they need to interpret become far more complicated and greater logical and deductive reasoning is necessary. All this points to geometry only becoming a problem after the subject choices have been made and it is possibly not that important a factor at the decision stage.

Girl D was the only exception to this and she felt that she had "enjoyed algebra", but as far as geometry was concerned she "didn't do well and didn't seem to be able to do it properly". Considering all four girls then, there appears to be a reasonable indication that algebra presents a problem to some pupils, particularly when introduced to it (which is usually in standard six).

The other six girls who were part of the interview programme all decided to carry on with mathematics, and it is interesting to note some of their comments about algebra. One of them (girl G) was part of an 'enrichment group' in standard five when she was first introduced to algebra and there didn't appear to be any problems for her and she "enjoyed it very much - she (teacher) challenged us a lot". A combination of being developmentally ready for being introduced to algebra, being attitudinally ready and having a teacher who presented it in a good way, all contributed to her making a successful start. Girl H is a top scholar who found when she started in high school that "maths was a shock to begin with (the first few days) because we started with algebra. I'd never seen it before and I didn't catch on in the beginning - I was totally confused with 'like terms' and so on .... A lot of the class struggled and from junior school it was a big jump". She said that in primary school it was just arithmetic, but in standard six "the algebraic terms were very puzzling - they were strange looking things. My marks dropped quite drastically to begin with, but by the second term I was O.K. again". She also maintained that she experienced this shock a little bit in physical science as well, "but not in the content subjects because you could go home and learn them".

This last comment ties up with an earlier suggestion concerning girl A who was coping adequately with mathematics while there "was only one step", but who in standard six when "there were lots of steps", started to flounder. She (girl A) and girl H, both found that in standard six they coped easily with the 'learning subjects', but mathematics presented a problem. Girl H recovered after a few months (her intelligence and determination probably being the main reasons), but for girl A (and many others) recovery was far more difficult. Much would also depend on any anxieties towards the subject that might develop. Some might view the setback as temporary, but others might be beginning an ever-increasing spiralling descent into the depths of mathematics anxiety.

As for girl H who recovered from an algebra setback, so too did another girl (also a top pupil - girl I) who also found algebra to be unsettling at the start. Her class started algebra on the first day in high school and she maintained that many were baffled by it, but "I clicked after a few days". She had puzzled over "why use x and y when you can use *1* and *2*. The rules for indices were funny and we couldn't grasp that". Here was another girl who survived the transition to algebra and high school, but it would appear that much more thought needs to be given to its introduction as well as a need for a heightened awareness of the difficulties being experienced by the pupils and the consequences thereof, as it seems to be a possible 'breeding ground' for mathematics anxiety.

As far as physical science was concerned, none of the interviewees showed any apprehensiveness towards the subject at all, and there were no indications of any outward symptoms of anxiety. The eight who had dropped physical science had all completed the mathematics and physical science attitude questionnaire (discussed in chapters four and five respectively) as well as the post-interview questionnaire which was completed at the end of the standard seven year. When these questionnaires were examined, it was interesting to note that the girls generally did not indicate by their responses that they felt anxious about physical science (which was not the case for mathematics).

Thus the fact that the interviews (in both standards seven and eight) did not yield any comments which showed a lack of confidence in the girls' ability to cope with physical science was also in agreement with their questionnaire responses. In addition all the reasons advanced by them for dropping physical science did not seem to be anxiety-related at all. This does not mean that the pupils do not suffer physical science anxieties, but rather that only very few from the final interview sample of ten girls do. More important though, it probably means that unlike in mathematics where anxieties develop and play a major role in the mathematics performance and future of the child, there are other aspects of <u>physical science</u> that are seen by the pupils as being responsible for their final decision of whether or not to continue with it. In other words when there were any setbacks in mathematics, the girls often doubted their own ability to cope with the subject matter. This agrees with the findings of Wolleat et al (1980) and with Badger's (1981) review of research, where success in mathematics was attributed by girls to 'luck', while failure was seen as a result of lack of ability. Lack of persistence in a task would then be an obvious corollary of this attribution and could quite easily result in more girls giving up what they see as a 'hopeless task'.

For physical science though this did not seem to be the case and reasons were advanced which related more to interest in the subject and as was pointed out in chapter seven, this was linked to the perceived usefulness of the subject in terms of it being needed for possible careers, Hence those girls who were dropping physical science had no 'need' for the subject and consequently found that

> "I'm not enjoying science this year."
> "I don't like science, but I don't hate it."
> "I've never liked science and I don't know why."
> "I'd much rather do a subject I enjoy and consider other careers than sit through school struggling (with physical science)."
> "I didn't enjoy science .... I'm not interested in anything science (sic)."
> "Science didn't apply to me - I couldn't relate to it."

It can be seen that there was no hint of any anxiety related to the subject, but rather that the subject was not relevant or necessary to their needs and consequently simply not liking it, was an entirely adequate reason for not continuing with it. It was really an all-encompassing reason probably with many causes, not the least of these being parental interests, but anxiety was neither a cause nor a result of their feelings towards physical science. As was discussed in the previous chapter, doing well (or badly) was not an important reason in deciding whether or not to take physical science, whereas for mathematics it was the most important factor militating against someone taking the subject. This is linked to the comments about the pupils being more aware of mathematics anxieties and their consequent effect than of physical science anxieties, because performance in the former seemed to be of greater importance, than did performance in the latter.

It should be borne in mind that absolute measurements of anxiety are not possible and interpretations of any data need to be undertaken with circumspection, as subject-specific anxiety cannot be viewed as a unique and isolated affective factor. Trends obvious from questionnaire responses as well as group differences which emerge, do of course provide plenty of information, but the feelings expressed by individuals in an interview situation provide even more as has been seen by the information provided in the previous two sections.

8.4 Socialization

Socialization teaches us how to interact with other people, what behaviours are expected of us in various situations and what things are valued in our society (Forsyth, 1987). It takes place through social learning and we often learn attitudes by observing and imitating the actions and attitudes expressed by social models, such as our parents or peers (Bandura and Walters, 1963). Socialization also occurs when children (and adults) are subtly bombarded by the symbolic cues that define our culture. These hidden themes usually give rise to various stereotypes and are more often than not responsible for establishing the superiority of one sex over another in a particular area or activity. This process occurs in television programmes and commercials, books, comics, newspapers, etc. and even children who are not already sexist tend to become so if they watch a lot of television (Morgan, 1982).

The learning process begins very early in a child's life - probably soon after birth and this process is linked to the culture into which the baby is born and is also part of that culture. The baby will be cared for and learn from its parents, siblings and many others, all of whom are already socialized, but to varying degrees. The baby has certain needs and while everyone with whom the child comes into contact interacts with it, the immediate family (particularly the mother in most societies) is the primary agency in the early socialization processes. There are of course many things to be learned and also patterns of expected behaviour that must be followed. As the child grows there are socialization agents outside the home with which it comes into contact: relations, friends of the family, (pre-primary) school, church, playmates, etc. Ballantine (1983) writes that "variations in the process of early childhood socialization are tremendous, dependent on variables such as social class and family background, whether the child was wanted, and the health and personality of the family members and child." The implications of this in relation to attitudes towards education in general and mathematics and physical science in particular, are great. It can be expected that the immediate family and friends of pupils could have a considerable effect on determining whether or not that pupil decides to choose to carry on with these two subjects in the senior secondary phase of high school. (See Noble, 1986 as well as Section 2.3.2.5 where the environmental effects were mentioned and structured in a diagram.)

The socialization process is of course continuous even in a person's adult years, but an individual can be regarded as socialized when he or she "behaves so that other people in the society can predict his behaviour within reason and deports himself in a manner that 'fits him' into the company of those people". (Dressler and Carns, 1973.) It also means that the attitudes a child may have in relation to mathematics and physical science will continue to be built on (or changed) and that the cumulative nature of the socialization process will contribute to this on-going acquisition of culture and of attitudes towards education.

Socialization is achieved by both formal and informal means. The major factor in formal socialization is by means of direct instruction and here the school plays the dominant role. Much of this was discussed in chapters six and seven and specifically in Section 8.2 where the role of the teacher in the determining of attitudes and the subsequent subject choices made. This discussion was from the point of view of the pupils and used the information they had provided over the three-year span of the longitudinal study. At school though, informal socialization also takes place through the pupil's interaction with the peer group and informal contact with the teaching staff. Out of school hours the family, friends and important others (e.g. relatives, other adults) are all part of the informal acquisition of societal norms, but because there are so many varied sources of input, conflict can develop. Dressler and Carns (1973) maintain that "the more in agreement the socializing agents are, the more securely and rapidly socialization of the individual takes place". The home frequently transmits ideas that clash with those of the peer group and even the school, which could then be a third side of a triangle in this regard. The attitude of a parent toward formal schooling or the importance of mathematics or physical science as necessary school subjects could easily clash with the ideas of the school and this could result in the impeding of the socialization process.

Raven (1980) is of the opinion that "different parents want their children to develop very different qualities". He maintains that more parents from the upper socio-economic groups are more likely to emphasise the importance of their children's developing intellectual abilities and interests and wish them to think for themselves, to be curious and to question authority. Those parents with lower socio-economic status are more likely to emphasise the importance of their children "developing not independence but deference, obedience, and dependence".

He makes the interesting point that the schools are probably closer to the latter situation and appear therefore to be guided by 'working class' values and not by 'middle-class' values as has been thought to be the case. It is important that the child values the goals towards which he or she is working and with the home probably being the major influence in this regard, the school must obviously set the tone. Raven continues by saying that "it might be more desirable to seek to make schools more like the homes of these parents (the better informed members of society) than to try to make the homes of 'working-class' parents more like most schools". If the school doesn't adopt this stance, then lacking the agreement of the two socialization influences, the outcome is uncertain. In the situation where the 'working-class' values are being sought, if what Raven maintains is in fact correct, then the reinforcement of the two agencies will continue the stereotype and unquestioning obedience and compliance with external standards will become the goal. This would result in a completely undesirable situation as far as education is concerned and confirms the need for the schools to take the lead.

There are many socialization agencies, but during the interviews conducted with the ten girls and their parents during the final year of the longitudinal study, the role of the family, the home environment, 'important others' and the stereotypic views of sex roles and career opportunities all emerged as playing significant roles in the formation of attitudes towards physical science and mathematics and ultimately in their decision as to whether or not they should take these subjects in standards eight, nine and ten.

Forsyth (1987) notes that "the beliefs and expectations about yourself that are based on your biological gender are collectively termed your sex role". Femininity and masculinity were once regarded as being on opposite ends of a continuum, but during the mid-seventies this assumption began to be questioned and Bem (1975) suggested that masculinity and femininity were separate traits. She propounded that androgynous individuals were those individuals that displayed both masculine and feminine attributes and characteristics. By contrast those who were low in both masculinity and femininity were termed undifferentiated.

Sex roles affect our perceptions of the world around us to the extent that strongly sex-typed individuals divide the world up into two mutually exclusive categories, male versus female, and then place items in one of these categories (Larsen and Seidman, 1986). Forsyth (1987) notes that many differences between male and female that were thought to be caused by biological factors, "are in fact determined by social factors". He is of the opinion that men are not destined to be masculine or women feminine, but rather that "our culture creates masculine men and feminine women by convincing us that certain actions and attributes are reserved for males and others for females".

The interviews with the girls and their parents will be discussed under various headings in an attempt to highlight the parts that these forces play in the socialization process.

8.4.1 The Parents - General Attitudes and Importance of the Subjects

During the interviews with the parents, they were asked in a non-specific way (non-specific because of the way the interviews were structured) how important they thought mathematics and physical science were as school subjects. This was not aimed at how it related to their own daughter, but rather to their perceived general importance of the subjects.

With one exception, all the parents rated mathematics from being fairly important to vitally important. One set of parents was not all that convinced about its value though, and were somewhat scornful and felt that other "parents think it's the be-all and end-all to have maths in matric (standard ten)". There are two points to be made from this comment. Firstly, it shows an acknowledgment by them of how important mathematics is thought to be by most people and secondly it provides a strong pointer as to some of the possible reasons why their daughter decided to give up mathematics (this latter point will be discussed later). There was an undoubted feeling though that mathematics was very necessary and they all, to varying degrees, wanted their children to take it if possible. Their reasons for rating it as an important subject were, however, totally along career lines in that they thought it was necessary in order to have a wider choice of careers. Enjoyment was hardly ever a reason and nor was it ever attributed to developing an individual's 'roundedness' or general outlook on life.

Some of the reasons given were:

> "Virtually any career they want to do they have to have maths for."
>
> "It is important for a youngster's future .... because it's a technological field and people need maths."
>
> "Maths is very important in this electronic and computer age .... when they go job-hunting, if they write down maths it is definitely a good basis whether its a maths-related job or not."
>
> "When you are taking on personnel, the first thing they get asked it 'have they got maths?' .... people with maths will always get the vacancies."

The next comment sums the above up very nicely, but poses a problem at the same time.

> "You have a wider choice of careers if you have maths, but I don't know why."

There seems to be a blind acceptance of the importance of the subject, not only by parents but by employers and society alike. This is almost certainly the view that most people have that (rightly or wrongly) mathematics results serve as a readily available intelligence score by which much can be evaluated. The following quotes from the parents of a girl who actually dropped mathematics, illustrate this point:

> "If you hear somebody saying .... if he says maths is his good subject you automatically think that that child is brilliant, but it just falls into place that everything is working out for him, meanwhile maths could be his only strong point .... It's such a feature .... it's the most important subject at school. If he's good at maths then it's taken that he's a general achiever .... parents are more concerned about maths than any other subjects."

There is of course no harm in people holding this point of view, except where it is not (entirely) justified because the person who is not able to continue with mathematics (for whatever reason) will in fact be discriminated against. This will be mathematics acting as a "critical filter" (Sells, 1978), sifting out people and preventing or discouraging them from continuing into areas where they could possibly have coped even without mathematics. Another aspect to achievement in mathematics being seen as a type of 'intelligence test' is that as mentioned in Section 8.3, anxieties can develop which are then detrimental to further mathematical development and even possibly in other subjects as well. All this can probably be attributed to the pressures which are brought to bear on the children and the over-emphasis on mathematics results being necessary to achieve academic competence and success.

Returning to the quotes from the parents it is obvious how narrow the reasons are that were given as to the importance of mathematics. For a pupil who does not find mathematics relevant or 'necessary for a career', there can be no reason whatsoever to take the subject and it would seem that from the home situation no justification would be found either and the consequences are then predictable.

All of the above deals with the importance of mathematics as viewed by the parents of the girls involved in the final stage of the longitudinal study. What then of their view of the importance of physical science and the desirability of taking it through to standard ten. There was a great deal of uniformity in the discussions in this area and the consensus was that it was important, but in every case it was viewed as being of lesser importance than mathematics. However, a major difference in what the parents felt about the two subjects is that while they thought that mathematics was important and desirable for everyone, physical science was less important, but should only be taken by someone who was inclined in that direction. The following quotes should illustrate this:

"Maths is much more important than science, ... but I would push both if they can do them."

"Maths is a little ahead of science (in importance)."

"Science is also important, but not in the same league (as mathematics)."
"Maths is more important at school than science .... it depends on your interests and where your future lies."
"Science is important if they enjoy it and if it links to a career."

While the parents regarded mathematics as being important from a career point of view, the careers would rarely have been mathematics-related, but mathematics would have been serving as a qualification in order to proceed to the next step. Physical science on the other hand was regarded as important, but only in relation to it being relevant to someone who already showed an interest (or a 'bent' as one parent described it) in that direction i.e. it was specifically career-orientated unlike mathematics which had a more general application.

Viewing this from the socialization angle, it is very clear how the parents have been socialized in a remarkably consistent pattern as far as both mathematics and physical science importance and need are concerned. The on-going process in turn has been carried on to their own children and the next section should demonstrate if this is in fact happened or not.

8.4.2 The Parents and the Pupils

How then did the daughters of these parents perceive what their parents views regarding mathematics and physical science were and what they would have wanted them (the girls) to do as far as their subject choices were concerned? In this section the pupils' views and the views of their parents will be discussed together, but will be done in three groupings which are determined by their subject choices.

8.4.2.1 Those Dropping Mathematics

Although these four girls also dropped physical science, they were the only individuals dropping mathematics in the group and thus it was this subject that was given most attention in their interviews and comment is therefore limited to mathematics.

Girl A received a great deal of encouragement from her parents and she was well aware of what they wanted. "They encouraged me and wanted me to do maths .... 'if your sister can do it then so can you'. They felt it was necessary". This was in fact correctly interpreted by her as the comment of one of her parents shows.

> "I tried to encourage her, I didn't try to force her .... We thought an A-stream child (their own labelling of her above average general academic ability) should do maths."

If she received such positive treatment what then could possibly have caused her to drop out of mathematics? Two factors probably contributed to this. Firstly her parents both admitted that they couldn't "grasp" mathematics at school and that their own uncertainty about the subject was almost certainly conveyed to their daughter. Seeking advice is obviously an essential part of the decision-making process, but the mother's comment about how they went about it, hints at uncertainties that the daughter was experiencing that could have been magnified by their discussions. "I asked her to get advice from school, because I don't really know how to advise her there - it worried me". This could well have contributed significantly to the second factor which was the girl's strong feelings of anxiety about mathematics. It was reported in Section 8.3 that she of all the ten girls showed the most anxiety (girl A) and despite the outward positive encouragement received from the parents, their doubts about their own abilities and their ability to assist with the decision, could well have been the deciding factor in helping her to convince herself (and her parents) that she should drop out of mathematics.

Girl D received weak encouragement from her father to carry on with mathematics, but then as she said, "he wouldn't have forced me to do it". It was in fact her mother who exerted the greatest influence on her and even during her interview the previous year during standard seven, she had stated that her mother had done mathematics at school, but didn't like it and had found it very difficult. The daughter said that she was "scared she was going to fail it in matric" (standard ten) and that her mother had said it "If I wasn't going to enjoy maths I mustn't take it because it's going to spoil my last few years at high school." This was an amazingly short-term outlook the mother had, but it seemed to be a fairly common situation and occurred in some of the other families as well. This girl (D) had coped very well with mathematics at primary school when she knew <u>exactly</u> what was expected of her, but had faltered in high school (see Sections 8.2 and 8.3) when the problems had more than one step and the requirements were less prescriptive. Although she was academically sound, her mathematics marks and confidence had dropped a lot and with her mother creating this totally negative escape for her, she took it gratefully.

Girl B was also exposed to positive attitudes from her father and in fact experienced a very similar home environment to the previously discussed girl (D), in that her mother had also had very negative school experiences as far as mathematics was concerned. The daughter was aware of this and said about her parents:

> "My dad was very mathematical .... he would've liked me to carry on, but he didn't shout at me when I stopped. My mother doesn't like maths, she can't do maths .... she battled at school. I was always aware that she couldn't do maths at school because she'd say 'I couldn't do maths either, you've got my half'."

The daughter was certainly not left in any doubt about her mother's feelings and when in standard seven she encountered difficulties with her mathematics teacher and her mathematics (see Section 8.2), the die was already cast. Her mother confirmed her daughter's feelings (without knowing what they were) and while she still insisted (not all that firmly though) that she would have preferred her daughter to take mathematics, she agreed that she had very definitely conveyed her own attitudes to her daughter and "that's why it was O.K. for me that she dropped it". She added that "I'm also (like the daughter) geared more towards art - maths and science don't interest me one little bit."

Thus a girl who at the end of standard six had anticipated continuing with mathematics through to standard ten, encountered difficulties during standard seven and with her mother leaving her no doubt as to what she thought she should do, she rapidly fell apart during the year and consequently dropped out of mathematics.

The fourth girl of this group who dropped out of mathematics (girl C), was academically well above average and although she was not doing as well in high school mathematics as she had in primary school, she was still scoring sixty percent. To her mind this was not good enough, and during standards six and seven her attitude towards the subject deteriorated drastically. When the parents' feelings and experiences related to mathematics are considered though, the fact that their daughter suffered this decline is hardly surprising. She (the daughter) was left under no illusion as to how her parents felt as the following comments show:

> "My parents never said that we (the children) must do maths, but other adults did .... my parents were totally neutral about maths as no-one in the family is interested in maths .... They didn't mind what subjects I took as long as I was happy."

Once again this rather surprising short-term view was exhibited. The daughter had a fairly clear picture of the situation, but when the parents were interviewed they painted an even stronger picture.

> "When I met T... (husband's name) and mentioned to him how weak at maths I was, he said, 'welcome to the club' - so our poor children didn't have a chance .... All the children are far better at language and content and battle with maths and have the family maths block."

This last sentence says it all. The whole family (2 boys and 2 girls) were destined to be steered away from mathematics even though there were some positive efforts by the parents. However, comments such as "I'm sorry I can't do this sum, but I'll phone my cousin - he's good at maths and he'll come and help you" would have created an extremely difficult background against which to develop or maintain positive attitudes towards mathematics. The mother felt that her daughter would have passed maths in standard ten, but her parting shot was "why put yourself through all that unhappiness for three years - give it up" (the short-term view again) and this certainly put a seal on the whole debate as far as their decision was concerned.

Poffenberger and Norton (1959) established significant relationships between parental encouragement and the mathematics attitudes of their children, while Armstrong and Price (1982) found that participation in mathematics was significantly correlated with the encouragement given by both mothers and fathers. The reports of the four families presented above, all (to varying degrees) fall in the negative (or low) encouragement bounds and thus conform very well to the findings of these two pieces of research. Looking deeper at the fact that it was the very negative attitudes and the short-term views of the mothers in <u>all four</u> cases that probably had a profound effect on the attitudes and decisions of the four girls, a study quoted by Fox et al (1979) showed that 75% of the mothers of girls doing badly in mathematics accepted this as inevitable because of their own lack of ability in the subject. It must be realised that these were not situations that had arisen suddenly, but had been on-going environments in which the negative feelings that the mothers possessed (all of whom were fairly strong characters in the partnership), had played major affective roles in the socialization processes of their daughters.

8.4.2.2 Those Taking Mathematics and Dropping Physical Science

8.4.2.2.1 Their Mathematics

The home backgrounds of the three girls who opted to take mathematics, but drop physical science, are characterised by very strong influences to continue with mathematics. In two of these homes the fathers were the more dominant partners and their attitudes towards mathematics were very strong and positive. In the third home, the father was also positive, but his wife held very strong views which favoured her daughter taking mathematics. In this latter case the daughter was, however, more overtly influenced by her father as her comments indicate.

> "My father has always been interested in maths - when he talks about school, he talks about his maths .... Maths was important in his life".

The interesting part about the interview with these parents was that it was obvious, but only after studying the tape-recording several times, that at no stage was it necessary for them to convince (or even discuss with) the daughter whether or not she should take mathematics - it was simply assumed by all parties that she would. This incidentally was not the case for physical science as will be seen later.

In the other two cases, it was the wives who provided the information about their husbands' attitudes, but it was these attitudes that set the scene as far as the home was concerned. Both mothers were neutral about their daughters proceeding with mathematics and it could well have been that if the strong positive influence of the fathers had not prevailed, other subject choices might have resulted.

One of the girls (E) stated that her father "has a very positive attitude towards maths - he did well at maths. He thinks I'm clever and so I must do it, but mostly he wants me to do it because he did well at it". This seems to be a fair assessment of the situation, because her mother said his "involvement in maths has rubbed off on the children - in an indirect way they've picked up positive vibes". Her involvement with her children was minimal as far as mathematics was concerned and "maths - they won't come to me" says it all. She was satisfied because of her husband's strong involvement to take a back seat and she was only comparatively negative in that she was neutral about her daughter electing to continue with mathematics.

The other girl (G) was not really aware of what her parents felt, but while her father's influence might not have been strongly overt, judging by the mother's comment concerning how positive her husband's was, it must have been strongly covert. The daughter claimed that her father "recognises each individual's ability and takes it from there" and she construed this as not knowing what her father felt about mathematics (and science). Her mother was worried that she might have had a very negative effect on her, but it is possible that the daughter was unaware of these because her father had counteracted them effectively. The following quotes should illustrate this scenario.

> "I sometimes wonder if I scared her - I wondered if I'd given her a kind of feeling that maybe she'd inherited a maths block. One does influence one's children and sometimes in a negative sense - and not meaning to do that."
>
> *Interviewer:* "How?"
>
> "By saying `oh your mother's a duffer .... and I've never found I needed maths".

And then some comments about their older daughter which summarise this effectively:

> "In the high school when she (other daughter) started to

> encounter difficulties - my response was 'maybe you should change subjects', but I haven't gone on with that because B.... (husband) has such a positive attitude towards it (mathematics) so there possibly is a balance in our family and now she's beginning to pick up again".

This last quote indicates quite clearly what easily could happen when someone encounters difficulties and then is allowed to fall by the wayside. However, it also makes quite clear what effect positive attitudes can have and here the fact that the daughter was "beginning to pick up again" was encouraging to the whole family.

In summary then, just as the negative parental outlooks and encouragement mentioned in the previous Section (8.4.2.1) could well have resulted in negative attitudes and a consequent dropping out by the four girls, so the effect of positive encouragement and attitudes probably has a positive effect on their attitudes and mathematical futures. This is then in agreement with the findings of Poffenberger and Norton (1959) and Armstrong and Price (1982), as well as those reported by Fox et al (1979). In particular, Poffenberger and Norton (1959) had established that the children's attitudes correlated with their father's attitudes, but not with their mother's and this is borne out in these interviews with the group.

8.4.2.2.2 Their Physical Science

The three girls discussed above had all opted for mathematics, but had dropped physical science. The home background as far as mathematics was concerned was generally positive (especially the father's) and the possible results of that were mentioned, but what of their feelings about physical science?

In Section 8.4.1 it was stated how much emphasis was placed by the parents on the importance of physical science being linked to career opportunities only. The three families interviewed for this section were certainly no exception. Girl E felt that as far as her parents were concerned, "he (father) hasn't pushed me at all and my mother didn't do science and I'm like her, I'm not interested". Her father actually was very keen for her to take physical science, but this message didn't get through to her as her comment above suggests. Her mother's attitudes were more dominant and were quite clear.

> "Unless it's something that's going to help her in her profession .... I don't know if it's important at all".

Her father felt that she showed aptitude for "mechanical things" and was therefore disappointed that she was dropping the subject. She had decided to take accountancy though and so physical science did not fit into her career plans and therefore fell by the wayside.

Girl H had similar career aspirations and as far as she was concerned her father saw mathematics as being important, but "science is not as important in his life". Her mother had a similar outlook to the previous case discussed and felt that "they can't indulge in the luxury of doing science if they need to do accountancy .... A few exceptional girls are particularly interested in science .... biology is more functional".

There seems little doubt that physical science only had career-importance in these families and that the feelings were so strong about those girls not following any career related in any way to physical science, that the possibility of them taking the subject was not even given a second thought. In the case of the third family, this was probably also the case, but in this situation there was evidence as to why this might be so. The reason is almost certainly related to stereotypes and sex-roles and so will not be discussed here, but rather in a later section where these topics will be dealt with specifically.

8.4.2.3 Taking Mathematics and Physical Science

Three girls fell into this category, but one of the three had originally planned not to do physical science and was selected originally on that basis. She (girl F) had an interesting background in that her parents had encouraged her academically, but their own mathematics and science backgrounds were so limited that by their own admission they gave her no real direction because "we didn't know enough about it". Fortunately for all concerned, the daughter was getting over eighty percent for mathematics and was self-motivated in deciding that she would carry on with it. When still in standard six she had thought that she would and her reasoning was "I think it will give me a wider choice of careers". When making her choice in standard seven she cited the subject's interest to her and its usefulness as being the reasons for her decision. She felt that her parents had given her "no real encouragement" and that they were "both very easy about this". Mathematics as a subject had always appealed to her to such an extent that despite no real encouragement and despite experiencing some anxieties about her ability (while nevertheless scoring good marks - see Section 8.3), she had no doubts or problems about continuing with it.

Physical science, however, was a different situation because she did not find it at all interesting and as for the mathematics, got no encouragement from her parents at all. After having decided at the end of standard seven not to take it, she changed her mind during the Christmas holidays when close family friends (involved with education at school level) had discussed over a period of several weeks whether or not she had made the correct decision. She felt that "they (the adult friends) seemed to know a lot about it (subject choice)." It was the first adult advice that she had been given and after many of her friends (who had decided to take science) had raised doubts in her mind a few weeks before about not taking science, she was very receptive to the discussion and the benefit of the necessary guidance and counselling was warmly welcomed. It required very little encouragement for her to change her mind and likewise her parents, who had felt quite at sea about the decision were happy about the advice that was given.

The other two girls (I and J) who both selected mathematics and physical science, did so for more straightforward reasons. Both received good support and encouragement from their parents, but while one set of parents had engineering and paramedical backgrounds and their daughter had them as examples, the other had no scientific career backgrounds at all, yet their encouragement to their son (older than the daughter) and the daughter was firm and obvious to the children. In the latter case the encouragement in science was not as strong as it was in mathematics and it is possibly this difference which has been responsible for both their children (both still at school) not considering scientific careers, but still regarding science as a worthwhile subject to do at school. The parents of this girl admitted "we don't have the background" and although they felt that they "hadn't influenced her in any way", the daughter was of the opinion that "mathematics is strongly encouraged both outwardly and by transmission of feelings .... but science is not encouraged in the way that maths is".

The other girl had not felt that her parents had pushed her but that "he (her father) must think that maths is relevant because he's an engineer .... I don't talk to him specifically, I just notice it. Science is the same importance as maths - I think". The parents both thought that they couldn't let her drop science unless she absolutely hated it and "if she's unhappy with it, she must do it, and if she's debating between science and say geography, or science and art, I won't let her .... I would actually put my foot down". This hadn't actually been said to her daughter, but probably conveyed covertly over the years without any discussion.

Thus once again the value of encouragement and good parental attitudes are highlighted and would seem to fit in very effectively with the previous research mentioned -

Poffenberger and Norton (1959), Armstrong and Price (1982) and Fox et al (1979).

8.4.3 Stereotypes

"Whether positive or negative in value, stereotypes facilitate standardization of attitudes in a culture (Dressler and Carns, 1973). These stereotyped attitudes provide bases for anticipating the behaviour of others and possibly adjusting one's own behaviour accordingly. Thus stereotypes can influence the behaviour of individuals or even whole groups and consequently perpetuate cultural beliefs and values and in particular, sex-role behaviours. These stereotypes result from socialization and the role that societal systems play, but are also responsible for the perpetuation of beliefs for which the individual can have no justification other than, "it's always been like that - it's traditional". In a society where gender differentiates roles, it follows that attitudes and behaviour will be influenced by what is deemed to be sexually appropriate. If these attitudes are extended into the possible 'maleness' of mathematics and physical science then it is entirely likely that the level of effort and perseverance in these subjects will be different for boys and girls.

The interpretation of the male/female role (where applicable) will vary extensively with individuals and Badger (1981) concludes that "the value of any task reflects not only society's judgement of sexual appropriateness but the value that appropriateness holds for the individual". Thus the sex-appropriateness of tasks would probably affect behaviour by influencing the expectation that the pupils have and the values that they place on achieving success in a task.

Results from the two previous chapters would suggest that this group <u>has</u> been subjected to attitude and sex-role stereotypes and it is important to ascertain whether these girls are aware of the existence of such stereotypes (especially sex-role stereotypes) and if their parents are as well. Should this prove to be so, than it will be necessary to examine whether or not the parents played any part in the creation of any stereotypes or of effecting stereotypic behaviour in their children.

8.4.3.1 Are the Pupils Aware of Any Sex Stereotypes?

In order to answer this question, information from the standard six questionnaire (which was the starting point of the longitudinal study) as well as from the standard seven and eight interviews was examined.

A conclusion from the responses to the standard six questionnaire was that there was in fact a strong prevalence of sex-role stereotypes. This was in the area of mathematics, but more particularly physical science, for them being 'male domains' and also in the pupils' views on maths-related and science-related careers.

For the standard seven interviews a similar situation prevailed, but with distinct differences in opinions between the various groups of pupils who were either taking or not taking mathematics and those who were either taking or not taking physical science. (Discussions on the sex-role stereotypes and career stereotypes with regard to mathematics and physical science can be found in Sections 7.2.1.1 and 7.3.1.1 respectively.) Considering the ten girls who were followed through into standard eight and looking at some of their responses when they were interviewed during standard seven, it is interesting to note that of the four girls who opted not to continue with mathematics only one thought that mathematics was a 'boys subject'. However, all four of them thought that if they were boys they would have taken mathematics. A conclusion that can be drawn from this situation is that they do not see the subject mathematics as belonging to the 'male domain', but they do have a sex stereotyped view of mathematics-related careers. Physical science was viewed very differently though and six of the seven girls who subsequently dropped it, thought that it was a 'boys subject' and all seven of them would have taken the subject if they were boys. This implies that in their view, physical science has a much greater appeal to boys and that because of the 'maleness' of science-related careers, it was a subject that boys should not avoid at school.

8.4.3.2 Sex Stereotyping and the Home

Maccoby and Jacklin (1975) report sex-appropriate behaviour in children as young as four years of age and this could be interpreted as being damaging for the socialization theories which argue that sex typed behaviour is learned and not innate. Kelly, E. (1981) notes though that "the same studies which have demonstrated sex differences in young children's behaviour frequently make the point that, however early the differences appear, we should not assume they are innate". This is based on evidence that boy infants "are handled and physically stimulated more than girls, whereas girls are talked to more". As stated earlier, the socialization process starts very early in life and this particular aspect of socialization is (probably unwittingly by the parents and others) starting a process which can quite possibly lead later on to the formation of sex stereotypes which will affect the attitudes of the boys and girls towards many areas of life including education and towards mathematics and physical science in particular.

It is probable that sex stereotypes and stereotypic attitudes on the part of the parents resulted in the formation of similar stereotypes and attitudes in their daughters. The interviews conducted with these two groups will be analysed with a view to speculating on this possibility. More time was spent on this issue in the interviews with the parents than in those with their daughters, as it was the parents' part in the socialization process which was being investigated.

8.4.3.2.1 The Sex Stereotyping of Mathematics and Physical Science by the Parents

All but two of the sets of parents had fairly strongly held viewpoints that mathematics and physical science were sex stereotyped. A major difference though between children and parents when talking about these two subjects, is that the pupils will relate their ideas largely to their experience with the subjects as they meet them in the classroom, whereas the parents' ideas will be virtually completely related to their concepts of the subjects as they apply to maths-related or science-related careers. An idea of the various outlooks will be gained when considering some of the quotes from the parents. The purpose of this selection is simply to illustrate how sex stereotyped their perception of careers is. The quotes relating to mathematics and physical science will be dealt with separately.

> "It's more important for boys to go through with mathematics than it is for girls."
> "I felt that boys had the brain for maths more than girls."
> "Virtually everything a boy has to do deals with maths particularly."
> "If a boy doesn't have maths, he's very severely restricted .... more so than a girl."
> "Boys have more job opportunities related to maths and science than girls do."
> "Maths is more useful for males."
> "The careers (mathematics and science) are more suited to the boys, ... but there is a tendency for the boys to favour those subjects."
> "There is more of a field for a boy with maths."
> "I regard them (mathematics and science) as very important - particularly as far as boys are concerned."

These comments are from nine of the ten families and demonstrate the commonly held view that mathematics is more important for boys than it is for girls. An aspect worth noting is that this outlook is common to all the families representing all the various subject choice options. Thus the parents of the girls who have chosen mathematics and the parents of those who have dropped mathematics all have the same general opinion, but this doesn't necessarily mean that they think that this applied to their daughter, and it is here where the difference lies. This point will be looked at when individual families are discussed.

As far as the sex stereotyping of physical science was concerned, the comments were much the same as they had been for mathematics.

"Science is more important for boys .... Girls don't need science."
"I think it (science) should be equally important for boys and girls, but it's not."
"Girls can't indulge in the luxury of doing science if they need to do accountancy."
"A few exceptional girls are particularly interested in science .... biology is more functional."
"Possibly for the girls it's not so important (science)."
"Science is more for males - science is not as important for employment as maths is."
"It seems more expected of boys (taking science)."
"Science is not so critical for a girl, but it is for a boy."

There can be no doubt from both the physical science and mathematics comments above how the parents of this group of girls felt about the difference in the importance of the subjects for girls and for boys. This would seem to suggest that virtually all the girls would not be persuaded to take the subjects at school level, but this serves to highlight a point that has been made throughout this thesis that no one factor is ever responsible for a pupil's decision to drop out of a particular subject. In addition though, the attitude of a mother or father regarding boys and girls in general is not necessarily what they would want for their own son or daughter.

8.4.3.2.2 The Individual Cases

All of the ten girls and their parents have been quoted in the various sections of this chapter, but at differing lengths because the particular focus of interest varied with each person. As far as stereotypes are concerned, three of the ten girls (and their parents) made comments which were of a general nature rather than being specific to the three girls themselves. These three interviews focused on different areas and have been covered in previous sections of this chapter. Accordingly only the other seven of the ten cases will be discussed and these will be done separately, but will be grouped according to final subject choice.

8.4.3.2.2.1 Those Dropping Mathematics

Girl C

In this family, the mother and father had such incredibly strong negative feelings about mathematics because of their own experiences at school and these were made known in no uncertain terms to the four children. Like her older brothers and sister, this girl also dropped mathematics and thus justified perfectly what had been described by the parents as the "family maths block". She was well aware of her siblings' feelings and experiences and although maintaining "my brothers are quite intelligent in learning", (and she was regarded as being the most intelligent in the family) she quite correctly forecast her ultimate mathematical demise and bore out what Burton (1979) referred to as the self-fulfilling prophecy, also known as the Pygmalion effect (Forsyth, 1987). It is almost as though there was a family stereotype rather than a sex stereotype as far as mathematics was concerned. The daughter was aware of sex stereotypes because she said of one of her brothers (who has subsequently obtained a commerce degree) that he "was worried - a boy can't get anywhere without maths". He was persuaded by his mother that that wasn't so, despite the father maintaining that "there is more of a field for a boy with maths - there are more opportunities". She also thought that mathematics was a boys subject because 'boys need maths for their careers .... and are more interested in working out tough problems". For the girls in the family though, the decision to take or drop mathematics never really posed a major problem and one of the father's comments bears this out; "I would like to have had a son who was brilliant at maths". This possibly all shows that there was a sex stereotype of the subject, which thus enabled the father to go along with allowing his daughter (who was doing reasonably well at mathematics, but not well enough by her own standards) to drop the subject, but that this sex stereotype was overshadowed by the mother's negative outlook towards mathematics and also by what was termed above 'the family stereotype'.

Girl B

Although claiming that she disagreed, the mother of this girl thought that 'society' believes that for girls, mathematics is not as important and that the careers linked to mathematics are more suited to boys and so there is a tendency for boys to favour these subjects. However, nothing else that she said implied that she had in fact done anything to counter this sex stereotyped view that society had. In fact she stated that because she hadn't taken mathematics to standard ten "that's why it was O.K. for me that she dropped it" and that she had conveyed as much to her daughter. The father also thought that "possibly for the girls it's not so important" and while saying that he was keen for his daughter to continue with mathematics he accepted the situation because he didn't think that "as a girl it was all that necessary."

The mother hit the nail on the head as to what swayed her in helping make the decision for her daughter to opt out of mathematics when she stated, "boys are made - they are pre-programmed as far as these things (mathematics and related careers) are concerned. Girls are pre-programmed differently". This statement probably sums up what the mother's attitudes towards the subject were based on, and what she had conveyed to her daughter.

Two assisting factors in her decision not to continue with mathematics were: Firstly the family opinion on how her brothers had fared with mathematics in the higher standards when the father said, "the whole family is aware of how the brothers battled with maths"; and secondly the mother felt that "her friends don't do maths either and she was influenced by them". This latter point regarding the socialization process and the child's interaction with the peer group is an important factor and Serbin (1983) quotes several studies which determine that "the influences of peers as agents of differential reinforcement may thus be considerable".

In summarising these two cases it would appear that the negative experiences of older siblings and the negative attitudes towards mathematics which prevailed in these two homes, were strongly influenced by sex stereotypes which were both overtly and covertly conveyed to the members of the family by various socialization influences, but definitely via the parents.

8.4.3.2.2.2 Those Dropping Physical Science

Girl H

In this family the sex stereotyping of physical science being a male domain was not all that strong, but a comment which was quoted in an earlier section is certainly a pointer that stereotypes did exist. The mother (who has a forceful nature) proclaimed that girls "can't indulge in the luxury of doing science" and that only "a few exceptional girls are interested in science". Whatever the parents' outlook was, the daughter had the feeling that science "was a boys subject - a little bit" because "they enjoy it more .... and are more familiar with it". Of importance was that she thought that the home influence was important and at a later stage said of her father that "science is not as important in his life (as mathematics)".

An important factor, however, was the influence that her two older sisters had on her. They recommended that she didn't take science (they hadn't) and this advice was eminently acceptable to her in terms of her image of science and "fitted in more with what I wanted to do". In other words an atmosphere of non-science prevailed and the stereotype of the non-science involvement of girls was securely established and consequently this significant socialization factor had its effect.

Girl E

As for the girl last discussed, a strong socialization factor existed which totally rejected science as a possibility for the daughter (and possibly all girls). Both mother and father deemed science as being more important for boys, and girls quite simply didn't need science. Asked whether or not they thought boys coped better with the subject, the father thought that this was "possibly" the case and the mother felt, "yes - it comes naturally to them". There are no boys in this family and thus she had no way of gaining that knowledge other than by what she had heard from other people and of course from the generalised opinion of 'society' and what "everyone says". The daughter likewise was of the opinion that science was a boys subject because "it is relevant to their (boys') careers". In other words girls don't have science-based careers. This viewpoint has already been established earlier in this thesis (see Section 7.3.1.1) and fitted in well with the daughter's comment that "my mother didn't do science and I'm like her - I'm not interested".

Girl G

As is well known, the socialization process starts soon after birth. This girl stated that she knew when she was in standard two (age of nine) that she didn't like science, a subject that was very new to her. Finding a possible reason for this early opinion was both interesting and rewarding. She (during standard seven) had no idea why she had never liked the subject and suggested that it was to do with the syllabus content being very boring and being of no interest to her. What precipitated this outlook though? She said that it had nothing to do with the teacher, but eventually mentioned that her father "talks to my brother because he's interested, and not to us (her and her sister)". She explained further that she and her sister "complained that my dad wasn't doing enough with us, but he said he didn't know what to do with the girls - should he take them to the ballet or opera or whatever?" Here were classic symptoms of stereotypes of boys' and girls' interests being applied by a father who was in fact very concerned and involved with <u>all</u> his children. She then explained that her father had brought out his Meccano and his train set for the son (who was younger than both girls) and that at no stage had they ever been asked if they would like to play with those toys.

When the parents were interviewed a few weeks later, they verified everything that the daughter had said, but were not told at all what she had in fact discussed with the writer at her interview. The mother said he "pulled out his Meccano which he had kept (for his son) and .... we didn't give the girls the opportunity". The father confessed that "I didn't really consider them - the train as well." This is in keeping with what Kelly, E. (1981) reported on as being part of the perpetuation of traditional stereotypes as far as toys were concerned. The father also felt that he did far more with his son than he did with his daughters and as the interview proceeded he stated that "it's funny - I think I might be fitting into this male/female thing .... I think I was (referring to his daughters) more orientated towards the more traditional male careers". He was realising for the first time that he had prevented his daughters from developing any interest in science and continued, "despite what I said earlier on about the importance of science, I can't say that I really encouraged her <u>not</u> to drop". Even this stage would have been too late though, as the whole parental involvement with the socialization process had been continuing for years - and the effect completely unbeknown to both mother and father. The mother confirmed that her husband "does more with his son than his daughters" and he claimed "I would have liked to have done more (with the girls) than I have done, but they haven't responded in the same way". This was probably because they had 'successfully' been taught their particular sex role and were therefore hardly likely to have responded positively anyway. This was almost certainly confirmed when he stated that "he was very keen to develop a sense of what the son's (all boys) position is in society .... and that the male is more dominant as far as leadership is concerned".

Returning to the daughter's categorical statement "science has been out since standard two", it is therefore hardly surprising that the two girls both dropped science, having both been subjected to such emphatic sex-role stereotyping. The socialization process that they experienced at home was definite and influential and had the consequent sex-typed effect.

8.4.3.2.2.3 Those Taking Both Mathematics and Physical Science

Two of the girls who chose to take both mathematics and physical science will be discussed. Both of them were subjected to sex stereotypes, but were able to counter these because of other factors which were positive e.g. the encouragement they received from their parents. It is interesting to note though, that in <u>all</u> the situations where the other girls dropped either mathematics or physical science, the mothers were not encouraging (and often negative) about their daughters continuing with the subjects, whereas for subjects which the girls decided to take, they were in favour. The latter was also the case for these two girls.

Girl I

The parents of this girl did not really feel it necessary for their daughter to do physical science, but were both very pleased that she did choose to do them. They did feel that if a girl has mathematics and physical science "she can go into the man's world .... she can compete on a man's level". They acknowledged the existence of stereotypes, but did not discourage their daughter from entering into this man's world and by doing so they reinforced the daughter's determination to carry on with science. They had both been positive about both subjects (mathematics in particular) and the daughter commented that "maths is strongly encouraged, but science not quite as much". This was an example of the professed existence of sex stereotypes being countered by other socialization factors.

The daughter noted about children's toys that it was quite acceptable that girls could play with so-called 'boys toys', but that the reverse was frowned upon by society. This commonly held view can be seen as an entrenchment of the stereotype of the male domain being the norm. Science and maths would correspond to this and could be entered by females, but they would know that they were then playing with 'boys toys'.

This same girl made another interesting comment about girls who weren't achieving in mathematics. She claimed that they don't try to improve "because they are scared that they are not going to be able to". This is sex stereotyping excusing the poor performance of a girl because she wouldn't be expected to do any better and once again invoking the self-fulfilling prophecy. This is similar to Schildkamp-Kundiger's (1983) opinion that "the linking of mathematics to the male domain can explain a great deal of any inferior achievements .... in mathematics".

Girl J

The parents of this girl thought that it should be equally important for boys and girls to do mathematics and science, "but it's not". They were aware of stereotypes, but didn't see them as a threat to their daughter. The daughter was equally aware of these stereotypes and even said that she played with dolls as a child "because that's what little girls are supposed to do". She was also aware of the sex roles that readers such as *Janet and John* reinforced. It would seem that she had been exposed to influences outside the home which had 'socialized' her into accepting these stereotypes, but within the home there was obviously a 'balancing-out' factor. One element of the counter-socialization was obviously the careers of the parents (engineer and physiotherapist), which because of their scientific natures meant to her that mathematics and science were important subjects for both boys and girls. A second element was the actual verbal encouragement of the parents and their insistence that she do it. The daughter acknowledged this as can be gauged by her comment, "it was always accepted that I would take science".

As far as both of these girls were concerned, the fact that they took mathematics (and science) despite the strong sex stereotype connotations, was explained by a similar finding by Sherman (1982b) when she stated, "some of these girls felt that they were personally different and able to handle tasks in a 'male domain' even if the rest of their sex could not". They had been influenced by the same societal factors that all the other girls had experienced, but even though this was also the case in <u>their</u> homes, the additional socialization experiences provided by their parents ensured a healthy balance. The girls were thus allowed an opportunity to make rational decisions and the presence of well entrenched sex stereotypes had proved no difficulty to them at virtually any stage of their educational careers.

8.5 Conclusion

Much anecdotal evidence has been presented which has identified and highlighted <u>some</u> of the more important factors which affect the formation of mathematics and physical science attitudes and the subsequent decisions by the pupils as to whether or not they should continue through to standard ten with these subjects.

Mathematics anxiety was shown to be a major manifestation of problems and setbacks that had been encountered at various stages of the girls' schooling. It proved impossible to establish whether mathematics anxiety was the cause or the effect of the problems that arose, but there was no doubt as to its presence and the effect that it had on the pupils' confidence. Physical science anxiety did not seem to be of great concern to the girls, but the relevance of physical science curricula to careers was the main issue in terms of the importance of the subject.

The other issues which were concentrated on in the interviews were all aspects of the socialization process. Here the importance of teacher-effect in relation to that person's interaction with the pupils from curriculum, personal relationship and attitude points of view, was dealt with in depth. Socialization is a subtle and delicate process in which the child is not passive but plays an active part. The fact that we live in a patriarchal society has meant that many of the stereotypes that exist as part of our on-going transmission of culture are based on rigidly stereotyped sex-roles which appear to be firmly entrenched in our society. Parents are aware of them, but either feel powerless to react to them, or feel that it is unnecessary to do so. Sex stereotypes were shown to have a major effect on attitudes towards mathematics and physical science, but their negative consequences were successfully countered in some instances by both overt and covert encouragement and example on the part of the parents. The parents play a major part in the socialization process and this influence was clearly evident from the content of the interviews. Considerable effort would be required in order to achieve the balanced participation of girls in both mathematics and physical science at all levels of the high school system.

CHAPTER NINE

SUMMARY AND RECOMMENDATIONS

9.1 Summary and Discussion

9.1.1 Some General Comments

Mathematics and physical science are considered by many people (parents, teachers and pupils) to be very difficult subjects, and pupils who do well in these areas are almost regarded with awe, but certainly with envy. The higher the level of achievement in terms of progression through the educational system, the greater is the respect which that person commands. The two subjects, but mathematics in particular, are at the centre of what could almost be considered as a controversy in terms of the large numbers who don't ever master the subjects and more pertinent to this study, to the disparate numbers of boys and girls who opt to take these subjects when given the opportunity to continue with or drop them.

A study of the relevant literature certainly revealed that this was the case and data gathered from the sample in this study showed similar discrepancies in terms of the distribution of boys and girls in both subjects. One of the problems that is caused by this anomaly is that mathematics holds the key to so many doors, to the extent that it has been termed "the critical filter". While this label has some justification, using mathematics as a filter can be undesirable as it turns out that it is often used an indicator of general intelligence, particularly by employers and even educational institutions and in many instances unfairly so.

This of course is no new phenomenon, but it wasn't until the last twenty five years or so that the issue received any real attention, first in the United States of America and some ten years later in the United Kingdom, these being the two countries where most research has been undertaken. Much of the impetus for this research has been as a consequence of the feminist movements as well as by anti-sexist legislation in the two countries. The complexity of the interrelationships between the factors which affect academic success and attitudes towards the subjects, make it impossible for any one investigation to present the whole picture. It must be accepted therefore that no set of conclusions can be regarded as complete and any deductions made are made with this as background, because the number of variables both cognitive and affective is quite intimidating.

The broad aim of the study was to investigate the significant drop-out rate of girls at the end of the junior secondary phase of education (standard seven) in both mathematics and physical science and this was to be done by two relatively separate studies. The flow diagram presented in Appendix H gives a good idea of the routes that were followed and how the study developed over the three years.

The cross-sectional study entailed administering two attitude questionnaires, one each for mathematics and physical science, to some three and a half thousand standard six, seven and eight pupils from four co-educational, two all-boys' and two all-girls' schools. These schools were from two geographically separate towns which are nevertheless fairly similar in the respect that they are coastal towns and have similar industrial, commercial and socio-economic structures. In the main, the pupils involved were drawn largely from the middle and upper socio-economic groups and had similar language and cultural backgrounds.

The second leg of the overall investigation entailed a longitudinal study involving pupils from two of the co-educational and one of the all-girls' schools from one of the towns. This was a progressively-focused study starting with 358 standard six girls and boys, then the sample narrowed down to 78 boys and girls in standard seven and finally to only 10 girls from standard eight. Because it commenced with such a broad base (which was necessary in order to cover all possible subject choice combinations), the information-gathering during the first year of the longitudinal study (standard six) was achieved by using a questionnaire. This provided information about liking for and various rankings of all subjects, attitudes, feelings about parents and teachers, percentages obtained for mathematics and physical science, thoughts about subject choice and possible careers, and the sex-appropriateness of mathematics and physical science. During the second phase of the longitudinal study a second mode of enquiry was used. Interviews were conducted with the seventy eight boys and girls, and then ten girls from this group were followed through into standard eight. As the sample size decreased through the three years, so the interviews became progressively more focused in order to achieve greater depth in the discussions. In addition, the parents of these ten girls were interviewed in order to gain some insight into the role that they played in the socialization process of their children and also so that the ten families presented more detailed case studies.

9.1.2 The Cross-Sectional Study

9.1.2.1 The Mathematics Attitude Questionnaire

Various attitudes towards mathematics were measured by this questionnaire which was a modified version of the Riedesel Inventory of Children's Attitudes towards Mathematics (RICATM). It was a Likert-type questionnaire developed by Riedesel and Burns (1977) which contained fifty two statements yielding six attitude factors. Comparisons of the frequencies of different groups of pupils were undertaken using chi-square comparisons in order to ascertain if there were any significant differences between the sexes, between the two types of schools (single-sex and co-educational) and between the different standards for the six different attitudes as measured by this questionnaire.

Statistically significant differences were obtained for all of the groupings measured above, but there being some 636 different comparisons made, it is necessary to consult chapter four to get the details of these differences. It is possible, however, to present an overall picture of these results and although in some cases they are generalisations, they do very accurately represent the strong trends that were evident from the numerous comparisons.

9.1.2.1.1 Comparing the Sexes (See Section 4.2.2)

In comparing the sexes using the entire sample, the results were quite staggering. For all three standards separately and for all six attitudes, there was a total rejection of the null hypotheses that there were no sex differences. This result was very much in line with those mentioned in the literature review, but the analysis went further and identified that in fact the sex differences were evident in the three standards and in all the single-sex and co-educational schools as well.

9.1.2.1.2 Comparing Co-Educational and Single-Sex Schools (See Section 4.2.3)

In view of the sex differences evident in the single-sex and co-educational schools, it was important to ascertain whether or not there were any differences between the pupils in these two types of schools. Comparisons involving the whole sample, as well as boys and girls separately, all pointed to the single-sex schools having significantly better attitudes than did their counterparts in the co-educational schools, Of the fifty four comparisons made, only five showed no differences between the groups being compared, these being mostly for the standard eight girls.

9.1.2.1.3 Comparing the Standards (See Section 4.2.4)

The various groups were compared in order to establish whether or not there were any differences between the standards. There were very few differences evident when the standard sixes were compared with the standard sevens and only the attitude *perceived usefulness* of mathematics showed a downward trend from standard six to standard seven. However, between standard seven and standard eight there was a dramatic drop and when the whole sample was used, all six attitudes showed statistically significant negative trends.

The decline in attitudes towards mathematics over the three-year span was strongly evident, but still occurred such that the strong sex differences existed over the entire three standards as did the differences which were established between the pupils from the single-sex and co-educational schools.

9.1.2.1.4 Comparing Those Who Take and Those Who Don't Take Mathematics (See Section 4.2.5)

Because there had been a more dramatic difference between standards seven and eight than between standards six and seven, comparisons were made between the attitudes of the standard sevens and those pupils in standard eight who either were taking or were not taking mathematics. Numerous comparisons were made with the following theory being formulated:

1. Girls are strongly guided by their attitudes towards mathematics as to whether or not they will take the subject in standard eight.

2. Boys are affected by their attitudes towards mathematics in electing to take (or not take) mathematics, but they might still take the subject even if they have negative feelings about it, which is not the situation for girls.

9.1.2.2 The Physical Science Attitude Questionnaire

The physical science questionnaire was adapted from the mathematics questionnaire and had the identical structure. As for the mathematics attitudes some 636 comparisons involving the sexes, types of school (single-sex and co-educational) and the different standards, were made. The chi-square test was used to compare the frequencies for the attitude scores for the various groups in order to detect any statistically valid differences between the groups.

9.1.2.2.1 Comparing the Sexes (See Section 5.2)

Fifty four comparisons between the sexes were made for various groups (e.g. different standards and single-sex and co-educational schools). Only five of these showed any deviation from the very strong significant sex differences which favoured the boys. Where all the boys were compared with all the girls in the three standards separately, all six of the attitudes towards physical science strongly favoured the boys. For the separate analyses for the single-sex and co-educational schools the trend was also quite obvious.

9.1.2.2.2 Comparing Co-Educational and Single-Sex Schools (See Section 5.3)

There were a lot more variations in the comparisons, but overall the results could be generalised to there being strong science attitude differences between standard six pupils in single-sex and co-educational schools, with the former showing the better attitudes. However, for standards seven and eight there were no real differences and only the attitude *perceived usefulness* showed any consistent trend (favouring the single-sex schools) throughout the three standards. Thus a comparison between the standards for the two types of schools was necessary if further clarity was needed.

9.1.2.2.3 Comparing the Standards (See Section 5.4)

Unlike the comparison between standards six and seven for the mathematics questionnaire, for the physical science attitudes between these two standards, the differences were very marked indeed. In all six attitudes the standard sevens showed much less favourable attitudes towards the subject than the standard sixes. The same deterioration was evident between standard seven and standard eight with the exception of 'perceived usefulness' which was mentioned in the previous section. It was suggested in Section 5.4 that physical science might be seen by pupils as a subject only to be taken in the higher standards if it led somewhere career-wise. The perceived usefulness of science was already low in standard six and thus was not likely to drop further, indicating that career directions were possibly already reasonably well indicated. The longitudinal study did in fact produce evidence that the perceived usefulness of science was strongly linked to career choices and this in turn to whether or not the pupils would elect to take science in the higher standards. The sex differences were in evidence at all levels and this meant that the pattern of far fewer girls opting to take physical science in standard eight was already well established in standard six.

9.1.2.2.4 Comparing Those Who Take and Those Who Do Not Take Physical Science (See Section 5.5)

Similar to the proposal made for mathematics, it appeared, for physical science as well, that girls with positive attitudes continue with science, while those with negative attitudes drop the subject. While for the boys there are still a number who either elect to take or drop the subject contrary to their general attitudes towards it. This trend was, however, not as decisive for physical science as it was for mathematics, but 'perceived usefulness' of the subject as far as career plans were concerned was a major factor and this was borne out in the longitudinal study.

9.1.3 The Longitudinal Study

9.1.3.1 Standard Six

In examining the responses to the numerous questions in the standard six questionnaire there were many differences which came to light. Of particular note though were two areas, one related to sex stereotypes and the other to teachers they would have preferred.

The science-related careers had a strong association with sex stereotypes in that the boys showed a much stronger leaning towards these careers than did the girls. In addition most of the pupils (boys and girls) thought that science was a subject more suited to boys and with the exception of the girls from the co-educational schools, they thought the same about mathematics.

Both subjects were marked as having a strong 'maleness' about them, but physical science probably more so than mathematics. The majority of girls and boys would have preferred a male teacher for physical science, but for mathematics more would have preferred a female teacher. This suggests that as far as mathematics is concerned, a more sympathetic approach was indicated, but this was not confirmed during the remaining stages of the longitudinal study.

Reasons that were advanced for either taking or not taking mathematics fell into distinct categories. Interest, enjoyment and the challenging nature of mathematics were cited as important reasons for wanting to continue with mathematics through to standard ten and a large number also thought that it would help with their careers. Those boys and girls who anticipated at this early stage that they might drop the subject later, all felt that they did not understand mathematics and that it was too difficult for them and thus they did not enjoy it.

For physical science, careers played a much greater role in the pupils' feelings about their future in the subject. Interest and enjoyment were cited as important reasons for wanting to continue with science, but the subject's usefulness in terms of careers was also vital.

Those pupils who thought they would be dropping out of science at the end of standard seven stated that they did not like the subject and did not need it for their anticipated careers when they left school.

From the above, it is obvious that stereotypes have a major influence on pupils' attitudes towards mathematics and physical science, and that career considerations (especially for physical science) are extremely important. Both of these issues were extensively dealt with at later stages of the study and these theories were found to be valid.

9.1.3.2 Standard Seven

9.1.3.2.1 Reasons for Dropping Mathematics

The most common reasons given for deciding not to continue with mathematics all centred around marks that were not good enough, and finding the subject too difficult. What was established though, was that girls generally regarded a higher mark as being the minimum necessary to regard one marks as being 'good enough' to continue, than did the boys. This probably is in line with what was found in Section 4.2.5.5 that there is a significantly greater number of girls in the non-taking group doing better at the subject than there are boys. It is also in agreement with the fact that of those continuing with mathematics, the girls' attitudes are as good as, if not better than the boys' attitudes.

A second aspect concerned the sex stereotyping of the subject. Girls overtly agreed that mathematics was equally appropriate for men and women, but the group nevertheless behaved in a stereotypical way when selecting mathematics courses. It was suggested that societal influences have their effect in developing stereotypes in the girls, but when questioned directly about them the girls somehow deny their existence, but in fact respond to them in course and career selection. It was recommended that guidance and counselling in these areas could well remedy this situation.

9.1.3.2.2 Reasons for Taking Mathematics

Once again the role of guidance and counselling was stressed because the reasons were again very similar to those given by the group when they were in standard six. The common theme was the perceived usefulness of the subject and the need for it in terms of careers and also as an `insurance policy' in situations where pupils were not sure what career they might follow or what courses they might take when leaving school.

9.1.3.2.3 Reasons for Dropping Physical Science

It was noteworthy how many different reasons were given by the pupils for deciding not to continue with physical science. Unlike mathematics the reasons were varied, but amongst the diverse combinations there was nevertheless some reasonably common ground. Finding it boring and not needing it for a career were high on the list. There seemed also to be a strong case for physical science being stereotyped as a male domain and it is more than likely that all the other reasons offered, explained why so many boys and girls did not decide to take the subject, but that the sex stereotypes were responsible for the considerable sex differences in the discrepant numbers of boys and girls taking it.

9.1.3.2.4 Reasons for Taking Physical Science

The career needs of the boys were seen as being much greater in terms of physical science than they were for the girls and this was by far the most important reason for taking the subject. The girls still felt that the subject was more geared towards boys, but their strong positive feelings about the subject in general and its usefulness to them outweighed the negative sex stereotypes.

9.1.3.2.5 Electricity as a 'Boys Topic'

Electricity was mentioned time and time again as being the reason that physical science was regarded as a subject more suitable for males. The evidence suggested that it was entirely feasible that the electricity topics in the physical science syllabus play a major role in affecting the attitudes of girls towards the subject and consequently have a major effect on many pupils' decisions as to whether or not they should continue through to standard ten with the subject.

9.1.3.3 Standard Eight

Anecdotal evidence presented by the ten girls and their parents in the interviews, highlighted some of the more important factors which affect the formation of mathematics and physical science attitudes and subsequent decisions by the pupils as to their futures in these two areas.

Mathematics anxiety was shown to play an important part in many of the problems and setbacks which were encountered by the girls during their schooling. It was indicated that anxiety and confidence were strongly linked and that teachers could unknowingly and sometimes in good faith contribute to the manifestation of subject-specific anxieties in their pupils. An idle comment from a teacher could easily lead to the shattering of any confidence a pupil might have had and cause them to doubt their ability in the subject, but also spark anxieties which might escalate into major problems. By the same token, teaching encouragement was thought to be a major positive step in counteracting negative attitudes that had developed and also in boosting confidence.

Their introduction to algebra which came with their transition from primary to high school was a well-remembered incident in their lives and gave rise to uncertainties amongst almost all the interviewees. The succeeding months were then vital in determining what negative attitudes might develop and it is here where teacher effect played a vital role. This transition also coincided with a change from what the girls regarded as rigid and well-structured mathematics in which they felt secure and comfortable, into the substantially different 'high school approach'. For the girls this created uncertainty and insecurity and thus the socialization influences of teachers, parents, siblings and peers were more critical and influential at this crucial stage.

The fact that we live in a patriarchal society has meant that many stereotypes exist as part of our on-going transmission of culture and these are often based on stereotyped sex-roles which seem to be firmly entrenched in society. The parents play a major part in the socialization process and they regarded mathematics as a very important and necessary subject for a child (boy or girl) to take at school. Physical science was seen as being not quite as essential, but the way in which the parents have been 'socialized', as far as the importance and need of both mathematics and physical science were concerned, was patently obvious. In most cases they had absolutely no idea why they held the particular views that they did, but somehow knew it was important. The parents were aware of the stereotypes, but either felt that they didn't need to do anything about them or that they were powerless to do so.

Parental attitudes and encouragement played the vital role in establishing the attitudes and outlooks of their children and showed that they could be entirely successful in countering negative socialization and educational factors. If their influence was in agreement with any of the other variables then socialization was that much more secure, but if it was contrary to other factors then the level of the parents' encouragement was put to the test and often found to be lacking, but very often because of the extreme short-term views held by a number of the mothers as to the value of a subject like mathematics.

9.2 Recommendations

9.2.1 Recommendations For Possible Action

There are many facets to the complexity of the network of factors which determine the attitudes that pupils have towards mathematics and physical science. Correspondingly there are many areas where action, remedial or otherwise, can be implemented, but mainly they are in the school situation itself. The school influences operate at various levels: the teacher in the classroom; the subject department; the policies of the schools and even those of the education authorities. However, school influences cannot be divorced from out-of-school influences, but particularly not from those of the home and any intervention strategies will only be effective if they spill over from the school into parental involvement and knowledge as well. Despite this though, all action should probably take place either in or via the school, including the education of the parents involved in any of the strategies. The strategies which take place in the teaching situation will be dealt with first and as most of them apply to both mathematics and physical science, the strategies will not be dealt with separately unless it is necessary to do so.

9.2.1.1 Classroom Strategies

(i) Teachers should not discriminate in the classroom and it is not good enough to 'treat the girls the same as the boys'. They should be treated differently in the way that any pupils with different academic abilities and different personalities would be treated differently. Similarly girls (or boys for that matter) should not be lumped together as a homogeneous group and all treated in the same (stereotyped) manner. All pupils have different background experiences and different personality traits. Whether these are biological or social in origin is largely irrelevant to the teacher, but it is important that the teacher responds to these differences and that includes sex differences as well.

(ii) One way of achieving the above would be to place more emphasis on things that girls do well. They pay far more attention to neatness and presentation than boys do and thus in physical science, in particular, it would be easy to cater for this attention to detail and tolerance for routine. It is the writer's experience that simple projects presented using a poster format are very acceptable to all girls and a worthwhile exercise for most boys. It was suggested in chapter eight that it was the disappearance of the structured work situation, when the girls moved from primary to high school, that gave rise to many uncertainties (and possibly anxieties). They had felt far more secure and comfortable when in mathematics they knew exactly what they had to do.

(iii) The previous two sections both require attention to actual teaching style as it is thought that while sarcasm and diffident tones are tolerable to boys, they certainly aren't to girls, who seem to respond better to praise and encouragement. In other words, methods that are successful for boys aren't necessarily suitable for girls. Disorganised and badly disciplined classes are probably less of a problem to boys than they are to girls.

(iv) Not only should teacher encouragement be strong for all pupils, but stereotypic expectations that girls don't do as well in mathematics and physical science should be avoided. The self-fulfilling prophecy is at its best in this situation and although they would deny it, most teachers are probably guilty of unwittingly encouraging this behaviour. Low teacher expectations will almost certainly result in low levels of performance. Teacher 'wait time' is according to some researchers different for the two sexes, but its effect has as yet not been firmly established, although it more than likely would reinforce the 'low expectation' syndrome.

(v) It has been shown that girls might do better in questions in mathematics which refer to feminine activities than in identical questions framed in a 'masculine' setting. The same is probably true of physical science, but although no research is available at this stage, it is certainly an area of examining which should receive attention. Reference was also made in the thesis to the possibility that girls are at a disadvantage in answering multiple-choice type questions in physical science.

9.2.1.2 Curriculum Possibilities

(i) A possibility which would be extremely difficult to change in this country because of the rigid syllabus and subject choice frameworks, would be for pupils to continue with physical science and mathematics to higher standards (and therefore higher ages) before making their final school subject choices. It is possible that at the ages at which choices are made at present are very close to the age of puberty and some girls who might be concerned with establishing and determining their femininity might avoid any activity and subject which has an attached 'maleness'.

Postponing the age at which a decision needs to be made would provide a more thorough grounding for school-leavers, but it has been shown in a very limited study (Kelly, 1981e) that this encouraged more girls to take A-level physics and must therefore be considered as a possibility. This was done at the end of the O-level stage which would be approximately the same as the end of standard nine in this country, but the end of standard eight would probably be a more suitable point to do this in our educational system.

(ii) In the physical science syllabuses, 'electricity' was deemed by almost every girl to be unsuitable for girls. While it is probably impossible to consider any curriculum without electricity topics, considerable thought needs to be given to making these sections of the syllabus more appealing and acceptable to girls. This can be accomplished by gearing some of the practical aspects of electricity to equipment and situations which involve and relate to females. In addition, teachers can present the topics in a way more suitable to girls, bearing in mind that girls and boys traditionally play with different types of toys and have different interests as a consequence of the differing sex roles that they have learned. Girls thus usually lack the background for many of the topics in physical science and boys often develop their spatial skills more by virtue of the toys they have and games that they play as young children. They therefore have differing degrees of relevant experience and teachers should gear their teaching accordingly.

(iii) Although in physical science, electricity was the area of the syllabus almost exclusively quoted by the girls as being more suited to boys, there were other topics mentioned. The possibility that other topics are also allowed a <u>portion</u> of female character or relevance, could well play a major role in reducing the strong male stereotype that physical science has. In short, a consideration must be made to 'humanise' these two subjects, as it could only lead to their improvement.

(iv) It is possible that the conceptual level of some of the syllabus content in both mathematics and physical science is beyond the level of the average pupil in standards six and seven, and that they are not yet operating at a cognitive developmental level in keeping with all the material they are expected to master. Boys have been shown to be more persevering when encountering difficulties, and this coupled with the lower levels of anxiety shown by them, could well account for the differences in the percentages of boys and girls carrying on with the two subjects.

9.2.1.3 School Policies

There are some areas of general school policy which need to be evaluated either by education authorities or the principals of schools. In some instances even the subject departments or individual teachers could attempt to implement certain ideas.

(i) The balance of men and women teachers could well make a difference in reinforcing other initiatives within the school which attempt to counter sex stereotyped attitudes.

(ii) As mentioned earlier, subject choice options which prevent physical science and mathematics being set against subjects which are traditional favourites amongst girls, should be avoided. The whole question of a suitable balance in subject options needs to be considered on an <u>on-going</u> basis. Too often options stay the same year after year, because "it seems to work" (debatable) or "it's always been like that".

(iii) A still unresolved issue is that of single-sex versus co-educational schools. This study established quite clearly, significant differences in attitudes towards mathematics and physical science between the two types of schools for this particular sample. In almost every situation the attitudes in the single-sex schools were better than those of their counterparts in the co-educational schools, but still the differences between the sexes were evident. Studies which have attempted single-sex classes in co-educational schools were reported for both mathematics and physical science and the results look very encouraging. This is an area which needs to be explored and could well lead to dramatic changes in outlook. It is certainly something that would focus the attention of many apathetic educationalists on the issue and while there are bound to be many vociferous opponents it still remains an interesting alternative.

(iv) Careers guidance and counselling are invaluable in encouraging girls (and boys) into taking mathematics and particularly physical science. The crucial nature of the subject choice dilemma at the end of standard seven is all too often underestimated and in the writer's opinion this stems from ignorance, both on the part of the school and the parents. It was obvious from the parent interviews how helpless some of them felt about what advice they could give to their children and how they were looking to the school for assistance, which to their minds was not always forthcoming. The result of this situation is that the traditional sex stereotypes are all that the parents have to fall back on and this happens with the obvious entrenchment of traditional sex roles. Careers advice needs to be a long-term process and it is vital that parents are involved as well. It would appear that written contact is not adequate for this and that other schemes need to be devised by the schools in order to ensure this.

There also needs to be contact by the girls with women mathematicians and scientists who represent a variety of the careers belonging to the 'male domain'. Guidance in the schools linked to this and discussions on discriminatory sex roles, will make inroads into obtaining more favourable boy/girl ratios in the mathematics and science fields. The intervention strategies mentioned in Section 2.4.4 which worked in this area were particularly successful. In the United Kingdom WISE, GEMSAT, GIST and GATE are examples of programmes that worked, and in the United States WAM, TEAM, EQUALS and Multiplying Options and Subtracting Bias programmes were similarly successful.

Careers advice would, however, be meaningless if there were not suitable job opportunities. The interviews with the parents exposed just how sex stereotyped employers are in this field and this is an area beyond the scope of the school to which urgent attention needs to be given. Influential organizations would need to take a lead in what would be a very long-term project which would have a major impact on sex roles and sex stereotypes. Contact between the schools and the parents during the careers counselling stage would be a small, but important part of this process.

(v) Much of what was suggested in the previous section (part (iv)) was aimed at parents. However, not only is it important that parents are involved in the career guidance aspect of their children's education, but they should know why this is so. The parents have enormous influence, but as already discussed, it is a sex stereotyped influence and because they (as was obvious from the interviews) base their outlook on their own schooldays, many of them are completely out of touch with the realities of today. They will admit to not knowing about mathematics and science, but will nevertheless understandably base any advice on their own experiences.

For this reason, schools need to discover what the parents' views are in these matters and a whole thrust geared towards their needs will have to be designed and implemented. The virtues of mathematics and physical science need to be made known to them and if these are linked to careers guidance and education away from sex-role stereotypes, the most important stage of the battle will have been won.

9.2.1.4 Some Questions to be Asked

Many suggestions have been made in the previous sections, but possibly before any strategies are embarked upon some questions need to be asked and answered in a particular school before anything is attempted.

(i) Is there a problem in your school with regards to the distribution of boys and girls doing science?

(ii) Is your school aware of the deterioration of attitudes of both boys and girls in mathematics and physical science over the standard five, six, seven, eight time-span? (Refer to the questionnaires in appendices B1 and B2, but there are others available.)

(iii) Do the girls in your school place a higher premium on what constitutes an 'acceptable' minimum mark for mathematics in standard seven for them to continue with the subject in standard eight?

(iv) In your school, do girls set more store by their attitudes towards mathematics and physical science when making their subject choices for standard eight, than the boys do? As was mentioned, their attitudes can be measured, but it should be realised that decisions should only be made on the basis of cumulative performances and records and should involve the subject teacher as well as the school guidance teacher.

(v) Is your school aware of Intervention Strategies that can and have been used in other countries? (Refer to Section 2.4.4)

(vi) What is the outlook of the counsellors and guidance teachers towards sex-role stereotypes in general and related to physical science and mathematics in particular? Are they aware that 'perceived usefulness' for example is a major factor in determining the attitudes and career aspirations in science-related areas?

(vii) Is there an orientation programme for standard six pupils when they arrive as new pupils in your school? Should this programme cater specifically for mathematics pupils or should the mathematics department evolve a 'bridging programme'? Is the mathematics department in your school aware that pupils can experience setbacks when encountering algebra for the first time and that in the higher standards, geometry usually presents more of a problem to girls than it does to boys?

9.2.2 Recommendations for Further Research

The following recommendations for further research are made with the knowledge that they will help to clarify issues that are part of this very involved interrelated structure which determines whether or not pupils continue with mathematics and physical science in the higher standards and whether or not they do so for the correct reasons.

(i) If a question (examination or otherwise) is framed such that it refers to a feminine activity, does it lead to a better performance by girls than if it was posed in a non-sexist or male setting?

(ii) Do girls fare worse in answering multiple-choice type questions (or any other specific type of question) than boys do?

(iii) When selecting subjects for the higher standards, will choices be any different if selection takes place at a later stage than the end of standard seven?

(iv) Does the balance of male/female teachers in a mathematics or physical science subject department affect course selection or attitudes towards those subjects in any way?

(v) What effect do the qualifications, attitudes and interests of primary school mathematics and physical science teachers have on short-term and long-term attitude formation of their pupils?

(vi) What effect do the subject-choice combinations of different schools have on mathematics and physical science selection and what subjects if when offered as alternatives to these two, are taken by girls because of their 'feminine' connotations as opposed to the 'maleness' of mathematics and particularly physical science?

(vii) The development of suitable simple (and possibly detailed) standardised mathematics and physical science attitude questionnaires should be of invaluable assistance to the classroom and guidance teachers.

(viii) There is limited evidence that for mathematics and physical science, girls in single-sex classes in co-educational schools get better marks than they would if they were in mixed classes in the same schools. This is an important issue which needs to be evaluated.

(ix) It is possible that the conceptual level of many of the topics in the syllabuses for mathematics and physical science are beyond the cognitive developmental level of even the average pupil at that particular stage. In addition, the sequencing of syllabus material needs to be investigated, particularly as a consequence of the introduction of calculators into the curriculum. This all needs urgent attention.

(x) A number of the topics in the junior physical science syllabuses, but especially electricity, would appear to need to have greater relevance to the needs and interests of girls in order to move away from the strong male stereotype that this subject has.

(xi) Are mathematics bridging courses a good idea for pupils entering high school, with particular reference to their introduction to algebra?

(xii) Can attitudes towards mathematics and physical science be changed and if so, how? It would appear that small-group work is probably necessary to achieve any attitudinal changes, but the intervention strategies already being employed both formally (particularly in the U.S.A. and the U.K.) and informally need to be evaluated and adapted for possible use in this country.

(xiii) The 'education' of parents in careers guidance and counselling and their subsequent involvement in these programmes is essential in attempting to counter the entrenched sex stereotyping of careers and inflexible sex roles. Strategies which will achieve this, need to be developed and evaluated.

9.3 Postscript

It is unavoidable that unforeseen difficulties and obstacles are encountered during a research investigation. For many of these this entails either adding a new dimension to the study or else changing direction to circumvent the problem. There are nevertheless regrets that the writer had when opportunities to investigate certain issues that arose, had already slipped by. If these had not been passed by though, this investigation would never have reached completion. No study is ever complete, and this one was no exception as a number of avenues requiring further investigation have been identified or highlighted. Research is an on-going process and this effort is but a small part of what is still to follow.

A major regret though, concerns the parents who were interviewed. If they could somehow have been identified when their daughters were still in standard six and they had been part of the longitudinal study, even more about the socialization process involving their daughters could have been learned. As it was, their involvement was only included at a late stage, but their importance to the study was invaluable.

The writer having been out of the classroom for the past year will be returning to school with much enthusiasm, trepidation and a desire to see if he can `practise what he preaches'. This study has provided many ideas and given rise to some uncertainties as to the situation in the writer's own school. This next year will be one where the overall situation in the school will be assessed with the view to either implementing or re-evaluating some of the recommendations that have been made as far as research and the proposals concerning classroom, curriculum and school strategies are concerned.

Of particular interest will be the girls who were part of the longitudinal study, as some of them will be taught by the writer. Thus the longitudinal study will in a limited way, continue. This is all with a view to the eventual dissemination of the information and of possible proposals to alleviate the problems disclosed by the investigation.

APPENDIX A

ATTITUDE QUESTIONNAIRES

INSTRUCTIONS

1. You each require a soft pencil and an eraser.

2. There is no time limit, but please work carefully and steadily.

3. Please fill in the information at the top of <u>both</u> questionnaires before you start responding to the statements. These questionnaires will be separated at a later stage, which is why the information is required on both pages. Please do <u>not</u> separate them as I need to give them the same code number.

4. Please note that you respond by placing a tick in ONE of the boxes next to the statement and you must only make one tick per statement, but you must respond to ALL the statements.

5. You may not discuss the statements with each other and must please be quiet. If you have a question please raise your hand and I will come to you.

6. You must be absolutely honest in your responses otherwise the information will be of no use to anyone.

7. This is not a test, but only an attempt to gather information about how you feel about Mathematics and Physical Science.

8. A large number of schools in both East London and Port Elizabeth will be participating in the study and your views are very important to me.

9. The Physical Science questionnaire refers only to Physical Science and NOT General Science, i.e. Biology is not involved.

10. Thank you for your help, please start now.

APPENDIX B1

ATTITUDES TOWARDS MATHEMATICS

Date .... Standard ..... Sex ..... (M or F)

Code (leave blank) ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
1 2 3 4 5 6 7 8

Below are some statements that might describe how you feel about MATHEMATICS. Place a tick (✓) in the column which BEST describes how you feel.	Strongly Agree	Agree	Disagree	Strongly Disagree	Leave Blank	
1. I like mathematics.					*	* * 9
2. I'd rather answer short easy questions than long interesting questions.					*	* *10
3. It scares me to have to take mathematics.					*	* *11
4. Mathematics is very useful to everyone.					*	* *12
5. Sometimes I work on extra mathematics problems.					*	* *13
6. I usually understand what we are talking about in the mathematics class.					*	* *14
7. Mathematics is easy for me.					*	* *15
8. It's fun to do mathematics.					*	* *16
9. I would like a job that doesn't use any mathematics.					*	* *17
10. It makes me nervous even to think about doing mathematics.					*	* *18
11. I like to solve new problems in mathematics.					*	* *19
12. I don't like to study mathematics.					*	* *20
13. I have trouble with some of the terms and symbols used in mathematics.					*	* *21
14. No matter how hard I try, I cannot understand mathematics.					*	* *22
15. Mathematics is important in everyday life.					*	* *23
16. I am more interested in mathematics than in most other school subjects.					*	* *24
17. No matter how hard I try, I have trouble working with mathematics.					*	* *25
18. I feel relaxed and happy when working with numbers.					*	* *26
19. There is very little need for mathematics in most jobs.					*	* *27
20. My marks in mathematics have usually been lower than my marks in other school subjects.					*	* *28
21. I think that mathematics is a very dull subject.					*	* *29
22. I have always enjoyed mathematics.					*	* *30
23. Mathematics is not very important for most people.					*	* *31
24. Mathematics makes me feel worried and confused.					*	* *32
25. I have a good feeling about mathematics.					*	* *33

	Strongly Agree	Agree	Disagree	Strongly Disagree	Leave Blank
26. You need mathematics in order to get a good job.					*34
27. I don't like mathematics very much.					*35
28. Mathematics is important for the country.					*36
29. I have a bad feeling about mathematics.					*37
30. I often think "I can't do it" when a mathematics problem seems hard.					*38
31. Most of what we learn in mathematics is not useful.					*39
32. I feel calm and confident when doing mathematics.					*40
33. I have never enjoyed studying mathematics.					*41
34. Word problems in mathematics have always been difficult for me.					*42
35. Mathematics makes me feel nervous and uncomfortable.					*43
36. My mathematics marks have usually been higher than my marks in other subjects.					*44
37. Mathematics contributes to science and other fields of knowledge.					*45
38. I am good at working at mathematics.					*46
39. To most people mathematics is less important than other subjects.					*47
40. I feel at ease in mathematics classes.					*48
41. I find mathematics very boring.					*49
42. I like mathematics very much.					*50
43. I am able to do mathematics without trying very hard.					*51
44. Mathematics is not very important in everyday life.					*52
45. I just don't like mathematics.					*53
46. I am not frightened nor afraid of mathematics.					*54
47. I feel I could do better in mathematics if I tried harder.					*55
48. I feel anxious when someone talks about mathematics.					*56
49. Mathematics is one of my favourite subjects.					*57
50. Mathematics is a very worthwhile and necessary subject.					*58
51. I remember most of the things I learn in mathematics.					*59
52. I feel sure of myself when working at mathematics.					*60

FOR STD 8 PUPILS ONLY
(Please tick the
appropriate blocks)

	Yes	No	
Do you take ... Mathematics?			*61
Science?			*62
Biology?			*63

APPENDIX B2

ATTITUDES TOWARDS PHYSICAL SCIENCE

Date .... Standard ..... Sex ..... (M or F)

Code (leave blank)								
	1	2	3	4	5	6	7	8

Below are some statements that might describe how you feel about PHYSICAL SCIENCE. Place a tick (✓) in the column which BEST describes how you feel.	Strongly Agree	Agree	Disagree	Strongly Disagree	Leave Blank
1. I like science.					* * *__* 9
2. I'd rather answer short easy questions than long interesting questions.					* * *__*10
3. It scares me to have to take science.					* * *__*11
4. Science is very useful to everyone.					* * *__*12
5. Sometimes I work on science problems that are not for homework.					* * *__*13
6. I usually understand what we are talking about in the science class.					* * *__*14
7. Science is easy for me.					* * *__*15
8. It's fun to do science.					* * *__*16
9. I would like a job that doesn't use science.					* * *__*17
10. It makes me nervous even to think about doing science.					* * *__*18
11. I like to solve new problems in science.					* * *__*19
12. I don't like to study science.					* * *__*20
13. I have trouble with some of the terms and symbols used in science.					* * *__*21
14. No matter how hard I try, I cannot understand science.					* * *__*22
15. Science is important in everyday life.					* * *__*23
16. I am more interested in science than in most other school subjects.					* * *__*24
17. No matter how hard I try, I have trouble working with science.					* * *__*25
18. I feel relaxed and happy when working on science problems.					* * *__*26
19. There is very little need for science in most jobs.					* * *__*27
20. My marks in science have usually been lower than my marks in other school subjects.					* * *__*28
21. I think that science is a very dull subject.					* * *__*29
22. I have always enjoyed science.					* * *__*30
23. Science is not very important for most people.					* * *__*31
24. Science makes me feel worried and confused.					* * *__*32
25. I have a good feeling about science.					* * *__*33

	Strongly Agree	Agree	Disagree	Strongly Disagree	Leave Blank
26. You need science in order to get a good job.					* *34
27. I don't like science very much.					* *35
28. Science is important for the country.					* *36
29. I have a bad feeling about science.					* *37
30. I often think "I can't do it" when a science problem seems hard.					* *38
31. Most of what we learn in science is not useful.					* *39
32. I feel calm and confident when doing science.					* *40
33. I have never enjoyed studying science.					* *41
34. When a question in science is long, I usually find it difficult to answer.					* *42
35. Science makes me feel nervous and uncomfortable.					* *43
36. My science marks have usually been higher than my marks in other subjects.					* *44
37. Science contributes to other fields of knowledge.					* *45
38. I am good at working at science.					* *46
39. To most people science is less important than other subjects.					* *47
40. I feel at ease in science classes.					* *48
41. I find science very boring.					* *49
42. I like science very much.					* *50
43. I am able to do science without trying very hard.					* *51
44. Science is not very important in everyday life.					* *52
45. I just don't like science.					* *53
46. I am not frightened nor afraid of science.					* *54
47. I feel I could do a lot better in science if I tried harder.					* *55
48. I feel anxious when someone talks about science.					* *56
49. Science is one of my favourite subjects.					* *57
50. Science is a very necessary and worthwhile subject.					* *58
51. I remember most of the things I learn in science.					* *59
52. I feel sure of myself when working at science.					* *60

FOR STD 8 PUPILS ONLY
(Please tick the
appropriate blocks)

Do you take ...	Yes	No	
Mathematics?			* *61
Science?			* *62
Biology?			* *63

APPENDIX C1

STD 6 QUESTIONNAIRE

1. Do you LIKE Mathematics?
   Physical Science (Science)?
   Biology?

2. What are your <u>reasons</u> for answering as you have done in the previous question?

3. Which of these three subjects do you like
   BEST (1) SECOND BEST (2) THIRD BEST (3)?

4. Rank ALL your subjects in TWO different ways:

   In order of LIKING In order of DIFFICULTY

5. What PERCENTAGE do you USUALLY get for these three subjects?
   Mathematics?
   Science?
   Biology?

6. What PERCENTAGE do you THINK you will get for these subjects in the end-of-year examinations?

(Questions 7 - 14)
At the END of Standard 7 you will have to make choices as to whether or not you will carry on with certain subjects for standards 8; 9 and 10. I am interested in just THREE subjects:
Mathematics; Science and Biology.

7. Have you thought much about your subject choice yet?

8. Do you think you will carry on with any of these subjects? (Irrespective of what subjects are offered at your school.)

9. What are your reasons for your answers to the previous question?

10. Is your subject choice in any way linked to a career?

    If you answered Yes (1) or Uncertain (2), which career were you thinking of?

11. Will your PARENTS want you to take any of these subjects?

12. Will your TEACHERS want you to take any of these subjects?

13. Which of these three subjects would you like to take simply because you ENJOY them and not because they might be useful or for any other reason?

14. Are there <u>any</u> other subjects that you would <u>really</u> like to take, even if they aren't normally offered at your school?

    If Yes (1) then list them.

15. Do your teachers in these subjects like you?

16. Do you like your teachers who teach you these subjects?

17. Who usually helps you with mathematics and science at home?

18. Are your teachers for these two subjects male or are they female?

19. Would you prefer male teachers or female teachers for these subjects?

20. Do your mathematics and science teachers direct their questions .... mainly to the girls
    mainly to the boys
    equally to the girls and boys.
    or haven't you really noticed
    or doesn't this apply to your school

21. Who do you think is better at mathematics and at science?

22. Who do you think works harder at mathematics and at science?

23. Do you think girls and boys should get different types of mathematics and science examination papers?

24. If you could take mathematics or science in a class with girls/boys only would .....
    you prefer it
    you not prefer it
    it not really make any difference to you

25. Do you usually feel rushed when you are writing a mathematics or a science examination?

26. Do you usually do better in tests than you do in examinations in mathematics and in science?

27. Would you prefer your end-of-year promotion mark in mathematics and in science to be based on ....
    class tests ONLY
    end-of-year examinations ONLY
    a combination of tests and examinations.

28. Do you think mathematics and science are very similar subjects?

29. Do you think that if you can do the one subject you can do the other?

30. Do you think you are suited to taking mathematics or science in Std. 8; 9 and 10?

31. What are your reasons for your answers to the previous question?

32. Do you have a career in mind that you would really like to do?

33. If you answered Yes (1) or Uncertain(2) then name (describe) the career.

34. Does this career have anything to do with Mathematics?
    Science?
    Biology?

35. What career do you think you might actually end up in?

36. If you were a member of the opposite sex, do you know what career you would choose?

37. If you answered Yes (1) or Uncertain (2) then name (describe) the career.

38. Does this career have anything to do with Mathematics?
Science?
Biology?

39. If you were a member of the opposite sex, would you choose to do the <u>same</u> SUBJECTS for standards 8; 9 and 10 as you will choose for yourself?

If you answered No (3), what subject(s) would you have chosen if you were the opposite sex?

40. What were your reasons for your answer to the first part of the previous question? i.e. Whether you answered Yes (1), Uncertain (2) or No (3).

41. Are any members of your family either studying subjects or working in occupations which have anything to do with Mathematics?
Science?
Biology?

42. When you are a parent one day and have to advise your children about what SUBJECTS to choose for standards 8; 9 and 10 would you advise them to take any of these subjects?

43. What career would you like a daughter/son to follow?

APPENDIX C2

RESPONSE SHEET

Surname ....

First Name ....

School ....

Class ......

A 1

☐☐☐☐☐ 2-6

1.

Yes	1
Uncertain	2
No	3

Mathematics	☐ 7
Science	☐ 8
Biology	☐ 9

2. Mathematics ....

....

.... ☐ 10

Science ....

....

.... ☐ 11

Biology ....

....

.... ☐ 12

3.

Best	1
Second Best	2
Third Best	3

Mathematics	☐ 13
Science	☐ 14
Biology	☐ 15

4.

Best	1
Second Best	2
Third Best	3
Fourth Best	4
Fifth Best	5
Sixth Best	6
Seventh Best	7
Eighth Best	8
Ninth Best	9
Tenth Best	0
DO NOT TAKE	0

In order of LIKING

English	☐ 16
Afrikaans	☐ 17
Mathematics	☐ 18
Science	☐ 19
Biology	☐ 20
History	☐ 21
Geography	☐ 22
Housecraft	☐ 23
Woodwork	☐ 24
Xhosa	☐ 25
Accounting	☐ 26
Latin	☐ 27
Music	☐ 28
Art	☐ 29
French	☐ 30

Most Difficult	1
Second Most Difficult	2
↓	3
	4
	5
	6
	7
	8
	9
easier	a
	b
	c
DO NOT TAKE	0

In order of DIFFICULTY

English	☐ 31
Afrikaans	☐ 32
Mathematics	☐ 33
Science	☐ 34
Biology	☐ 35
History	☐ 36
Geography	☐ 37
Housecraft	☐ 38
Woodwork	☐ 39
Xhosa	☐ 40
Accounting	☐ 41
Latin	☐ 42
Music	☐ 43
Art	☐ 44
French	☐ 45

5. Mathematics ...... ☐ 46
Science ...... ☐ 47
Biology ...... ☐ 48

6. Mathematics ...... ☐ 49
Science ...... ☐ 50
Biology ...... ☐ 51

7. No 0
Yes 1 ☐ 52

8. Yes 1 Mathematics ☐ 53
Uncertain 2 Science ☐ 54
No 3 Biology ☐ 55

9. Mathematics ....
.... ☐ 56

Science ....
.... ☐ 57

Biology ....
.... ☐ 58

10. Yes 1
Uncertain 2
No 3 ☐ 59

What career? ....
.... ☐ 60

11. Yes 1 Mathematics ☐ 61
Uncertain 2 Science ☐ 62
No 3 Biology ☐ 63

12. Yes 1 Mathematics ☐ 64
Uncertain 2 Science ☐ 65
No 3 Biology ☐ 66

13. Would like to take 1 Mathematics ☐ 67
Would NOT like to take 0 Science ☐ 68
Biology ☐ 69

14. Yes 1
No 0 ☐ 70

If you answered Yes (1) then please list these subjects here.

1. .... 2. .... ☐ 71
☐ 72
3. .... 4. .... ☐ 73
☐ 74

15. Yes 1 Mathematics ☐ 75
Uncertain 2 Science ☐ 76
No 3 Biology ☐ 77

16. Yes 1 Mathematics ☐ 78
Uncertain 2 Science ☐ 79
No 3 Biology ☐ 80

NEW CARD

B 1

17.

Helps	1
Does not help	0

Mathematics

Father ☐ 2
Mother ☐ 3
Brother ☐ 4
Sister ☐ 5
Someone else ☐ 6
No-one ☐ 7

Science

Father ☐ 8
Mother ☐ 9
Brother ☐ 10
Sister ☐ 11
Someone else ☐ 12
No-one ☐ 13

18.

Female	1
Male	2

Mathematics ☐ 14
Science ☐ 15

19.

Female	1
Male	2

Mathematics ☐ 16
Science ☐ 17

20.

Mainly the girls	1
Mainly the boys	2
Equally for boys and girls	3
Haven't really noticed	4
Doesn't apply	5

Mathematics ☐ 18
Science ☐ 19

21.

Girls	1
Boys	2
No difference	3
Uncertain	4

Mathematics ☐ 20
Science ☐ 21

22.

Girls	1
Boys	2
No difference	3
Uncertain	4

Mathematics ☐ 22
Science ☐ 23

23.

Yes	1
Uncertain	2
No	3

Mathematics ☐ 24
Science ☐ 25

24.

Prefer it	1
Not prefer it	2
No difference	3

Mathematics ☐ 26
Science ☐ 27

25.

Yes	1
Sometimes	2
Uncertain	3
No	4

Mathematics ☐ 28
Science ☐ 29

26.

Yes	1
Sometimes	2
Uncertain	3
No	4

Mathematics ☐ 30
Science ☐ 31

27.

Class Tests ONLY	1
End-of-year examinations ONLY	2
A COMBINATION of these	3

Mathematics ☐ 32
Science ☐ 33

28.

Yes	1
Uncertain	2
No	3

☐ 34

29.

Yes	1
Uncertain	2
No	3

☐ 36

30.

Yes	1
Uncertain	2
No	3

Mathematics ☐ 38
Science ☐ 39

31. Mathematics ....

.... ☐ 40

Science ....

.... ☐ 41

32. Yes 1
Uncertain 2
No 3 ☐ 42

33. If you answered Yes (1) or Uncertain (2) in the previous question then name (describe) the career.

....

.... ☐ 43

34. Yes 1 Mathematics ☐ 44
Uncertain 2 Science ☐ 45
No 3 Biology ☐ 46

35. Career ....

.... ☐ 47

36. Yes 1
Uncertain 2
No 3 ☐ 48

37. Career ....

.... ☐ 49

38. Yes 1
Uncertain 2
No 3 ☐ 50

39. Yes 1
Uncertain 2
No 3 ☐ 51

.... instead of .... ☐ 52 ☐ 53

.... instead of .... ☐ 54 ☐ 55

.... instead of .... ☐ 56 ☐ 57

40. Reasons for FIRST PART of previous answer.

....

.... ☐ 58

41. Yes 1 Mathematics ☐ 59
Uncertain 2 Science ☐ 60
No 3 Biology ☐ 61

42. Yes 1 your daughter: Mathematics ☐ 62
Uncertain 2 Science ☐ 63
No 3 Biology ☐ 64

your son: Mathematics ☐ 65
Science ☐ 66
Biology ☐ 67

43. Daughter (career) ....

.... ☐ 68

Son (career) ....

.... ☐ 69

APPENDIX D1

INTERVIEW QUESTIONS - STANDARD SEVEN

1. Do you like Mathematics?
   Science?
   Biology?

2. What are your reasons for your answers? Mathematics?
   Science?
   Biology?

3. Rank: Mathematics, Science, Biology.

4. Do you think Mathematics and Science are subjects that boys should take and girls shouldn't?

   And Biology?

5. Next year in Standard 8, are you going to carry on with

   Mathematics?
   Science?
   Biology?

6. Why have you decided to carry on/drop these subjects?

   Mathematics
   Science
   Biology

7. Have your parents/family/friends/someone else helped/ influenced you in your choice?

   Explain.

8. Is your subject choice in any way linked to a career?

9. Do you think some careers (say science or mathematics or related careers) are for boys only? ..... and for girls only?

   Which careers?

10. And biology related careers?

11. What career would you like to follow?

    Why?

12. If you were a boy would you choose the same subjects for Standard 8?

    Why?

13. What career would you choose if you were a boy? The same?

    Why?

14. Do you like doing practical work in

    Science?
    Biology?

    Explain.

15. Do you think that the advantages/discoveries/inventions that have been made in the Science field have been good/bad for the world?

    Why?

16. What is your image of a typical scientist?

17. What Science/Biology topic would you like to know more about?

    Why?

18. Do you think girls should do different topics in the science syllabus?

    Explain?

APPENDIX D2

POST-INTERVIEW QUESTIONNAIRE - STANDARD SEVEN

1. Are you taking mathematics next year?

2. What has your average percentage for mathematics been this year?

3. Did your parents want you to continue with mathematics?

4. Why have you chosen/not chosen to carry on with mathematics next year?
Place ticks opposite ALL those reasons that apply.
Fill in any others.

5. Are you taking science next year?

6. What has your average percentage for science been this year?

7. Did your parents want you to continue with science?

8. Why have you chosen/not chosen to carry on with science next year?
Place ticks opposite ALL those reasons that apply.
Fill in any others.

9. Do you think Mathematics is a subject for boys and not really for girls?

10. Why do you think this?

11. Do you think science is a subject for boys and not really for girls?

12. Why do you think this?

13 - 18. From the Standard 6 and 7 science syllabus, here are some questions I would like you to answer. Place a tick in one of the 3 blocks opposite the relevant number.

13. Did you enjoy doing electricity?

14. Was electricity boring?

15. Did you understand what you were doing in electricity?

16. Do you think that what you learnt about in electricity is relevant to everyday life?

17. Do you like connecting up electrical circuits on circuit boards?

18. Did you enjoy the chemistry section?

APPENDIX D3

RESPONSE SHEET FOR STANDARD SEVEN QUESTIONNAIRE

Name: .... M/F.... School: ....

1. Yes .....   No .....

2. Average percentage .....

3. Yes .... No .... I don't know .... They don't mind ....

4. (a) If you <u>are</u> taking mathematics, then please answer these: (ONLY THOSE THAT APPLY THOUGH.)

I do well at it ☐

I find it easy ☐

It's interesting ☐

It's useful ☐

I need it for my career ☐

It's necessary in order to get a job ☐

If there are any other reasons, please write them down

here ....

....

....

(b) If you are NOT taking mathematics, then please answer these: (ONLY THOSE THAT APPLY THOUGH)

I don't do well at it ☐

I find it difficult ☐

It's boring ☐

It's not useful ☐

I don't need it for my career ☐

It's not a necessary subject for a job ☐

If there are any other reasons, please write them down

here ....

....

....

5. Yes ..... No .....

6. Average percentage .....

7. Yes .... No .... I don't know .... They don't mind ....

8. (a) If you <u>are</u> taking science, then please answer these: (ONLY THOSE THAT APPLY THOUGH.)

I do well at it ☐

I find it easy ☐

It's interesting ☐

It's useful ☐

I need it for my career ☐

It's necessary in order to get a job ☐

If there are any other reasons, please write them down

here ....

....

....

(b) If you are NOT taking science, then please answer these: (ONLY THOSE THAT APPLY THOUGH.)

I don't do well at it ☐

I find it difficult ☐

It's boring ☐

It's not useful ☐

I don't need it for my career ☐

It's not a necessary subject for a job ☐

If there are any other reasons, please write them down

here ....

....

....

9. Yes ..... No .....

10. Give REASONS for your answer: ....

....

....

....

11. Yes ..... No .....

12. Give REASONS for your answer: ....

....

....

....

Questions 13 - 18.

	Yes	No	Not Sure
13			
14			
15			
16			
17			
18			

APPENDIX E1

AREAS COVERED IN THE STANDARD EIGHT PUPIL INTERVIEWS

A. Quick details

1. What subjects are taken in standard eight?
2. How many children in family?
3. What position in family?
4. Information about ages and occupations/school standards of brothers and sisters.
5. Did they take mathematics/physical science at school?
6. Occupations of mother and father and whether or not they took mathematics/physical science at school.
7. What primary schools attended?
8. Details about standard 3, 4 and 5 mathematics and general science teachers.

B. Discussion areas

1. Mathematics from about standard 3 to the present, but generally covering the following:

    - (i) teachers
    - (ii) what type of teacher preferred
    - (iii) teacher's nature and likes and dislikes
    - (iv) teaching styles
    - (v) setbacks experienced
    - (vi) examinations
    - (vii) panic/confidence
    - (viii) understanding
    - (ix) performance generally
    - (x) enjoyment of subject
    - (xi) algebra
    - (xii) geometry
    - (xiii) the nature of the subject

2. Physical science and biology

    - (i) teachers
    - (ii) what type of teacher preferred
    - (iii) teacher's nature and likes and dislikes
    - (iv) teaching styles
    - (v) setbacks experienced
    - (vi) examinations
    - (vii) panic/confidence
    - (viii) understanding
    - (ix) performance generally
    - (x) enjoyment of subject
    - (xi) science/biology relationship (preference)
    - (xii) teachers' attitude to science/biology
    - (xiii) practical work
    - (xiv) the way it was taught
    - (xv) the nature of the subject

3. Parents

   (i) relationship to mathematics/science
   (ii) attitudes towards daughter re mathematics/science
   (iii) encouragement for daughter
   (iv) the importance they attach to mathematics/science
   (v) their attitudes towards brothers/sisters about mathematics/science
   (vi) their feelings about careers

4. Siblings

   (i) their relationship with (attitudes towards) mathematics/science
   (ii) their personal relationship with sister

5. Toys

   (i) played with - especially dolls, Lego, etc.
   (ii) parents feelings about toys

6. Careers

7. Issues that arose from

   (i) the standard six questionnaire
   (ii) the mathematics and physical science questionnaires completed during standard seven
   (iii) the standard seven interview
   (iv) the standard seven post-interview questionnaire

(This was a very important aspect of the standard eight interview.)

Note: These were not necessarily questions that were asked, but areas possibly to be covered. Attention was always focused on any particular aspect which looked as though it might yield valuable information.

APPENDIX E2

AREAS COVERED IN THE PARENT INTERVIEWS

1. Is mathematics important? (and for different sexes?)
2. Is physical science important? (and for different sexes?)
3. Are girls' needs the same as boys' as far as subjects are concerned?
4. Is it acceptable that boys/girls drop out of mathematics/science?
5. Are there careers which are more suitable for boys/girls?
6. What does 'society' think?
7. Attitudes towards mathematics/science
8. Encouragement to take mathematics/science
9. Influence on children
10. Expectations of their other children
11. Other children in the family (what they are doing)
12. Science in the home (boys' or girls' work?)
13. Toys and Dolls

Note: These were not questions that were asked, but simply potential areas to be covered. Issues that arose during the three-year horizontal longitudinal study with their daughters were of prime importance in these interviews too.

APPENDIX F1 (TABLE 4.7)

A COMPARISON OF MATHEMATICS ATTITUDES BETWEEN THE TWO TOWNS
(Chi-Square Values)

Sex	Groups	Std	Attitude					
			Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	All	6	4,28	0,67	0,21	0,24	0,03	0,00
		7	3,71	0,81	0,21	2,66	0,00	0,31
		8	52,20	0,02	1,27	27,55	1,92	0,00
	S-S	6	25,97	0,45	16,78	0,80	27,47	3,78
		7	2,10	11,17	0,06	1,86	0,00	1,17
		8	38,38	0,17	2,45	8,14	3,51	0,31
	Co-Ed	6	3,30	2,84	17,38	2,35	21,89	3,34
		7	3,16	15,59	0,70	0,95	0,00	2,37
		8	17,55	0,03	0,03	20,26	0,18	0,24
Girls	All	6	56,34	0,96	26,82	18,95	20,35	3,34
		7	28,14	18,81	7,58	2,16	11,58	7,65
		8	1,03	0,19	4,90	0,16	19,54	0,00
	S-S	6	24,35	0,31	19,03	3,94	10,21	14,77
		7	5,88	3,23	3,48	8,32	0,18	6,89
		8	22,35	0,65	24,13	9,99	50,91	4,99
	Co-Ed	6	34,23	2,61	10,68	16,06	10,59	0,04
		7	67,66	14,56	3,61	14,95	13,95	2,23
		8	26,48	0,29	1,22	4,55	0,00	2,73

APPENDIX F2 (TABLE 4.8)

SEX DIFFERENCES IN MATHEMATICS ATTITUDES
(Chi-Square Values)

Hypothesis	Groups	Std	Attitude					
			Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
1	All	6	83,02	85,82	111,56	29,10	81,35	20,45
2		7	52,25	59,73	121,24	6,72	37,20	20,71
3		8	16,89	59,16	97,31	17,59	53,70	35,52
4	S-S	6	9,45	33,17	20,33	10,45	5,61	0,62
5		7	5,38	4,75	35,03	0,69	0,59	3,87
6		8	17,87	20,71	79,18	10,53	33,61	29,76
7	Co-Ed	6	61,93	39,01	69,85	12,49	71,21	19,02
8		7	44,94	48,96	73,23	9,70	38,36	14,27
9		8	2,74	32,69	26,73	6,59	18,05	9,48

APPENDIX F3 (TABLE 4.9)

DIFFERENCES IN MATHEMATICS ATTITUDES BETWEEN CO-EDUCATIONAL AND SINGLE-SEX SCHOOLS
(Chi-Square Values)

Hypothesis	Groups	Std	Attitude Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
10	All	6	119,11	76,76	161,44	41,07	113,95	31,76
11		7	48,95	104,20	66,30	18,24	110,61	33,77
12		8	7,50	96,85	24,94	10,80	63,38	17,56
13	Boys	6	27,78	35,31	49,29	19,01	20,37	4,67
14		7	7,15	21,89	19,41	1,58	20,98	9,38
15		8	11,09	41,84	32,53	7,53	42,42	19,14
16	Girls	6	79,86	28,02	91,76	15,92	89,59	26,16
17		7	39,90	76,19	33,96	19,69	91,50	21,19
18		8	0,13	49,36	0,94	2,80	18,88	2,05

APPENDIX F4 (TABLE 4.10)

DIFFERENCES IN MATHEMATICS ATTITUDES BETWEEN STANDARDS SIX, SEVEN AND EIGHT
(Chi-Square Values)

Part A: Standards Six and Seven

Sex	Hypothesis	Groups	Attitude Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	19	All	9,04	86,00	2,43	15,69	0,02	0,05
	20	S-S	11,57	48,23	6,16	18,50	0,00	0,43
	21	Co-Ed	0,85	38,56	0,03	2,01	0,00	0,04
Girls	22	All	0,77	61,04	2,72	1,24	10,09	0,15
	23	S-S	5,55	8,62	12,22	0,35	2,56	0,09
	24	Co-Ed	0,31	56,76	0,15	1,00	7,37	0,38

Part B: Standards Seven and Eight

Sex	Hypothesis	Groups	Attitude Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	25	All	40,67	13,70	24,27	4,43	25,98	11,25
	26	S-S	14,70	1,84	6,13	0,33	5,15	2,02
	27	Co-Ed	26,11	13,31	18,87	5,26	22,99	9,92
Girls	28	All	14,30	17,73	19,96	16,19	48,35	27,43
	29	S-S	32,65	14,06	30,68	16,52	52,89	26,16
	30	Co-Ed	0,33	9,29	2,59	4,58	12,89	8,71

APPENDIX F5 (TABLE 4.12)

DIFFERENCES IN MATHEMATICS ATTITUDES BETWEEN THOSE STANDARD EIGHTS WHO TAKE MATHEMATICS AND THOSE WHO DON'T

(Chi-Square Values)

		Attitude					
Hypothesis		Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
31	Boys	475	145	408	162	261	258
32	Girls	1536	341	895	491	578	321

APPENDIX F6 (TABLE 4.13)

DIFFERENCES IN MATHEMATICS ATTITUDES AMONGST PUPILS IN STANDARD EIGHT WHO DON'T TAKE MATHEMATICS

(Chi-Square Values)

Part A: Comparing the Sexes

		Attitude					
Hypothesis	Type of school	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
33	all schools	13,46	6,55	10,97	6,04	4,03	0,32
34	S-S	2,62	0,17	0,27	0,61	0,74	X
35	Co-Ed	12,61	12,41	8,69	5,34	2,33	0,09

Part B: Comparing the Types of Schools

		Attitude					
Hypothesis	Sex	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
36	all pupils	20,40	3,53	4,91	0,14	1,92	0,23
37	boys	X	0,41	1,82	0,03	0,10	X
38	girls	5,48	9,15	1,17	0,06	0,90	0,14

X denotes a chi-square value which has not been quoted, because the expected cell frequencies are too low.

APPENDIX F7 (TABLE 4.14)

DIFFERENCES IN MATHEMATICS ATTITUDES AMONGST PUPILS IN STANDARD EIGHT WHO TAKE MATHEMATICS (Chi-Square Values)

Part A: Comparing the Sexes

Hypothesis	Type of school	Attitude Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
39	all schools	62,60	0,95	0,66	6,48	0,42	2,06
40	S-S	24,00	2,17	1,58	4,83	0,97	1,23
41	Co-Ed	30,76	1,81	0,01	1,56	1,29	0,78

Part B: Comparing the Types of Schools

Hypothesis	Type of school	Attitude Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
42	all pupils	22,17	47,02	0,54	1,54	14,50	0,17
43	boys	7,71	14,62	0,00	1,48	3,33	0,11
44	girls	6,48	35,01	1,47	0,00	13,00	0,00

APPENDIX F8 (TABLE 4.15)

DIFFERENCE IN MATHEMATICS ATTITUDES BETWEEN PUPILS IN STANDARD EIGHT WHO TAKE MATHEMATICS AND ALL PUPILS IN STANDARD SEVEN (Chi-Square Values)

Hypothesis	Sex	Attitude Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
45	Boys	0,57	0,04	3,07	3,73	0,09	5,79
46	Girls	236,15	32,67	104,00	46,72	23,32	21,38

APPENDIX G1 (TABLE 5.1)

COMPARISON OF PHYSICAL SCIENCE ATTITUDES BETWEEN THE TWO TOWNS
(Chi-Square Values)

			Attitude					
Sex	Groups	Std	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	All	6	3,04	25,57	0,02	11,95	0,21	1,35
		7	72,62	4,76	51,86	17,81	34,22	12,57
		8	4,90	12,86	10,27	3,48	20,43	1,08
	S-S	6	6,36	25,81	35,06	1,96	14,24	7,81
		7	31,72	8,01	53,87	6,43	27,77	16,86
		8	2,31	20,92	2,40	2,48	30,51	1,07
	Co-Ed	6	21,45	5,91	25,86	11,66	16,81	14,81
		7	43,89	28,33	9,49	11,99	10,46	0,96
		8	2,61	0,54	8,71	1,20	1,31	0,21
Girls	All	6	2,45	2,32	1,52	0,19	3,48	3,82
		7	1,45	3,63	32,79	1,09	14,74	1,01
		8	0,55	0,87	5,94	3,71	2,32	0,66
	S-S	6	65,82	42,76	19,18	17,78	44,91	7,53
		7	0,68	2,38	13,32	1,55	3,21	0,00
		8	41,67	8,56	27,54	20,20	16,49	9,29
	Co-Ed	6	14,80	7,24	2,37	8,24	6,50	0,30
		7	1,08	0,97	21,29	0,24	13,76	1,76
		8	17,62	1,03	0,77	1,35	1,66	1,63

APPENDIX G2 (TABLE 5.2)

SEX DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES
(Chi-Square Values)

			Attitude					
Hypothesis	Groups	Std	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
47	All	6	434,27	276,08	238,94	192,54	229,58	34,32
48		7	418,87	263,23	173,12	157,62	130,70	20,07
49		8	272,35	221,87	103,54	143,21	138,09	28,64
50	S-S	6	174,07	71,75	114,20	58,44	42,96	8,76
51		7	34,13	45,00	0,50	14,40	0,13	4,17
52		8	19,65	59,65	0,77	14,38	15,00	0,07
53	Co-Ed	6	245,93	168,19	107,71	127,67	171,88	21,26
54		7	476,90	211,46	276,17	170,40	205,74	55,26
55		8	320,37	159,89	197,16	154,54	147,23	51,09

APPENDIX G3 (TABLE 5.3)

DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES BETWEEN CO-EDUCATIONAL AND SINGLE-SEX SCHOOLS
(Chi-Square Values)

Attitude

Hypothesis	Groups	Std	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
56	All	6	18,59	120,33	54,58	10,20	60,51	12,90
57		7	0,05	91,09	0,28	2,60	6,21	0,24
58		8	0,09	24,47	0,73	1,49	0,09	1,56
59	Boys	6	1,98	28,67	28,03	0,05	4,31	2,65
60		7	71,87	7,39	76,81	11,92	27,81	21,70
61		8	40,67	1,44	45,58	10,36	13,64	8,14
62	Girls	6	1,35	55,78	8,19	3,73	41,63	6,07
63		7	26,29	77,29	31,83	18,18	54,01	18,77
64		8	28,71	20,86	48,79	17,16	10,55	16,31

APPENDIX G4 (TABLE 5.4)

DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES BETWEEN STANDARDS SIX, SEVEN AND EIGHT
(Chi-Square Values)

Part A: Standards Six and Seven

Attitude

Sex	Hypothesis	Groups	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	65	All	282,43	47,76	252,38	92,28	135,61	58,83
	66	S-S	264,97	36,54	314,39	69,98	135,22	67,90
	67	Co-Ed	61,27	14,44	26,89	29,28	26,45	7,37
Girls	68	All	260,15	36,25	183,19	64,21	58,43	40,45
	69	S-S	56,87	11,85	45,42	13,49	20,80	8,63
	70	Co-Ed	213,74	28,62	144,72	55,01	42,18	34,46

Part B: Standards Seven and Eight

Attitude

Sex	Hypothesis	Groups	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
Boys	71	All	93,35	3,64	126,01	10,65	46,71	37,67
	72	S-S	30,53	4,20	45,18	4,48	14,51	10,69
	73	Co-Ed	65,78	0,55	84,17	6,20	33,21	29,55
Girls	74	All	48,31	1,92	86,97	11,90	65,85	57,96
	75	S-S	17,17	10,34	24,79	4,73	52,28	23,90
	76	Co-Ed	34,29	0,16	68,31	8,34	23,81	37,37

APPENDIX G5 (TABLE 5.6)

DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES BETWEEN THOSE STANDARD EIGHTS WHO TAKE PHYSICAL SCIENCE AND THOSE WHO DON'T
(Chi-Square Values)

		Attitude					
Hypothesis		Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
77	Boys	857	298	479	276	341	146
78	Girls	1417	363	806	426	660	160

APPENDIX G6 (TABLE 5.7)

DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES AMONGST PUPILS IN STANDARD EIGHT WHO DON'T TAKE PHYSICAL SCIENCE
(Chi-Square Values)

Part A: Comparing the Sexes

		Attitude					
Hypothesis	Type of school	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
79	all schools	25,44	29,34	6,91	18,34	20,97	0,18
80	S-S	17,87	0,04	18,90	1,06	1,50	7,09
81	Co-Ed	70,05	41,76	40,17	34,49	40,55	6,00

Part B: Comparing the Types of Schools

		Attitude					
Hypothesis	Sex	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
82	all pupils	6,98	1,71	1,64	1,27	3,16	0,78
83	boys	64,74	13,05	25,81	14,55	21,29	5,89
84	girls	8,37	1,09	27,69	2,63	1,75	7,86

APPENDIX G7 (TABLE 5.8)

DIFFERENCES IN PHYSICAL SCIENCE ATTITUDES AMONGST PUPILS IN STANDARD EIGHT WHO TAKE PHYSICAL SCIENCE

(Chi-Square Values)

Part A: Comparing the Sexes

		Attitude					
Hypothesis	Type of school	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
85	all schools	13,82	10,99	21,18	1,01	3,09	0,16
86	S-S	43,75	0,43	42,96	7,28	8,36	7,25
87	Co-Ed	9,24	18,16	3,23	19,88	1,58	8,83

Part B: Comparing the Types of Schools

		Attitude					
Hypothesis	Sex	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
88	all pupils	74,43	11,31	84,39	11,42	30,04	15,30
89	boys	111,91	0,18	108,89	33,44	36,46	29,59
90	girls	1,30	18,46	0,03	3,85	0,38	0,95

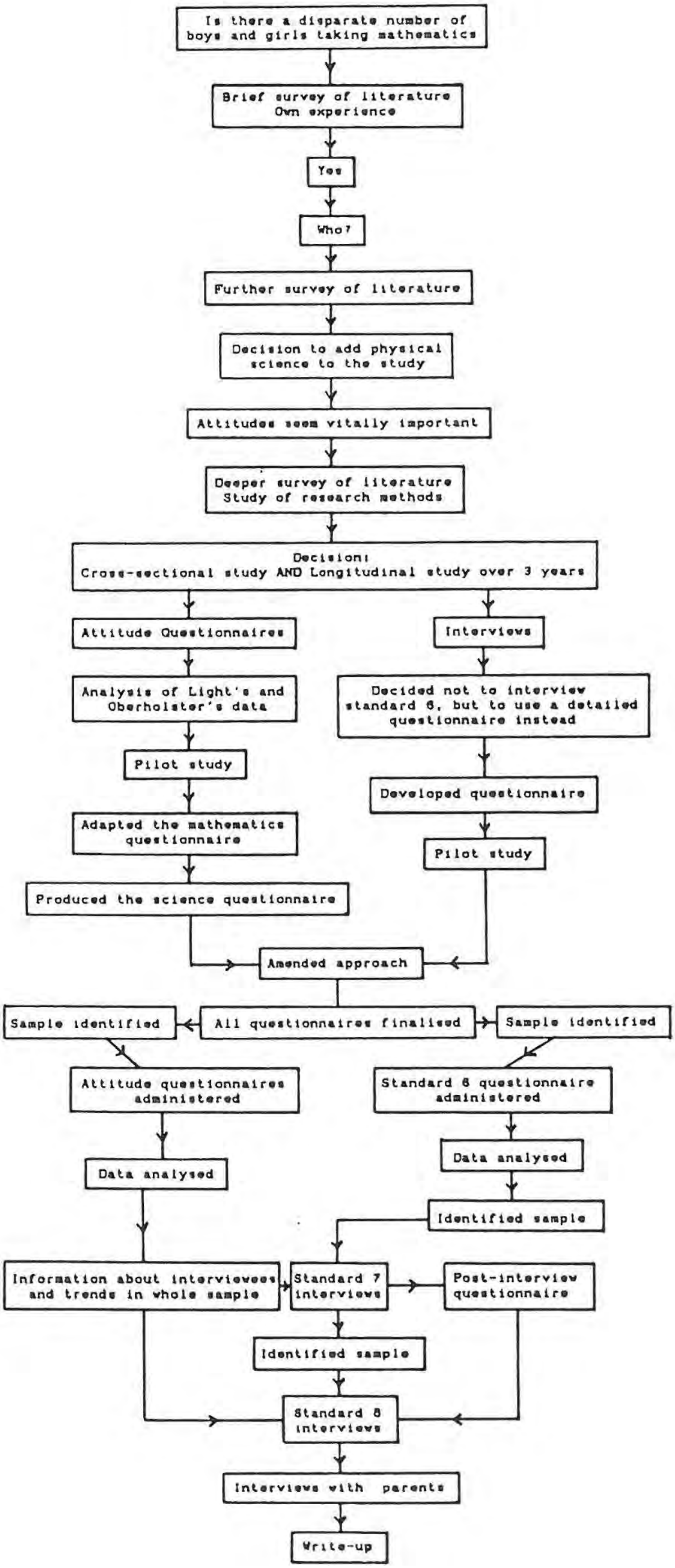
APPENDIX G8 (TABLE 5.9)

DIFFERENCE IN PHYSICAL SCIENCE ATTITUDES BETWEEN PUPILS IN STANDARD EIGHT WHO TAKE PHYSICAL SCIENCE AND ALL PUPILS IN STANDARD SEVEN

(Chi-Square Values)

		Attitude					
Hypothesis	Sex	Liking	Usefulness	Anxiety	Interest	Ability & Ach.	Understanding
91	Boys	25,48	39,42	0,01	22,50	5,25	0,34
92	Girls	446,62	150,98	182,86	127,54	133,24	14,66

APPENDIX H


Is there a disparate number of boys and girls taking mathematics
Brief survey of literature Own experience
Yes
Who?
Further survey of literature
Decision to add physical science to the study
Attitudes seem vitally important
Deeper survey of literature Study of research methods
Decision: Cross-sectional study AND Longitudinal study over 3 years
Attitude Questionnaires
Interviews
Analysis of Light's and Oberholster's data
Decided not to interview standard 6, but to use a detailed questionnaire instead
Pilot study
Developed questionnaire
Adapted the mathematics questionnaire
Pilot study
Produced the science questionnaire
Amended approach
Sample identified
All questionnaires finalised
Sample identified
Attitude questionnaires administered
Standard 6 questionnaire administered
Data analysed
Data analysed
Identified sample
Information about interviewees and trends in whole sample
Standard 7 interviews
Post-interview questionnaire
Identified sample
Standard 8 interviews
Interviews with parents
Write-up

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